Study on the use of the sub-700 MHz band (470-694 MHz)

Final Report

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Abstract

This study assesses the current state and the future trends of the use of the sub-700 MHz UHF band (470-694 MHz) within the European Union, and third countries around the world. In particular, the study investigates:

- technological developments and future trends within the Digital Terrestrial Television (DTT) and Programme Making and Special Events (PMSE) sectors;
- the evolution of consumer behaviour towards audio-visual (AV) consumption;
- public service media (PSM) mission requirements; and
- the current and future use of the sub-700 MHz band in third countries.

The study considers the extent to which Member States are making use of the most recent DTT and PMSE technologies, and the degree to which there remains room for further improvement. It also documents Member States' opinions on the future use of the band, and the implications foreseen on the ability of DTT and PMSE to continue operating satisfactorily in the event of any significant changes.

The study presents an analysis of the EU27 behaviour evolution in AV consumption. It provides data on the AV market in Europe and presents trends for linear TV and on-demand consumption and trends. It also examines the impact of the COVID-19 pandemic on AV consumption in Europe. The study forecasts trends for 2025 and 2030 using different prediction models (including exponential smoothing and Autoregressive Integrated Moving Average Model (ARIMA)). Following the consumer analysis, the study presents an analysis of public broadcasting services mission requirements.

Finally, the study looks at the use of the sub-700 MHz band in non-EU countries, in particular focussing on the status of the introduction of a new mobile band at 600 MHz, and other uses (such as private mobile radio (PMR)) which occur, especially in Asia.

Sommaire

Cette étude évalue l'état actuel et les tendances futures de l'utilisation de la bande UHF inférieure à 700 MHz (470-694 MHz) dans l'Union européenne et dans d'autres pays du monde. En particulier, l'étude examine :

- les développements technologiques et les tendances futures dans les secteurs de la télévision numérique terrestre (TNT) et de la réalisation de programmes et d'événements spéciaux (PMSE);
- l'évolution du comportement des consommateurs en matière de consommation audiovisuelle (AV);
- les exigences des missions des médias de service public (MSP); et
- l'utilisation actuelle et future de la bande inférieure à 700 MHz dans les pays tiers.

L'étude examine dans quelle mesure les États membres utilisent les technologies TNT et PMSE les plus récentes, et dans quelle mesure des améliorations sont encore possibles. L'étude informe également sur les opinions des États membres sur l'utilisation future de la bande et les implications prévues sur la capacité de la TNT et des PMSE à continuer à fonctionner de manière satisfaisante en cas de changements importants.

L'étude présente une analyse de l'évolution du comportement de l'UE-27 en matière de consommation AV. Elle fournit des données sur le marché AV en Europe et présente les tendances de la consommation et des tendances de la télévision linéaire et de la télévision à la demande. Elle examine ainsi l'impact de la pandémie de COVID-19 sur la consommation AV en Europe. L'étude prévoit les tendances pour 2025 et 2030 en utilisant différents modèles de prévision (notamment le lissage exponentiel et le Modèle de moyenne mobile intégré autorégressif (lAutoregressive Integrated Moving Average Model - ARIMA). Après l'analyse des consommateurs, l'étude présente une analyse des exigences de la mission de services publics de radiodiffusion.

Finalement, l'étude se penche sur l'utilisation de la bande inférieure à 700 MHz dans les pays non-membres de l'UE, en se concentrant notamment sur l'état d'avancement de l'introduction d'une nouvelle bande mobile 600 MHz, et sur les autres utilisations (telles que la radio mobile privée (Private Mobile Radio - PMR) qui ont lieu, notamment en Asie.

Abstrakt

In dieser Studie wird der aktuelle Stand und die künftigen Trends der Nutzung des Sub-700 MHz UHF-Bands (470-694 MHz) in der Europäischen Union und in anderen Ländern der Welt untersucht. Insbesondere wird in der Studie untersucht:

- technologische Entwicklungen und künftige Trends in den Bereichen digitales terrestrisches Fernsehen (DTT), und Programmerstellung und Veranstaltungen (PMSE);
- die Entwicklung des Verbraucherverhaltens in Bezug auf die audiovisuelle (AV) Nutzung;
- Anforderungen bzgl. dem Auftrag der öffentlich-rechtlichen Medien (PSM); und
- die derzeitige und künftige Nutzung des Sub-700-MHz-Bands in Drittländern.

In der Studie wird untersucht, inwieweit die Mitgliedstaaten die neuesten DTT- und PMSE-Technologien nutzen und inwieweit es noch Raum für weitere Verbesserungen gibt. Sie dokumentiert auch die Meinungen der Mitgliedstaaten über die künftige Nutzung des Frequenzbands und im Falle von wesentlichen Änderungen, welche voraussichtlichen Auswirkungen dies auf den ordnungsgemäßen Betrieb von DTT und PMSE haben könnte.

Die Studie präsentiert eine Analyse der Entwicklung des Konsums der AV Nutzung innerhalb den EU27 Staaten. Sie liefert Daten über den AV-Markt in Europa und stellt Trends für den linearen TV- und On-Demand-Konsum und Trends vor. Sie untersucht auch die Auswirkungen der COVID-19-Pandemie auf die AV-Nutzung in Europa. Die Studie prognostiziert die Trends für 2025 und 2030 anhand verschiedener Vorhersagemodelle (einschließlich exponentieller Glättung und ARIMA-

Modelle (Autoregressive Integrated Moving Average Model)). Neben der Analyse der Nutzung enthält die Studie auch eine Analyse der Anforderungen des öffentlichen Rundfunks.

Abschließend befasst sich die Studie mit der Nutzung des Sub-700-MHz-Bandes in Nicht-EU-Ländern, insbesondere mit dem Stand der Einführung eines neuen Mobilfunkbandes bei 600 MHz, sowie mit anderen Nutzungsarten (wie privater Mobilfunk (PMR)), die vor allem in Asien vorkommen.

Executive Summary

The sub-700 MHz band (470-694 MHz) represents a piece of radio spectrum reserved in the European Union (EU) for digital terrestrial television (DTT) and wireless audio equipment for programme making and special events (PMSE) such as radio microphones. As viewing habits change and video technology improves, questions have been raised on the extent to which DTT will remain an important delivery platform. Technological innovations and advancements, especially a switch from analogue to digital terrestrial television broadcasting, have increased the spectrum efficiency of broadcasting services. Historically, this led to other spectrum in the UHF band previously used for television broadcasting, being repurposed for wireless broadband services.

At the forthcoming International Telecommunications Union (ITU) World Radiocommunication Conference in 2023, at which worldwide decisions on the allocation of radio spectrum are made, the question of whether the sub-700 MHz band should be allocated also to mobile services in Europe, Africa and the Middle East is under study and decisions taken at that conference could impact its use in Europe.

At an EU level, the Lamy report[1] (published in August 2014) on the future use of the UHF band, based its results on the work of a High Level Group involving top executives from Europe's broadcasters, network operators, mobile companies and technical associations, and proposed to:

- Dedicate the 700 MHz band (694-790 MHz) to wireless broadband across Europe by 2020 (±2 years);
- Ensure regulatory security and stability for terrestrial broadcasters in the remaining UHF spectrum below 700 MHz until 2030; and
- Assess technology and market developments by 2025.

As a result of this report, the UHF Decision[2] provided long-term investment predictability and stimulated innovation by safeguarding, under Article 4, the availability of the sub-700 MHz band for DTT and PMSE services until at least 2030 in all Member States (MS) while taking into account the principle of technological neutrality. It further allowed alternative use in a MS, provided that such use is compatible with national broadcasting needs and the provision of broadcasting services in neighbouring countries.

Under Article 7 of the UHF Decision, the Commission is required to report to the European Parliament and the Council on developments in the use of the sub-700 MHz frequency band with a view to ensuring efficient use of spectrum. In doing so, it should take into account the social, economic, cultural and international aspects affecting the use of the band, further technological developments, changes in consumer behaviour, and the requirements in connectivity to foster growth and innovation across the EU.

[1] https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=8423

[2] Decision (EU) 2017/899 of the European Parliament and of the Council of 17 May 2017 on the use of the 470-790 MHz frequency band in the Union

This report considers the current status and the future trends of the use of the sub-700 MHz band across the EU, as well as changes in viewing habits, the role of DTT in public service media (PSM) distribution and international developments relating to the use of the band. It has been prepared in the context of Article 7, for the Commission, by LS telcom and VVA.

Latest technological developments and future trends in the areas of DTT and 5G broadcasting

DTT technology has been constantly evolving. Two primary aspects of the DTT service have been through significant improvement:

- The transmission standard has migrated from DVB-T (1997) to DVB-T2 (2009), providing additional capacity for television services in the same amount of radio spectrum;
- The techniques used for digitally encoding video have improved over time from MPEG-2 (1996), to MPEG-4 (1999) to the latest standard HEVC (2013), each improvement using a smaller proportion of the available capacity for each video stream.

These changes have permitted the introduction of High Definition (HD) services in the same amount of spectrum which used to be required for Standard Definition (SD) services. Other improvements in picture quality such as the introduction of Ultra High Definition (UHD a.k.a. 4K), High Frame Rate and High Dynamic Range could be introduced on the DTT platform but would reduce the number of video services available due to their need for higher bandwidths.

Across MS, approximately 60% of national multiplexes are already using the most advanced transmission standard (DVB-T2) with around 40% of national multiplexes using the most advanced encoding standard (HEVC). There has been good progress in adopting the newer standards, however there are improvements that can be made in a number of MS.

Single Frequency Networks (SFNs) permit multiple transmitters to simultaneously operate on the same frequency, reducing the need for spectrum for DTT services by around 25% albeit with added complexity and constraints on local or regional content. At least 12 MS are already using SFNs to some extent in their DTT networks.

Any further changes to the MS' DTT platforms to further improve efficiency (where possible) are likely to lead to significant costs, and appetite to do so may be limited without sufficient regulatory certainty regarding continued access to the sub-700 MHz band.

5G Broadcasting uses 5G technology to deliver live video content to multiple users. It is seen as a promising alternative to DTT, with early trials showing that a similar capacity to DTT can be obtained over 5G Broadcasting assuming good reception conditions. However, the business models that could support 5G Broadcasting are unclear, for example in how it is funded and who is responsible for the network. The availability of 5G Broadcasting equipment today (in particular user handsets) is minimal. Trials are ongoing to encourage manufacturers to include support for the standard within devices, though manufacturers have provided no timescales as to when this may occur.

As the UHF Decision safeguards the sub-700 MHz band for terrestrial broadcasting and PMSE until at least 2030, amongst MS there is little consensus on future regulatory approaches to the sub-700

MHz band, other than that large changes (for example the introduction of a dedicated mobile sub-band or conversion of the whole band to permit equal access to broadcast and mobile services) will require significant co-ordination effort. There are differing views as to whether such changes would cause significant impact to DTT (in the form of economic impacts or the platform's ability to meet pluralist and free-to-air requirements) or how such a change would impact socio-economic benefits through an increase of spectrum for mobile services at the cost of spectrum availability for broadcast services.

The varying views from MS are further highlighted when considering their assessment of the extent of demand for additional sub-1 GHz spectrum for mobile services. The majority of MS stated that they do not have sufficient information to comment on the likelihood of additional sub-1 GHz spectrum being required, potentially because the current focus for administrations is on making the 5G pioneer spectrum bands (700 MHz, 3.6 GHz and 26 GHz) available to operators.

Consumer behaviour evolution

AV content in the EU is delivered by a number of different methods, and associated delivery platforms:

- Linear TV (i.e. watching a programme as it is transmitted) is delivered through DTT, satellite and cable networks, as well as via streaming over broadband connections (known as IPTV). These services may be free-to-view or pay TV;
- Non-Linear TV (i.e. watching a programme at a time selected by the viewer) is streamed over broadband internet connections, and comes in a number of different forms:
    - Catch-up TV allows viewers to watch a catalogue of recently transmitted programmes, usually from a particular broadcaster;
    - Over-the-top (OTT) services allow viewers to watch a catalogue of material that has been produced or bought by a content aggregator (such as Netflix, Discovery, Disney or Amazon).

  Both of the above may be termed video-on-demand (VoD) which may be free, or be accessible through a regular subscription (SVoD) or on a transactional, pay-as-you-watch basis (TVoD).

In 2020, the size of the European AV market amounted to slightly more than EUR 82 billion according to the European Audiovisual Observatory (EAO, 2020). Revenues from AV service providers (both linear and non-linear) accounted for around 70% of the total (excluding public funding[3]).

Linear TV broadcasting trends

Consumption of TV in the EU is higher than worldwide averages and varies by age group; generally older viewers watch more TV while younger generations spend more time watching VoD.

The Covid-19 pandemic had a significant impact on TV viewing: on the one hand, it increased viewership due to interest in news coverage and at the same time it introduced restrictions in terms of live sport and programme production.

[3] Adding public funding increases the share of audio-visual services to 96% of the total AV market.

The characteristics of the European AV market are also changing. There has been a general decrease in the concentration of the European audience market due to a loss of share by former market leaders over time. This has been caused by the increase in the number of players in the market, the introduction of DTT making more channels available to consumers, and a decrease in share of historic terrestrial services which dominated analogue distribution. Over a five-year period from 2016 to 2020, average audience market shares of the four leading TV channels[4] in Europe's national markets decreased by 4.6% (EAO, 2021). However, over the same period, the daily audience market shares of the same channels varied strongly among MS, for instance:

- Cyprus and Poland displaying sharp decreases of 23.2% and 19.9% respectively;
- Denmark, Ireland and Sweden showing increases of 9.5%, 11.6% and 7.1% respectively.

The share of public service broadcasting (PSB) groups in national audience markets is also in decline. From 2015 to 2020, the average audience market share of European PSBs contracted by 2%. Again, there are major differences between MS:

- In Denmark, Lithuania and the Netherlands, the weight of public service broadcasting increased by 14%, 46% and 16% respectively;
- In Spain, Bulgaria, Cyprus and Hungary, the weight of public service broadcasting decreased between 29% and 36%.

On demand consumption and trends

VoD consumer revenues in the EU grew in the period from around EUR 640 million in 2011 to EUR 11.6 billion in 2022: a Compound Annual Growth Rate (CAGR) of 38%. In 2019, VoD represented only 7% of the total revenues generated in the EU27 + UK AV market (EAO, 2021). However, TVoD and SVoD revenues were the fastest growing segments in 2019, a trend that was also the case during the Covid-pandemic in 2020 (EAO, 2021).

Subscription Video on Demand services

There were 140 million SVoD subscriptions at the end of 2020 in the EU27 + UK (EAO, 2021). As SVoD is becoming mainstream and other players are preparing launches of services, the market is likely to continue to see growth in coming years (EAO, 2021).

COVID-19 impact on audio-visual consumption in the EU27

Research suggests that the AV sector in Europe lost over 6% of its revenues in 2020 compared to 2019 and close to 9% excluding on-demand services (EAO, 2020). However, many parts of the market resisted this crisis, including SVoD, Pay TV, VoD and public funding for broadcasters (Arrieta, 2020).

Consumption forecasting

Forecasts predict a decrease in linear TV viewing of 6% by 2025 and 13% by 2030 compared to 2019 (reported by Eurodata TV Worldwide), although differences in this trend are observed across MS, especially between the Nordic countries where the decrease is more marked and certain countries in

[4] Although EAO does not name the channels, according to Ampere Analysis (via Statista) the four largest TV groups in Europe (2020) are Comcast (12% of the market share), Netflix (6.1%), ARD (5.7%) and BBC (4.2%).

Central and Eastern Europe where instead an increase is predicted. For VoD, forecasts predict significant growth in the near future with an increase in revenues for on-demand AV services of 126% by 2025 and 254% by 2030 compared to 2020 (EAO). The use of internet to watch TV is predicted to grow 21% by 2025 and 26% by 2030 compared to 2021 (Eurodata TV Worldwide).

A sharp growth is also foreseen for the TVoD and the SVoD markets. Forecasts predict an increase in revenues for retail TVoD (where users purchase unlimited usage rights to a specific video file) of a factor of 15 by 2025 and a factor of 20 by 2030. Rental TVoD (where users access a piece of content for a limited time for a fee) is expected to increase by 335% by 2025 and 446% by 2030.

The number of households with SVoD subscriptions is foreseen to more than double by 2025 (+109%) and reach full penetration by 2027, resulting in a sharp growth for the SVoD. In most markets, however, SVoD revenues are still a small part of AV market revenues ranging from 1.1% to 14.8%, especially in markets where pay TV prices are low, pay TV penetration is widespread, broadband penetration is below the EU average and the number of available SVoD services is smaller.

PSM mission requirements

Public Service Media (PSM) broadcasting has been a major source of social interpretation for news and events in much of Europe. Dialogue, debate and deliberation are three core ingredients of the PSM and another role of PSM is to mediate the interests of representative and participatory democracy (Trappel, 2008).

The obligations of PSM are built upon fulfilling these roles, which are not limited simply to linear TV but also include “new media” services under the operations of the PSM (Council of Europe, 2006). PSM must also maintain a high-quality level and, typically, “universal service” to further social, political and cultural cohesion and to justify public finance. The European Broadcasting Union (EBU) also states that in order to fulfil the basic principles which determine the business model of PSM, a set of general requirements are considered relevant for the distribution of linear broadcasting services. These include (among other things) universality of access and appeal, delivering public value, promoting citizenship, and free-to-air services or equivalent, which is to say at no additional cost for the viewers and listeners.

The low cost of DTT technology for consumers means that it remains a common method of accessing PSM content (Plum, 2021). Many markets still rely heavily on DTT for television broadcasts, particularly in markets where this has historically had a high market share. However, for PSM the decline in the traditional TV audience and the fragmentation of audiences across multiple services, platforms and modes of content consumption, affects their ability to sustain high levels of reach, impact and value to audiences (Plum, 2021).

Across the EU, the TV market landscape varies significantly: in some markets (such as Italy and Spain) DTT penetration and usage remain high. Migration from DTT to alternative platforms would require large investments, either borne by individual households or governments (EBU, 2019). The latter may be difficult due to platform neutrality considerations (EBU, 2019). Even in markets where the demand for linear TV is declining, certain audience segments, such as the older viewers and low-income households, may still be dependent on DTT. PSM channels are subject to accessibility requirements to ensure that people with disabilities, particularly those with sight and hearing impairments, are able to watch programmes. There are no similar requirements for on-demand services (including the PSM's own services and SVoDs) (Ofcom, 2021).

Spectrum needs and technology trends in PMSE

PMSE in the sub-700 MHz band primarily consists of radio microphones and in-ear audio monitors and the sub-700 MHz band represents the main piece of radio spectrum used for these technologies. PMSE equipment requires high (audio) quality and low latency when used for live performances: any interruptions or delays can cause significant complications. Some PMSE use is time and location specific (i.e. at occasional outdoor events) whereas other use is more continuous (i.e. in television studios).

Audio PMSE devices historically employed analogue technology which used the radio spectrum inefficiently. As a result of developments in technology, such equipment is now able to deliver around 3 times the number of audio channels in a fixed amount of radio spectrum whilst achieving acceptable levels of quality.

An alternative technology, DECT, allows access to additional spectrum outside the sub-700 MHz band but may not be suitable for the most latency and quality sensitive applications. Techniques such as Cognitive-PMSE and more advanced spectrum management approaches could help to retain audio quality in congested spectrum and open-up possibilities for usage of alternative spectrum bands. The extent to which these have been adopted is unclear.

Whilst the capabilities of PMSE equipment are growing, demand for PMSE is also growing:

- Approximately 50% of MS indicated an observed growth in PMSE spectrum demand, for example by approximately 10% a year in the Netherlands and 20% a year in Spain;
- A study by Swiss broadcaster SRF found that the daily requirement for PMSE spectrum, based on the technologies currently in use, varied between 42 MHz for small, local events to 115 MHz for large events. The requirement for major events was as high as 174 MHz. Demand for PMSE spectrum is increasing, potentially requiring as much as 224 MHz for major events in the future (i.e. the whole sub-700 MHz UHF band).

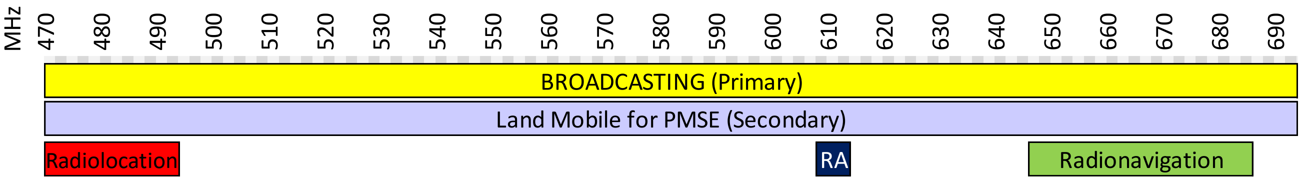
In some areas securing access to such large amounts of spectrum would currently be difficult, given that the sub-700 MHz band is shared with DTT transmissions. Securing access to sufficient spectrum would be made more difficult following any further reduction in the amount of sub-700 MHz spectrum available.

There are further developments that seek to either improve the spectral efficiency of PMSE or use new frequency bands or technologies. The innovation demonstrated by WMAS, utilising wideband systems and digital encoding schemes, shows promise, however it is unlikely to be applicable in all use cases and equipment is not yet widely commercially available. Similarly, usage of alternative frequency bands will not be applicable in all use cases due to their sub-optimal propagation characteristics. The use of alternative frequency bands also requires the development and acquisition of new equipment, which will require investment and time.

5G is showing promise as a potential enabling technology for some PMSE applications, with early trials showing that certain network configurations are starting to approach the requirements for some of the most demanding PMSE use cases. However, even if further development is able to meet latency and reliability requirements, there are additional issues in the form of ensuring ease of access to 5G networks and dedicated spectrum for PMSE users.

International developments

In ITU Region 1 (Europe, Africa and the Middle East)[5], radio spectrum in the sub-700 MHz band is allocated to broadcasting on a primary basis. In 86 countries from the region, including the majority of MS (excluding Cyprus, Greece and Slovenia), the band is also allocated to the land mobile service, intended for PMSE, on a secondary basis (which must not cause harmful interference to, nor claim protection from harmful interference from, broadcasting). Within the EU (see the chart below) parts of the band also have allocations to radioastronomy (RA), radiolocation (Austria, Czechia, Denmark, Estonia and Germany) and aeronautical radionavigation (in Bulgaria only).



A number of countries in Africa and the Middle East have also identified parts of the band for fixed and mobile services on a secondary basis.

In the rest of the world there is also a primary allocation to broadcasting for the entire 470-694 MHz range. In addition:

- In ITU Region 2 (the Americas), there are secondary mobile and fixed allocations in the frequency ranges 470–512 MHz and 614–698 MHz, with parts of the range identified for IMT in a number of countries;
- In ITU Region 3 (Asia-Pacific), the whole of the frequency range 470–694 MHz has an additional primary allocation to fixed and mobile services, and from 585–610 MHz has an additional primary allocation to radionavigation. Parts of the band (typically the bottom 30 MHz or so) are often allocated for mobile (PMR) uses in many countries.

A number of countries in both ITU Regions 2 and 3 are in the process of implementing a 600 MHz IMT band. In many other countries in these regions, however, the proliferation of terrestrial television services means that there is little scope to re-farm the band for new mobile services. At the April 2022 meeting of the Asia-Pacific Telecommunity (APT), a decision was taken to adopt a (slightly different to ITU Region 2) band plan for the use of the 600 MHz IMT band, indicating interest in this band across the region. The 600 MHz mobile band is under consideration in ITU Region 1 in both Saudi Arabia and the United Arab Emirates.

[5] ITU Region 1 contains 121 countries.

An analysis of international AV consumption changes indicated that globally, the market is highly competitive where players are competing not only on video distribution but in other adjacent industries like programme production. Such production is based on the global market, but adapted to localised requirements (OurWorld, 2020). The growth in content production is driven by strong consumer demand for local content. The shift towards national films and series is a normal competitive response of locally based OTT platforms, which realise that to better compete with global players they need to leverage indirect network effects as propelled by local content. This is the cycle that supports the development of localised programming across the world[6] (OurWorld, 2020).

[6] For example, in Brazil local productions reached 17.7% of pay-TV programme hours in 2017, while in 2019 national films currently represent 6.3% of the libraries of the top seven OTT platforms, and series amount to 23.1% (OurWorld, 2020).

Résumé exécutif

La bande inférieure à 700 MHz (470-694 MHz) représente une partie du spectre radioélectrique réservée dans l'Union européenne (UE) à la télévision numérique terrestre (TNT) et aux équipements audio sans fil pour la réalisation de programmes et d'événements spéciaux (PMSE) tels que les microphones radio. Avec l'évolution des habitudes de consommation et les progrès de la technologie vidéo, on se demande dans quelle mesure la TNT restera une plateforme de diffusion importante. Les innovations et les progrès technologiques, en particulier le passage de la radiodiffusion télévisuelle analogique à la radiodiffusion télévisuelle numérique terrestre, ont augmenté l'efficacité du spectre des services de radiodiffusion. Historiquement, cela a conduit à ce que d'autres fréquences dans la bande UHF, précédemment utilisées pour la télédiffusion, soient réaffectées aux services sans fil à large bande.

Lors de la prochaine conférence mondiale des radiocommunications de l'Union internationale des télécommunications (UIT) en 2023, au cours de laquelle sont prises les décisions mondiales sur l'attribution du spectre radioélectrique, la question de savoir si l'utilisation de la bande inférieure à 700 MHz devrait être attribuer aussi aux services mobiles en Europe, Afrique et Moyen-Orient est à l'étude et les décisions prises lors de cette conférence pourraient avoir un impact sur son utilisation en Europe.

Au niveau de l'UE, le rapport Lamy[7] (publié en août 2014) sur l'utilisation future de la bande UHF, s'est appuyé sur les travaux d'un groupe de haut niveau réunissant les principaux dirigeants des radiodiffuseurs, des opérateurs de réseaux, des sociétés de téléphonie mobile et des associations techniques en Europe, et a proposé de :

- dédier la bande 700 MHz (694-790 MHz) au haut débit sans fil dans toute l'Europe dès 2020 (±2 ans) ;
- garantir la sécurité et la stabilité réglementaires pour les radiodiffuseurs terrestres dans le reste du spectre UHF inférieur à 700 MHz jusqu'en 2030 ; et
- évaluer l'évolution des technologies et du marché jusque 2025.

À la suite de ce rapport, la décision UHF[8] a assuré la prévisibilité des investissements à long terme et stimulé l'innovation en préservant, en vertu de l'article 4, la disponibilité de la bande inférieure à 700 MHz pour les services TNT et PMSE jusqu'en 2030 au moins dans tous les États membres, tout en tenant compte du principe de neutralité technologique. Elle autorise en outre une utilisation alternative dans un État membre à condition que cette utilisation soit compatible avec les besoins nationaux en matière de radiodiffusion et avec la fourniture de services de radiodiffusion dans les pays voisins.

En vertu de l'article 7 de la décision UHF, la Commission est tenue de faire rapport au Parlement européen et au Conseil sur l'évolution de l'utilisation de la bande de fréquences inférieure à 700 MHz dans le but d'assurer une utilisation efficace du spectre. Ce faisant, elle doit tenir compte des aspects

[7] https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=8423

[8] Décision (UE) 2017/899 du Parlement européen et du Conseil du 17 mai 2017 relative à l'utilisation de la bande de fréquences 470-790 MHz dans l'Union.

sociaux, économiques, culturels et internationaux qui influent sur l'utilisation de la bande, des nouvelles évolutions technologiques, des changements de comportement des consommateurs et des exigences en matière de connectivité pour favoriser la croissance et l'innovation dans l'UE.

Ce rapport examine l'état actuel et les tendances futures de l'utilisation de la bande inférieure à 700 MHz dans l'UE, ainsi que l'évolution des habitudes de consommation, le rôle de la TNT dans la distribution des médias de service public (MSP) et les développements internationaux relatifs à l'utilisation de la bande. Il a été préparé dans le cadre de l'article 7, pour la Commission, par LS telcom et VVA.

Dernières évolutions technologiques et tendances futures dans les domaines de la diffusion TNT et 5G.

La technologie TNT est en constante évolution. Deux aspects principaux du service TNT ont fait l'objet d'améliorations importantes :

- La norme de transmission a migré de la DVB-T (1997) à la DVB-T2 (2009), offrant une capacité supplémentaire pour les services de télévision dans la même quantité de spectre radio ;
- Les techniques utilisées pour le codage numérique de la vidéo se sont améliorées au fil du temps, de MPEG-2 (1996) à MPEG-4 (1999) et à la dernière norme HEVC (2013), chaque amélioration utilisant une proportion plus faible de la capacité disponible pour chaque flux vidéo.

Ces changements ont permis l'introduction de services haute définition (HD) dans la même quantité de spectre qui était auparavant nécessaire pour les services de définition standard (SD). D'autres améliorations de la qualité de l'image, telles que l'introduction de l'ultra-haute définition (UHD ou 4K), de la fréquence d'images élevée et de la gamme dynamique élevée, pourraient être introduites sur la plateforme TNT, mais réduiraient le nombre de services vidéo disponibles en raison de leur besoin de bandes passantes plus élevées.

Dans les États membres, environ 60 % des multiplex nationaux utilisent déjà la norme de transmission la plus avancée (DVB-T2) et environ 40 % des multiplex nationaux utilisent la norme de codage la plus avancée (HEVC). L'adoption des nouvelles normes a bien progressé, mais des progrès peuvent être réalisés dans un certain nombre d'États membres.

Les réseaux monofréquences (SFN) permettent à plusieurs émetteurs de fonctionner simultanément sur la même fréquence, réduisant ainsi d'environ 25 % le besoin en spectre pour les services TNT, mais avec une complexité accrue et des contraintes sur le contenu local ou régional. Au moins 12 États membres utilisent déjà les SFN dans une certaine mesure dans leurs réseaux TNT.

Toute nouvelle modification des plateformes TNT des États membres en vue d'améliorer encore l'efficacité (lorsque possible) entraînera probablement des coûts importants, et l'appétit pour ces modifications pourrait être limité en l'absence de certitude réglementaire suffisante concernant l'accès continu à la bande inférieure à 700 MHz.

La diffusion 5G utilise la technologie 5G pour diffuser du contenu vidéo en direct à de multiples utilisateurs. Elle est considérée comme une alternative prometteuse à la TNT, les premiers essais montrant qu'une capacité similaire à la TNT peut être obtenue sur la diffusion 5G en supposant de bonnes conditions de réception. Cependant, les modèles économiques qui pourraient soutenir la diffusion 5G ne sont pas clairs, par exemple en ce qui concerne le mode de financement et la responsabilité du réseau. La disponibilité actuelle des équipements de diffusion 5G (en particulier les combinés des utilisateurs) est minimale. Des essais sont en cours pour encourager les fabricants à inclure la prise en charge de la norme dans les appareils, bien que les fabricants n'aient fourni aucun calendrier quant à la date à laquelle cela pourrait se produire.

Étant donné que la décision UHF protège la bande inférieure à 700 MHz pour la radiodiffusion terrestre et PMSE jusqu'en 2030 au moins, les États membres ne s'accordent guère sur les approches réglementaires futures de la bande inférieure à 700 MHz, si ce n'est que les changements importants (par exemple l'introduction d'une sous-bande mobile dédiée ou la conversion de la bande entière pour permettre un accès égal aux services de radiodiffusion et aux services mobiles) nécessiteront un effort de coordination considérable. Les avis divergent quant à savoir si de tels changements auraient un impact significatif sur la TNT (sous la forme d'impacts économiques ou de la capacité de la plateforme à répondre aux exigences de pluralisme et de gratuité) ou comment un tel changement aurait un impact sur les avantages socio-économiques par une augmentation du spectre pour les services mobiles au détriment de la disponibilité du spectre pour les services de radiodiffusion.

Les différents points de vue des États membres sont également mis en évidence lorsqu'on examine leur évaluation de l'ampleur de la demande de spectre supplémentaire dans la bande des 1 GHz pour les services mobiles. La majorité des États membres ont déclaré qu'ils ne disposaient pas d'informations suffisantes pour se prononcer sur la probabilité d'un besoin supplémentaire de spectre dans la bande des 1 GHz, peut-être parce que les administrations se concentrent actuellement sur la mise à disposition des opérateurs des bandes de fréquences pionnières de la 5G (700 MHz, 3,6 GHz et 26 GHz).

Évolution du comportement des consommateurs

Dans l'UE, le contenu AV est diffusé par un certain nombre de méthodes différentes et de plateformes de diffusion associées:

- La télévision linéaire (c'est-à-dire le fait de regarder un programme tel qu'il est transmis) est fournie par la TNT, le satellite et les réseaux câblés, ainsi que par la diffusion en continu sur des connexions à large bande (appelée IPTV). Ces services peuvent être gratuits ou payants;
- La télévision non linéaire (c'est-à-dire le fait de regarder un programme à un moment choisi par le téléspectateur) est diffusée en continu sur des connexions internet à large bande et se présente sous différentes formes :
    - La télévision de rattrapage permet aux téléspectateurs de regarder un catalogue de programmes récemment transmis, généralement par un diffuseur particulier,
    - Les services Over-the-top (OTT) permettent aux téléspectateurs de regarder un catalogue de matériel produit ou acheté par un agrégateur de contenu (comme Netflix, Discovery, Disney ou Amazon).

Dans les deux cas, il peut s'agir de vidéo à la demande (VoD), qui peut être gratuite ou accessible par un abonnement régulier (SVoD) ou sur la base d'un paiement à la consommation (TVoD).

En 2020, la taille du marché AV européen s'élevait à un peu plus de 82 milliards d'euros selon l'Observatoire européen de l'audiovisuel (EAO, 2020). Les revenus des fournisseurs de services AV (linéaires et non linéaires) représentaient environ 70 % du total (hors financement public[9]).

Tendances de la télédiffusion linéaire

La consommation de télévision dans l'UE est plus élevée que les moyennes mondiales et varie selon le groupe d'âge ; en général, les téléspectateurs plus âgés regardent davantage la télévision tandis que les jeunes générations passent plus de temps à regarder la VoD.

La pandémie de Covid-19 a eu un impact significatif sur l'écoute de la télévision : d'une part, elle a augmenté le nombre de téléspectateurs en raison de l'intérêt pour les reportages d'actualité et, d'autre part, elle a introduit des restrictions en termes de sport en direct et de production de programmes.

Les caractéristiques du marché AV européen sont également en train de changer. On observe une diminution générale de la concentration du marché européen de l'audience en raison d'une perte de parts des anciens leaders du marché au fil du temps. Ce changement est dû à l'augmentation du nombre d'acteurs sur le marché, et l'avènement de la TNT avec une augmentation du nombre de canaux disponibles pour les consommateurs et une perte de part des services terrestres historiques qui dominaient la distribution analogique. Sur une période de cinq ans, de 2016 à 2020, les parts de marché d'audience moyennes des quatre principales chaînes de télévision[10] sur les marchés nationaux européens se sont contractées de 4,6 % (EAO, 2021). Cependant, sur la même période, les parts de marché de l'audience quotidienne des mêmes chaînes variaient fortement entre les États membres, par exemple :

- Chypre et la Pologne affichent de fortes baisses, respectivement de 23,2% et 19,9% ;
- le Danemark, l'Irlande et la Suède ont enregistré une augmentation de 9,5 %, 11,6 % et 7,1 % respectivement.

La part des groupes de radiodiffusion de service public (RSP) dans les marchés d'audience nationaux est également en déclin. De 2015 à 2020, la part moyenne du marché de l'audience des radiodiffuseurs publics européens s'est contractée de 2 %. Là encore, il existe de grandes différences entre les États membres :

- Au **Danemark**, en Lituanie et aux Pays-Bas, le poids de la radiodiffusion de service public a augmenté de 14%, 46% et 16% respectivement ;
- En Espagne, en Bulgarie, à Chypre et en Hongrie, le poids de la radiodiffusion de service public a diminué entre 29% et 36%.

Consommation à la demande et tendances

Les revenus de consommation de la VoD dans l'UE sont passés au cours de la période d'environ 640 millions d'euros en 2011 à 11,6 milliards d'euros en 2022 : un taux de croissance annuel composé

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[9] Si l'on ajoute le financement public, la part des services audiovisuels passe à 96 % du marché total de l'audiovisuel.

[10] Bien que l'EAO ne nomme pas les chaînes, selon Ampere Analysis (via Statista), les quatre plus grands groupes de télévision en Europe (2020) sont Comcast (12% de la part de marché), Netflix (6,1%), ARD (5,7%) et BBC (4,2%).

(TCAC) de 38 %. En 2019, la VoD ne représentait que 7 % des revenus totaux générés sur le marché AV de l'UE27 + Royaume-Uni (EAO, 2021). Toutefois, les revenus de TVoD et SVoD ont été les segments qui ont connu la croissance la plus rapide en 2019, une tendance qui a également été observée pendant la pandémie de Covid en 2020 (EAO, 2021).

Services de vidéo à la demande par abonnement

Il y avait 140 millions d'abonnements à la SVoD à la fin de 2020 dans l'UE27 + Royaume-Uni (EAO, 2021). Comme la SVoD se généralise et que d'autres acteurs préparent des lancements de services, le marché devrait continuer à connaître une croissance dans les années à venir (EAO, 2021).

COVID-19 impact sur la consommation audiovisuelle dans l'UE27

Les recherches suggèrent que le secteur audiovisuel a perdu plus de 6 % de ses revenus en 2020 par rapport à 2019, et près de 9 % en excluant les services à la demande (EAO, 2020). Cependant, de nombreuses parties du marché ont résisté à cette crise, notamment la SVoD, la télévision payante, la VoD et le financement public des diffuseurs (Arrieta, 2020).

Prévision de la consommation

Les prévisions annoncent une diminution de l'écoute de la télévision linéaire de 6 % d'ici 2025 et de 13 % d'ici 2030 par rapport à 2019 (rapporté par Eurodata TV Worldwide), bien que des différences dans cette tendance soient observées entre les EM, notamment entre les pays nordiques où la diminution est plus marquée et certains pays d'Europe centrale et orientale où l'on prévoit plutôt une augmentation. En ce qui concerne la VoD, les prévisions annoncent une croissance significative dans un avenir proche, avec une augmentation des revenus pour les services AV à la demande de 126% d'ici 2025 et de 254% d'ici 2030 par rapport à 2020 (EAO). L'utilisation d'Internet pour regarder la télévision devrait augmenter de 21 % d'ici 2025 et de 26 % d'ici 2030 par rapport à 2021 (Eurodata TV Worldwide).

Une forte croissance est également prévue pour les marchés de la TVoD et de la SVoD. Les prévisions annoncent une augmentation des revenus pour la TVoD de détail (où les utilisateurs achètent un droit d'utilisation illimitée d'un fichier vidéo spécifique) d'un facteur 15 d'ici 2025 et d'un facteur 20 d'ici 2030. La TVoD de location (où les utilisateurs accèdent à un contenu pour une durée limitée moyennant paiement) devrait augmenter de 335 % d'ici 2025 et de 446 % d'ici 2030.

Pour la SVOD, on prévoit que le nombre de ménages abonnés fera plus que doubler d’ici 2025 (+109%) et atteindra sa pleine pénétration à partir de 2027, ce qui entraînera une forte croissance de la SVoD. Sur la plupart des marchés, cependant, les revenus de la SVoD représentent encore une petite partie des revenus du marché AV, allant de 1,1 % à 14,8 %, notamment sur les marchés où les prix de la télévision payante sont bas, où la pénétration de la télévision payante est répandue, où la pénétration du haut débit est inférieure à la moyenne de l'UE et où le nombre de services de SVoD disponibles est plus faible.

Exigences de la mission MSP

Les médias de service public (MSP) ont été une source majeure d'interprétation sociale des nouvelles et des événements dans une grande partie de l'Europe. Le dialogue, le débat et la délibération sont trois ingrédients essentiels des MSP et un autre rôle des MSP est de servir de médiateur entre les intérêts de la démocratie représentative et participative (Trappel, 2008).

Les obligations des MSP reposent sur l'accomplissement de ces rôles, qui ne se limitent pas simplement à la télévision linéaire, mais incluent également les services de " nouveaux médias " relevant des opérations des MSP (Conseil de l'Europe, 2006). Les MSP doivent également maintenir un niveau de qualité élevé et, en général, un "service universel" afin de favoriser la cohésion sociale, politique et culturelle et de justifier le financement public. L'Union européenne de radio-télévision (UER) indique également qu'afin de respecter les principes de base qui déterminent le modèle économique des MSP, une série d'exigences générales doivent être respectées pour la distribution de services de radiodiffusion linéaires. Il s'agit notamment de l'universalité de l'accès et de l'attrait, de l'apport d'une valeur publique, de la promotion de la citoyenneté et de services gratuits ou équivalents, c'est-à-dire sans coût supplémentaire pour les téléspectateurs et les auditeurs.

Le faible coût de la technologie TNT pour les consommateurs signifie qu'elle reste une méthode courante d'accès au contenu des MSP (Plum, 2021). De nombreux marchés s'appuient encore largement sur la TNT pour les diffusions télévisées, notamment sur les marchés où cette technologie a historiquement une part de marché élevée. Cependant, pour les PSM, le déclin de l'audience de la télévision traditionnelle et la fragmentation des audiences à travers de multiples services, plateformes et modes de consommation de contenu, affectent leur capacité à maintenir des niveaux élevés de portée, d'impact et de valeur pour les audiences (Plum, 2021).

Dans l'UE, le paysage du marché de la télévision varie considérablement : sur certains marchés (comme l'Italie et l'Espagne), la pénétration et l'utilisation de la TNT restent élevées. La migration de la TNT vers des plateformes alternatives nécessiterait des investissements importants, supportés soit par les ménages individuels, soit par les gouvernements (UER, 2019). Cette dernière solution pourrait être difficile en raison de considérations liées à la neutralité de la plateforme (UER, 2019). Même sur les marchés où la demande de télévision linéaire est en baisse, certains segments d'audience, tels que les téléspectateurs les plus âgés et les ménages à faibles revenus, peuvent encore être dépendants de la TNT. Les chaînes PSM sont soumises à des exigences d'accessibilité afin de garantir que les personnes handicapées, notamment celles souffrant de déficiences visuelles et auditives, puissent regarder les programmes. Il n'existe pas d'exigences similaires pour les services à la demande (y compris les services propres au PSM et les SVoD) (Ofcom, 2021).

Besoins en spectre et tendances technologiques dans le domaine des PMSE

Les PMSE dans la bande inférieure à 700 MHz se composent principalement de microphones radio et de moniteurs audio intra-auriculaires et la bande inférieure à 700 MHz représente la principale partie du spectre radioélectrique utilisée pour ces technologies. Les équipements PMSE nécessitent une qualité (audio) élevée et une faible latence lorsqu'ils sont utilisés pour des spectacles en direct : toute interruption ou tout retard peut entraîner des complications importantes. Certaines utilisations des PMSE sont ponctuelles et localisées (par exemple, lors d'événements occasionnels en plein air), tandis que d'autres sont plus continues (par exemple, dans les studios de télévision).

Les appareils audio PMSE fonctionnaient autrefois avec une technologie analogique qui utilisait le spectre radioélectrique de manière inefficace. Grâce à l'évolution de la technologie, ces équipements sont désormais capables de fournir environ trois fois plus de canaux audio dans une quantité fixe de spectre radioélectrique tout en atteignant des niveaux de qualité acceptables.

Une autre technologie, le DECT, permet d'accéder à un spectre supplémentaire en dehors de la bande inférieure à 700 MHz, mais peut ne pas convenir aux applications les plus sensibles à la latence et à la qualité. Des techniques telles que le Cognitive-PMSE et des approches plus avancées de la gestion du spectre pourraient aider à conserver la qualité audio dans un spectre encombré et ouvrir des possibilités d'utilisation de bandes de fréquences alternatives. La mesure dans laquelle ces techniques ont été adoptées n'est pas claire.

Alors que les capacités des équipements PMSE s’accroissent, la demande de PMSE augmente également :

- Environ 50% des États membres ont indiqué une croissance observée de la demande de spectre PMSE, par exemple d'environ 10% par an aux Pays-Bas et de 20% par an en Espagne.
- Une étude réalisée par le radiodiffuseur suisse SRF a révélé que les besoins quotidiens en spectre PMSE, sur la base des technologies actuellement utilisées, variaient entre 42 MHz pour les petits événements locaux et 115 MHz pour les grands événements. Pour les grands événements, les besoins atteignaient 174 MHz. La demande de spectre PMSE est en augmentation et pourrait atteindre 224 MHz pour les grands événements à l'avenir (c'est-à-dire toute la bande UHF inférieure à 700 MHz).

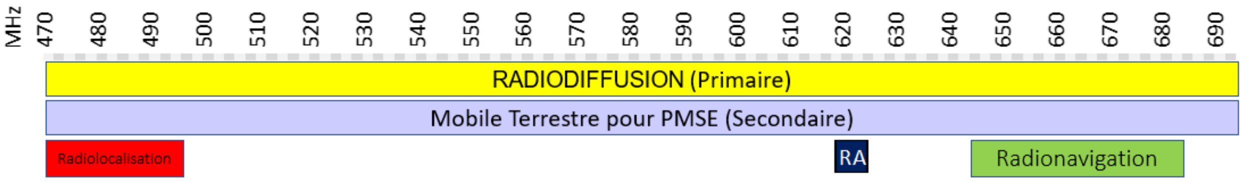
Dans certaines régions, il serait actuellement difficile de garantir l'accès à de telles quantités de spectre, étant donné que la bande inférieure à 700 MHz est partagée avec les transmissions TNT. L'accès à une quantité suffisante de spectre serait rendu plus difficile par toute nouvelle réduction de la quantité de spectre disponible dans la bande des 700 MHz.

D'autres développements visent à améliorer l'efficacité spectrale des PMSE ou à utiliser de nouvelles bandes de fréquences ou technologies. L'innovation démontrée par les systèmes audio multicanaux sans fil (Wireless Multichannel Audio Systems – WMAS), qui utilisent des systèmes à large bande et des systèmes de codage numérique, est prometteuse, mais il est peu probable qu'elle soit applicable à tous les cas d'utilisation et les équipements ne sont pas encore largement disponibles dans le commerce. De même, l'utilisation de bandes de fréquences alternatives ne sera pas applicable dans tous les cas de figure en raison de leurs caractéristiques de propagation non optimales. L'utilisation de bandes de fréquences alternatives exige également le développement et l'acquisition de nouveaux équipements, ce qui nécessitera des investissements et du temps.

La 5G est prometteuse en tant que technologie d’activation potentielle pour certaines applications PMSE, les premiers essais montrant que certaines configurations de réseau commencent à se rapprocher des exigences des cas d'utilisation PMSE les plus exigeants. Cependant, même si les développements ultérieurs sont en mesure de répondre aux exigences de latence et de fiabilité, garantir un accès aisé aux réseaux 5G et au spectre dédié pour les utilisateurs PMSE reste problématique.

Développements internationaux

Dans la région 1 de l'UIT (Europe, Afrique et Moyen-Orient)[11], le spectre radioélectrique dans la bande inférieure à 700 MHz est attribué à la radiodiffusion à titre primaire. Dans 86 pays de la région, y compris la majorité des EM (à l'exception de Chypre, de la Grèce et de la Slovénie), la bande est également attribuée au service mobile terrestre, destiné aux PMSE, à titre secondaire (qui ne doit donc pas causer d'interférences nuisibles à la radiodiffusion, ni prétendre à une protection contre les interférences nuisibles). Au sein de l'UE (voir le tableau ci-dessous), certaines parties de la bande ont également des attributions à la radioastronomie (RA), à la radiolocalisation (Autriche, République tchèque, Danemark, Estonie et Allemagne) et à la radionavigation aéronautique (en Bulgarie uniquement).



Un certain nombre de pays d'Afrique et du Moyen-Orient ont également identifié des parties de la bande pour les services fixes et mobiles sur une base secondaire.

Dans le reste du monde, il existe également une attribution primaire à la radiodiffusion pour toute la gamme 470-694 MHz. En outre :

- Dans la Région 2 de l'UIT (les Amériques), il existe des attributions secondaires mobiles et fixes dans les plages de fréquences 470-512 MHz et 614-698 MHz, avec des parties de la plage identifiées pour les IMT dans un certain nombre de pays.
- Dans la région 3 de l'UIT (Asie-Pacifique), l'ensemble de la gamme de fréquences 470-694 MHz fait l'objet d'une attribution primaire supplémentaire aux services fixes et mobiles, et de 585 à 610 MHz, d'une attribution primaire supplémentaire à la radionavigation. Certaines parties de la bande (généralement les 30 derniers MHz environ) sont souvent attribuées à des utilisations mobiles (PMR) dans de nombreux pays.

Un certain nombre de pays des régions 2 et 3 de l'UIT sont en train de mettre en place une bande IMT de 600 MHz. Dans de nombreux autres pays de ces régions, cependant, la prolifération des services de télévision terrestre signifie qu'il y a peu de possibilités de réaffecter la bande à des nouveaux services mobiles. Lors de la réunion d'avril 2022 de la Télécommunauté Asie-Pacifique (APT), il a été décidé d'adopter un plan de bande (légèrement différent de celui de la Région 2 de l'UIT) pour l'utilisation de la bande IMT de 600 MHz, ce qui témoigne de l'intérêt pour cette bande dans toute la région. La bande mobile de 600 MHz est à l'étude dans la Région 1 de l'UIT, tant en Arabie saoudite qu'aux Émirats arabes unis.

[11] La Région-1 de l'UIT contient 121 pays.

Une analyse de l'évolution de la consommation audiovisuelle internationale a montré que le marché mondial est très concurrentiel et que les acteurs se disputent non seulement la distribution vidéo mais aussi d'autres secteurs adjacents comme la production de programmes. Cette production est basée sur le marché mondial, mais adaptée aux exigences locales (OurWorld, 2020). La croissance de la production de contenus est stimulée par la forte demande des consommateurs pour des contenus locaux. L'évolution vers des films et des séries nationaux est une réponse concurrentielle normale des plateformes OTT (over-the-top) locales, qui réalisent que pour mieux concurrencer les acteurs mondiaux, elles doivent tirer parti des effets de réseau indirects, propulsés par le contenu local. C'est le cycle qui soutient le développement de la programmation localisée à travers le monde[12] (OurWorld, 2020).

[12] Par exemple, au Brésil, les productions locales ont atteint 17,7 % des heures de programmes de télévision payante en 2017, tandis qu'en 2019, les films nationaux représentent actuellement 6,3 % des bibliothèques des sept principales plateformes OTT, et les séries s'élèvent à 23,1 % (OurWorld, 2020).

Zusammenfassung

Das Sub-700-MHz-Band (470–694 MHz) stellt einen Teil des Funkspektrums dar, der in der Europäischen Union (EU) für digitales terrestrisches Fernsehen (DTT) und kabellose Audiogeräte für Sendungsproduktionen und Sonderveranstaltungen (PMSE), zum Beispiel für Funkmikrofone, reserviert ist. Mit den sich verändernden Fernsehgewohnheiten und der Verbesserung der Videotechnologie, stellt sich die Frage, inwiefern DTT eine wichtige Zugangsplattform bleiben wird. Technologische Innovationen und Verbesserungen, insbesondere die Verlagerung von analoger zu digitaler terrestrischer Fernsehübertragung, haben die Spektrumseffizienz der Rundfunkdienste gesteigert. In der Vergangenheit hat dieses dazu geführt, dass andere Frequenzen im UHF-Bereich, die zuvor für die Fernsehübertragung genutzt worden sind, für drahtlose Breitbanddienste umgewidmet wurden.

Bei der kommenden International Telecommunications Union (ITU) World Radiocommunication Conference 2023, bei der weltweite Entscheidungen über die Zuordnung von Funkfrequenzen getroffen werden, wird die Frage untersucht, ob das Sub-700-MHz-Band für Mobilfunkdienste in Europa, Asien und dem Nahen Osten bereitgestellt werden sollte. Die auf dieser Konferenz getroffenen Beschlüsse könnten sich auf dessen Nutzung in Europa auswirken.

Auf EU-Ebene stützt sich der (im August 2014 veröffentlichte) Lamy-Bericht[13] über die künftige Nutzung des UHF-Bands auf die Arbeit einer hochrangigen Gruppe, an der sich Spitzenvertreter von europäischen Rundfunkanstalten, Netzbetreibern, Mobilfunkunternehmen und technischen Verbänden beteiligen, und enthält folgende Vorschläge:

- Zuweisung des 700-MHz-Bandes (694-790 MHz) für drahtlose Breitbandverbindungen in ganz Europa bis zum Jahr 2020 (±2 Jahre);
- Gewährleistung der Regulierungssicherheit und -stabilität für terrestrischen Rundfunk im verbleibenden UHF-Spektrum unterhalb von 700 MHz bis zum Jahr 2030 und
- Bewertung der Entwicklungen von Technologie und Markt bis zum Jahr 2025.

Infolge dieses Berichts sorgte der UHF-Beschluss[14] für vorausschauende langfristige Investitionen und stimulierte Innovationen, indem er gemäß Artikel 4 die Verfügbarkeit des Sub-700-MHz-Bereichs für DTT- und PMSE-Dienste mindestens bis zum Jahr 2030 in allen Mitgliedstaaten (MS) sichert, während gleichzeitig der Grundsatz der technologischen Neutralität berücksichtigt wird. Er gestattete des Weiteren die alternative Nutzung in einem MS, unter der Voraussetzung, dass solch eine Nutzung mit dem nationalen Rundfunkbedarf und der Bereitstellung von Rundfunkdiensten in den Nachbarländern vereinbar ist.

Gemäß Artikel 7 des UHF-Beschlusses muss die Kommission dem Europäischen Parlament und dem Rat über die Entwicklungen der Nutzung des Sub-700-MHz-Frequenzbands Bericht erstatten, um eine effiziente Frequenznutzung sicherzustellen. Dabei sollte sie die sozialen, wirtschaftlichen, kulturellen und internationalen Aspekte, die die Nutzung des Bandes betreffen, berücksichtigen, aber

[13] https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=8423

[14] Beschluss (EU) 2017/899 des Europäischen Parlaments und des Rates vom 17. Mai 2017 über die Nutzung des Frequenzbands 470–790 MHz in der Union

auch die technologischen Entwicklungen, Änderungen im Verbraucherverhalten und die Anforderungen an die Konnektivität, um Wachstum und Innovation in der ganzen EU zu fördern.

In diesem Bericht wird der aktuelle Stand und die künftigen Trends der Nutzung des Sub-700-MHz-Bands EU-weit berücksichtigt, aber auch die Veränderungen in den Fernsehgewohnheiten, die Rolle des DTT für das öffentlich-rechtliche Medienangebot (PSM) und internationale Entwicklungen im Zusammenhang mit der Nutzung des Frequenzbands. Er wurde im Kontext des Artikels 7 für die Kommission von LS telcom und VVA erarbeitet.

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Neueste technologische Entwicklungen und zukünftige Trends in den Bereichen DTT und 5G Broadcast

Die DTT-Technologie entwickelt sich konstant weiter. Zwei Hauptaspekte des DTT-Diensts haben dabei eine deutliche Verbesserung erfahren:

- Der Übertragungsstandard wurde von DVB-T (1997) auf DVB-T2 (2009) umgestellt und liefert zusätzliche Kapazitäten für Fernsehdienste auf denselben Funkfrequenzen;
- Die Techniken zur digitalen Video-Kodierung wurden im Laufe der Zeit verbessert, von MPEG-2 (1996) über MPEG-4 (1999) bis hin zum neuesten Standard HEVC (2013). Mit jeder Verbesserung wurde ein kleinerer Teil der verfügbaren Kapazität pro Videostream verwendet.

Diese Veränderungen haben die Einführung von High Definition-Diensten (HD) innerhalb desselben Spektrums, der früher für die Bereitstellung der Standard Definition-Dienste (SD) benötigt wurden, ermöglicht. Andere Verbesserungen der Bildqualität, wie zum Beispiel die Einführung von Ultra High Definition (UHD bzw. 4K), hoher Bildfrequenz und hohem Dynamikumfang, könnten auf der DTT-Plattform eingeführt werden, aber sie würden die Anzahl der verfügbaren Videodienste verringern, da sie höhere Bandbreiten benötigen.

In den Mitgliedstaaten (MS) nutzen bereits 60 % der nationalen Multiplexe den neuesten Übertragungsstandard (DVB-T2), während ca. 40 % der nationalen Multiplexe den fortschrittlichsten Kodierungsstandard nutzen (HEVC). Es wurden gute Fortschritte bei der Übernahme der neueren Standards gemacht, allerdings wären in einigen MS Verbesserungen möglich.

Gleichwellennetze (SFNs) ermöglichen es, dass mehrere Sender gleichzeitig auf derselben Frequenz betrieben werden, wodurch sich der Frequenzbedarf für DTT-Dienste um ca. 25 % verringert, jedoch mit zusätzlicher Komplexität und Einschränkungen für lokale oder regionale Inhalte. Mindestens 12 MS verwenden bereits in einem gewissen Ausmaß SFNs in ihren DTT-Netzen.

Etwaige weitere Veränderungen an den DTT-Plattformen der MS zur weiteren Effizienzsteigerung (sofern möglich) führen sehr wahrscheinlich zu erheblichen Kosten und die Bereitschaft, dies zu tun, könnte sich in Grenzen halten, wenn keine ausreichende Regulierungssicherheit hinsichtlich des dauerhaften Zugangs zum Sub-700-MHz-Band besteht.

Für 5G Broadcast wird 5G-Technologie genutzt, um mehreren Nutzern Live-Videoinhalte zu liefern. Es wird als vielversprechende Alternative zum DVB-T/-T2 betrachtet. Gute Empfangsbedingungen vorausgesetzt, haben erste Versuche gezeigt, dass über 5G Broadcast eine ähnliche Kapazität wie bei DVB-T/-T2 erreicht werden kann. Die Geschäftsmodelle, die 5G Broadcast unterstützen könnten, sind jedoch weiterhin unklar. Wie soll es beispielsweise finanziert werden und wer wäre für das Netz verantwortlich? Die Verfügbarkeit von 5G Broadcast-Geräten (vor allem von Nutzerendgeräten) ist gegenwärtig minimal. Es laufen Versuche, um Hersteller dazu zu bewegen, den Standard in ihren Geräten zu unterstützen, aber die Hersteller haben noch keinen zeitlichen Rahmen genannt, ab wann dies eintreten könnte.

Da der UHF-Beschluss das Sub-700-MHz-Band mindestens bis zum Jahr 2030 für den terrestrischen Rundfunk und PMSE absichert, besteht unter den MS wenig Konsens über zukünftige Regulierungskonzepte bezüglich des Sub-700-MHz-Bandes, abgesehen davon, dass große Veränderungen (beispielsweise die Einführung eines speziellen Mobilfunksubbands oder die Umwandlung des gesamten Bandes, um einen gleichberechtigten Zugang zu Rundfunk- und Mobilfunkdiensten zu ermöglichen) einen erheblichen Koordinationsaufwand bedeuten würden. Es gibt verschiedene Ansichten dazu, ob sich solche Veränderungen stark auf das DTT auswirken würden (in Form wirtschaftlicher Auswirkungen oder der Fähigkeit der Plattform, die Anforderungen der Pluralität und des frei empfangbaren Fernsehens zu erfüllen) oder wie sich eine solche Veränderung auf den sozioökonomischen Nutzen durch eine Zunahme der Frequenzen für Mobilfunkdienste auf Kosten der Frequenzverfügbarkeit für Rundfunkdienste auswirken würde.

Die auseinandergehenden Ansichten der MS zeigen sich noch deutlicher anhand ihrer Einschätzung der Nachfrage nach zusätzlichen Sub-1-GHz-Frequenzen für den Mobilfunkdiensten. Die Mehrheit der MS gab an, dass ihnen keine ausreichenden Informationen vorliegen, um sich über die Wahrscheinlichkeit eines zusätzlichen Bedarfs an einem Sub-1-GHz-Bereich äußern zu können, möglicherweise, weil der aktuelle Fokus der Verwaltungen darauf liegt, die 5G-Pionierbänder (700 MHz, 3,6 GHz und 26 GHz) für die Betreiber verfügbar zu machen.

Entwicklung des Verbraucherverhaltens

In der EU werden AV Inhalte mithilfe verschiedener Methoden und den zugehörigen Bereitstellungsplattformen zur Verfügung gestellt:

- Lineares Fernsehen (d. h. das Ansehen eines Programms während dieses übertragen wird) wird über DTT, Satelliten- und Kabelnetze sowie als Streaming über Breitbandverbindungen (als IPTV bekannt) angeboten. Diese Dienste können frei empfangbar sein oder als Pay-TV zur Verfügung stehen;
- Nicht-lineares Fernsehen (d. h. das Ansehen eines Programms zu einer vom Zuschauer bestimmten Uhrzeit) wird über breitbandige Internetverbindungen gestreamt und wird in verschiedenen Formen angeboten:
  - Catch-up-TV ermöglicht es den Zuschauern, eine Reihe kürzlich ausgestrahlter Programme, normalerweise von einem bestimmten Sender, anzusehen.
  - Over-the-top-Dienste (OTT) ermöglichen es den Zuschauern, Inhalte anzusehen, die von einem sogenannten Content Aggregator, hergestellt oder eingekauft wurde (z. B. Netflix, Discovery, Disney oder Amazon).

Die beiden zuletzt genannten können auch als Video-on-Demand (VoD) bezeichnet werden, das kostenlos sein kann oder im Rahmen eines regulären Abonnements (SVoD) oder auf Transaktionsbasis, d. h. gegen Bezahlung, abrufbar ist (TVoD).

Im Jahr 2020 belief sich der europäische AV-Markt laut der Europäischen Audiovisuellen Informationsstelle (EAO, 2020) auf etwas mehr als EUR 82 Mrd. Die Umsatzerlöse von AV-Anbietern (sowohl linear als auch nicht linear) machten ca. 70 % des Gesamtbetrags aus (ohne öffentliche Mittel[15]).

Trends bei der linearen TV-Ausstrahlung

Der TV-Konsum in der EU liegt über dem weltweiten Durchschnitt und variiert je nach Altersgruppe. Generell sehen ältere Zuschauer mehr TV, während die jüngeren Generationen mehr Zeit mit dem Ansehen von VoD verbringen.

Die Covid-19-Pandemie hatte einen deutlichen Einfluss auf das Fernsehen: einerseits stiegen die Zuschauerzahlen aufgrund des Interesses an Nachrichtensendungen, andererseits wurden Einschränkungen im Live-Sport und für die Produktion von Programmen eingeführt.

Darüber hinaus verändern sich die Charakteristika des europäischen AV-Markts. Die Konzentration des europäischen Zuschauermarktes hat generell abgenommen, da einstige Marktführer im Laufe der Zeit aufgrund der wachsenden Zahl an Marktteilnehmern und durch das Aufkommen von DTT Anteile verloren haben, wobei den Verbrauchern mehr Kanäle zur Verfügung stehen und der Anteil historischer terrestrischer Dienste, die den analogen Vertrieb dominierten, zurückgegangen ist. Über einen Zeitraum von fünf Jahren – von 2016 bis 2020 – sanken die durchschnittlichen Zuschauermarktanteile der vier führenden Fernsehsender[16] auf den nationalen Märkten Europas um 4,6 % (EAO, 2021). Im gleichen Zeitraum gab es jedoch deutliche Unterschiede zwischen den MS bei den täglichen Markteilen des Publikums der gleichen Kanäle:

- In Zypern und Polen zeigt sich ein drastischer Rückgang von jeweils 23,2 % und 19,9 %;
- In Dänemark, Irland und Schweden hatten sie dagegen um jeweils 9,5 %, 11,6 % und 7,1 % zugenommen.

Der Anteil der öffentlich-rechtlichen Sendeanstalten (PSB) an den nationalen Zuschauermärkten ist ebenfalls rückläufig. Vom Jahr 2015 bis 2020 sank der durchschnittliche Zuschauermarktanteil der europäischen PSBs um 2 %. Auch hier gibt es wiederum starke Unterschiede zwischen den MS:

- In Dänemark, Litauen und den Niederlanden stieg der Anteil der öffentlich-rechtlichen Sendeanstalten jeweils um 14 %, 46 % und 16 %;
- In Spanien, Bulgarien, Zypern und Ungarn nahm der Anteil der öffentlich-rechtlichen Sendeanstalten zwischen 29 % und 36 % ab.

Konsum und Trends bei On Demand

Die VoD-Verbraucherumsätze in der EU stiegen von ca. EUR 640 Mio. im Jahr 2011 auf EUR 11,6 Mrd. im Jahr 2022: eine durchschnittliche jährliche Wachstumsrate (CAGR) von 38 %. Im Jahr 2019

[15] Zuzüglich öffentlicher Mittel erhöht sich der Anteil der audiovisuellen Dienste auf 96 % des gesamten AV-Markts.

[16] EAO nennt zwar nicht die Sender, aber laut Ampere Analysis (über Statista) sind die vier größten TV-Konzerne Europas (2020) Comcast (12 % Marktanteil), Netflix (6,1 %), ARD (5,7 %) und BBC (4,2 %).

machte VoD lediglich 7 % der auf dem EU27 + UK AV-Markt generierten Umsätze aus (EAO, 2021). Die TVoD- und SVoD-Umsätze waren im Jahr 2019 jedoch die am schnellsten wachsenden Segmente, ein Trend, der sich während der Covid-Pandemie auch 2020 fortsetzte (EAO, 2021).

Abonnement von Video-on-Demand-Diensten

Zum Jahresende 2020 gab es in der EU27 + UK 140 Mio. SVoD-Abonnements (EAO, 2021). Da sich SVoD zum Mainstream entwickelt und weitere Akteure die Einführung von Diensten vorbereiten, ist in den kommenden Jahren von einem weiteren Wachstum dieses Markts auszugehen (EAO, 2021).

Die Auswirkungen von COVID-19 auf den Konsum audiovisueller Medien in den EU27

Forschungsergebnisse lassen darauf schließen, dass der AV-Sektor Europas im Jahr 2020 im Vergleich zu 2019 mehr als 6 % Umsatzeinbußen verzeichnete[17] bzw. knapp 9 % ohne On-Demand-Dienste (EAO, 2020). Viele Teile des Markts hielten jedoch der Krise stand, einschließlich SVoD, Pay-TV, VoD und über Gebühren finanzierte öffentlich-rechtliche Sender (Arrieta, 2020).

Konsumprognose

Prognosen gehen von einem Rückgang des linearen Fernsehens bis zum Jahr 2025 um 6 % und bis 2030 um 13 % im Vergleich zum Jahr 2019 aus (gemeldet von Eurodata TV Worldwide), obwohl sich Unterschiede in diesem Trend über die Mitgliedstaaten (MS) hinweg beobachten lassen, insbesondere zwischen den nordischen Ländern, in denen der Rückgang deutlicher ist, und bestimmten Ländern in Zentral- und Osteuropa, wo hingegen eine Zunahme prognostiziert wird. Für VoD gehen die Prognosen von einem deutlichen Wachstum in naher Zukunft mit einer Umsatzsteigerung bei On-Demand-AV-Diensten von 126 % bis zum Jahr 2025 und von 254 % bis 2030 im Vergleich zu 2020 aus (EAO). Die Nutzung des Internets zum Fernsehen wird voraussichtlich bis zum Jahr 2025 um 21 % und bis zum Jahr 2030 um 26 % im Vergleich zu 2021 zunehmen (Eurodata TV Worldwide).

Auch für die TVoD- und SVoD-Märkte wird ein starkes Wachstum prognostiziert. Die Prognosen gehen von einer Zunahme des Umsatzes für Retail TVoD (bei dem die Nutzer das uneingeschränkte Nutzungsrecht an einer bestimmten Videodatei erwerben) mit einem Faktor von 15 bis zum Jahr 2025 und einem Faktor von 20 bis 2030 aus. Rental TVoD (bei dem die Nutzer gegen eine Gebühr Zugriff auf einen Teil der Inhalte erhalten) wird voraussichtlich bis zum Jahr 2025 um 335 % und bis zum Jahr 2030 um 446 % zunehmen.

Die Zahl der SVoD abonnierten Haushalte wird voraussichtlich bis 2025 mehr als verdoppeln (+109 %) und ab 2027 die volle Durchdringung erreichen. Auf den meisten Märkten machen SVoD-Umsätze weiter einen geringen Anteil an den AV-Marktumsätzen aus, der zwischen 1,1 % und 14,8 % liegt, insbesondere auf Märkten, wo die Pay-TV-Preise niedrig sind, die Pay-TV-Verbreitung hoch ist, die Breitbandverbreitung unter dem EU-Durchschnitt liegt und die Anzahl der verfügbaren SVoD-Dienste kleiner ist.

[17] Im diesem Fall bezieht sich Europa im gesamten geografischen Gebiet von Island und Norwegen im Norden bis zur Türkei im Süden und von Portugal im Westen bis nach Russland im Osten. In dieser Analyse wurden die folgenden Länder betrachtet: Schweiz, Island, Montenegro, Nordmazedonien, Norwegen, Russland und die Türkei.

Anforderungen des Auftrags des öffentlich-rechtlichen Rundfunks

Das Medienangebot des öffentlich-rechtlichen Rundfunks (PSM) ist in weiten Teilen Europas eine wichtige Quelle für die gesellschaftliche Interpretation von Nachrichten und Ereignissen . Die drei Kernbestandteile des PSM sind Dialog, Debatte und Beratung und eine weitere Aufgabe des PSM besteht darin, die Interessen der repräsentativen und partizipativen Demokratie zu vermitteln (Trapper, 2008).

Die Verpflichtungen der PSM beruhen auf der Erfüllung dieser Aufgaben, die sich nicht einfach nur auf das lineare Fernsehen beschränken, sondern auch die Dienste der „neuen Medien“ einschließen, die unter die Tätigkeit der PSM fallen (Europarat, 2006). Die PSM müssen außerdem ein hohes Qualitätsniveau und üblicherweise einen „Universaldienst“ aufrechterhalten, um den sozialen, politischen und kulturellen Zusammenhalt zu fördern und die öffentliche Finanzierung zu rechtfertigen. Die Europäische Rundfunkunion (EBU) stellt außerdem fest, dass zur Erfüllung der Grundprinzipien, die das Geschäftsmodell der PSM bestimmen, eine Reihe allgemeiner Anforderungen für die Verbreitung linearer Rundfunkdienste als relevant betrachtet werden. Dazu zählen (unter anderem) die Universalität des Zugangs und der Attraktivität, die Erzielung eines öffentlichen Nutzens, die Förderung des Staatsbürgerverhaltens und frei empfangbare Dienste oder gleichwertige Dienste, d. h. ohne zusätzliche Kosten für die Zuschauer und Zuhörer.

Die niedrigen Kosten der DTT-Technologie für die Verbraucher bedeuten, dass diese eine gängige Methode für den Zugriff auf PSM-Inhalte bleiben wird (Plum, 2021). Viele Märkte stützen sich bei der Fernsehübertragung noch immer stark auf DTT, insbesondere Märkte, in denen dieses Medium in der Vergangenheit einen hohen Marktanteil hatte. Die Abnahme des traditionellen TV-Publikums und dessen Aufsplitterung auf mehrere Dienste, Plattformen und Formen des Konsums von Inhalten beeinträchtigt die Fähigkeit der PSM, ein hohes Maß an Reichweite, Wirkung und Wert für das Publikum aufrechtzuerhalten (Plum, 2021).

Europaweit unterscheidet sich die Landschaft des TV-Markts deutlich: Auf einigen Märkten (wie zum Beispiel Italien und Spanien) bleiben die Verbreitung und Nutzung von DTT hoch. Der Wechsel von DTT zu alternativen Plattformen würde große Investitionen erfordern, die entweder von den Haushalten oder den Regierungen zu tragen wären (EBU, 2019). Für letztere wäre das aufgrund der Berücksichtigung der Plattformneutralität schwierig (EBU, 2019). Selbst auf Märkten, wo die Nachfrage nach linearem Fernsehen abnimmt, sind bestimmte Publikumssegmente, wie zum Beispiel ältere Zuschauer oder Haushalte mit geringem Einkommen, weiter von DTT abhängig. Die Programme des öffentlich-rechtlichen Rundfunks unterliegen Anforderungen der Zugänglichkeit, um sicherzustellen, dass Menschen mit Behinderungen, insbesondere hör- und sehgeschädigte Menschen, die Programme anschauen können. Es gibt keine ähnlichen Anforderungen an On-Demand-Dienste (einschließlich die PSM-eigenen Dienste und SVoDs) (Ofcom, 2021).

Frequenzbedarf und Technologietrends der PMSE Dienste

PMSE im Sub-700-MHz-Band bestehen hauptsächlich aus Funkmikrofonen und In-Ear-Audiomonitoren. Das Sub-700-MHz-Band stellt den wichtigsten Teil des für diese Technologien genutzten Frequenzspektrums dar. PMSE-Geräte müssen eine hohe (Audio-)Qualität und eine geringe Latenz besitzen, wenn sie für Live-Auftritte verwendet werden: Unterbrechungen oder Verzögerungen können zu erheblichen Komplikationen führen. Der Gebrauch einiger PMSE Dienste ist zeit- und ortsabhängig (d. h. für gelegentliche Freiluftveranstaltungen), während andere kontinuierlicher im Einsatz sind (d. h. in Fernsehstudios).

Für Audio-PMSE-Geräte wurde in der Vergangenheit analoge Technologie verwendet, die das Funkspektrum ineffizient nutzt. Aufgrund der Weiterentwicklungen der Technologie sind solche Geräte inzwischen in der Lage, ca. die 3-fache Anzahl von Audiokanälen im selben Funkspektrum zu übertragen und dabei ein akzeptables Qualitätsniveau zu erreichen.

Eine alternative Technologie, DECT, ermöglicht den Zugang zu einer zusätzlichen Frequenz außerhalb des Sub-700-MHz-Bands, aber sie ist möglicherweise nicht für die latenz- und qualitätsempfindlichsten Anwendungen geeignet. Techniken, wie zum Beispiel Cognitive-PMSE, und fortschrittlichere Frequenzmanagementansätze könnten dazu beitragen, die Audioqualität in überlasteten Frequenzen zu erhalten und Möglichkeiten für die Nutzung alternativer Frequenzbäder zu eröffnen. Inwiefern diese bereits eingesetzt werden, ist unklar.

Während die Fähigkeiten der PMSE-Geräte weiter zunehmen, wächst auch die Nachfrage nach PMSE:

a) Ca. 50 % der MS gaben an, dass die Nachfrage nach PMSE-Frequenzen gestiegen ist, beispielsweise um ca. 10 % pro Jahr in den Niederlanden und 20 % pro Jahr in Spanien.

b) In einer Studie des Schweizer Rundfunkveranstalters SRF wurde festgestellt, dass der tägliche Bedarf an PMSE-Frequenzen auf der Grundlage der derzeit verwendeten Technologien zwischen 42 MHz für kleine, lokale und 115 MHz für große Veranstaltungen liegt. Der Bedarf bei Großveranstaltungen lag sogar bei 174 MHz. Die Nachfrage nach PMSE-Frequenzen steigt, wodurch möglicherweise für Großveranstaltungen künftig bis zu 224 MHz benötigt werden (d. h. das gesamte Sub-700-MHz-UHF-Band).

In einigen Gebieten wäre die Sicherung des Zugangs zu einem solch großen Frequenzbereich schwierig, da das Sub-700-MHz-Band mit DTT-Übertragungen geteilt wird. Die Sicherung des Zugriffs auf einen ausreichenden Frequenzbereich würde durch eine weitere Verringerung der verfügbaren Sub-700-MHz-Frequenzen weiter erschwert werden.

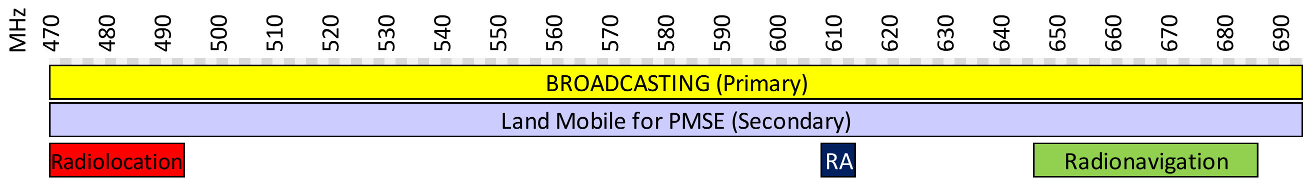
Es gibt weitere Entwicklungen, die entweder die spektrale Effizienz von PMSE verbessern oder neue Frequenzbänder bzw. Technologien nutzen sollen. Die von WMAS vorgestellte Innovation, bei der Breitband-Systeme und digitale Kodierungsverfahren genutzt werden, erscheint vielversprechend, aber ist wahrscheinlich nicht für alle Einsatzzwecke geeignet, außerdem sind die Geräte noch nicht überall im Handel erhältlich. Gleichermaßen ist die Verwendung alternativer Frequenzbänder aufgrund ihrer suboptimalen Ausbreitungsmerkmale nicht für alle Einsatzzwecke geeignet. Der Einsatz alternativer Frequenzbänder erfordert auch die Entwicklung und den Kauf neuer Geräte, wofür Investitionen und Zeit benötigt werden.

5G scheint eine vielversprechende Technologie für einige PMSE-Anwendungen zu sein, denn erste Versuche zeigen, dass sich bestimmte Netzkonfigurationen den Anforderungen für einige der anspruchsvollsten PMSE-Anwendungsfälle zu nähern beginnen. Aber selbst, wenn durch die weitere Entwicklung die Latenz- und Zuverlässigkeitsanforderungen erfüllt werden können, gibt es weitere

Probleme bei der Sicherung eines einfachen Zugangs zu 5G-Netzen und dedizierten Frequenzen für PMSE-Nutzer.

Internationale Entwicklungen

In der ITU-Region 1 (Europa, Afrika und Naher Osten) sind die Funkfrequenzen im Sub-700-MHz-Band vorrangig dem Rundfunk zugewiesen. In 86 Ländern der Region, einschließlich der Mehrheit der Mitgliedstaaten (außer Zypern, Griechenland und Slowenien), dient das Frequenzband auch für den mobilen Landfunkdienst, der für PMSE auf sekundärer Basis bestimmt ist (der keine funktechnischen Störungen des Rundfunks verursachen und keinen Schutz vor funktechnischen Störungen durch den Rundfunk fordern darf). Innerhalb der EU (siehe folgendes Diagramm) sind Teile des Frequenzbands auch der Radioastronomie (RA), der Funkortung (Österreich, Tschechische Republik, Dänemark, Estland und Deutschland) und der Flugfunknavigation (nur in Bulgarien) zugewiesen.



Eine Reihe von Ländern in Afrika und im Nahen Osten haben außerdem Teile des Frequenzbandes sekundär für Fest- und Mobilfunkdienste zugewiesen.

Im Rest der Welt besteht ebenfalls eine primäre Zuweisung des gesamten Bereichs von 470–694 MHz für den Rundfunk. Darüber hinaus:

c) In der ITU Region 2 (der amerikanische Kontinent) gibt es sekundäre Zuweisungen für Fest- und Mobilfunk in den Frequenzbereichen 470–512 MHz und 614–698 MHz, wobei Teile dieses Bereichs in einer Reihe von Ländern für IMT ausgewiesen sind.

d) In der ITU Region 3 (Asien-Pazifik-Region) besitzt der gesamte Frequenzbereich 470–694 MHz eine zusätzliche primäre Zuweisung für Fest- und Mobilfunkdienste, und der Bereich von 585–610 MHz ist zusätzlich primär der Funknavigation zugewiesen. In vielen Ländern sind Teile des Frequenzbandes (normalerweise die unteren 30 MHz) häufig der Mobilfunknutzung (PMR) zugewiesen.

Einige Länder in den beiden ITU Regionen 2 und 3 implementieren gegenwärtig ein 600-MHz-IMT-Band. In vielen anderen Ländern dieser Regionen lässt die Verbreitung terrestrischer Fernsehdienste nur wenig Spielraum dafür, das Band für neue Mobilfunkdienste umzuwidmen. Beim Treffen der Asia-Pacific Telecommunity (APT) im April 2022 wurde ein Beschluss getroffen, einen (leicht von ITU Region 2 abweichenden) Bandplan für die Nutzung des 600-MHz-IMT-Bands zu übernehmen, was das Interesse der gesamten Region an diesem Frequenzband zeigt. Das 600-MHz-Mobilfunkband wird in der ITU-Region 1 sowohl in Saudi-Arabien als auch in den Vereinigten Arabischen Emiraten geprüft.

Eine Analyse der Veränderungen im internationalen AV-Konsum zeigte, dass der Markt global betrachtet hart umkämpft ist, wobei die Akteure nicht nur bei der Programmverbreitung, sondern auch in anderen angrenzenden Branchen, wie der Programmproduktion, miteinander konkurrieren. Diese Produktion basiert auf dem globalen Markt, aber ist an die örtlichen Anforderungen angepasst (OurWorld, 2020). Das Wachstum bei der Produktion von Inhalten ist auf die starke Nachfrage der Verbraucher nach lokalen Inhalten zurückzuführen. Die Verlagerung hin zu nationalen Filmen und Serien ist eine normale Wettbewerbsreaktion lokal ansässiger Over-the-Top-Plattformen (OTT-Plattformen), die erkannt haben, dass sie indirekte Netzeffekte durch lokale Inhalte nutzen müssen, um sich im Wettbewerb mit globalen Anbietern besser durchsetzen zu können. Durch diesen Kreislauf wird die Entwicklung lokaler Programme weltweit gefördert[18] (OurWorld, 2020).

18 Beispielsweise erreichten in Brasilien lokale Produktionen im Jahr 2017 17,7 % der Pay-TV-Programmstunden, während im Jahr 2019 nationale Filme gegenwärtig 6,3 % der Bibliotheken der sieben führenden OTT-Plattformen und Serien 23,1 % ausmachen (OurWorld, 2020).

1 Introduction

1.1 General

This document represents deliverable D5, 'Final Report', for the project 'Study on the use of the sub-700 MHz UHF band (470-694 MHz)'. This project was conducted for the European Commission by LS telcom and VVA.

1.2 Document Structure

This document is structured as follows:

- Section 2 examines the various technological developments that affect the use of the sub-700MHz band by broadcasting, taking into account developments within EU Member States as well as future trends, focusing on developments in 5G Broadcasting;
- Section 3 details the evolution of consumer behaviour;
- Section 4 looks at the public service media (PSM) mission requirements;
- Section 5 reviews the spectrum needs and technological developments of the program making and special events (PMSE) service;
- Section 6 identifies international developments regarding the sub-700MHz band;
- Annex A contains the references used within the report;
- Annex B contains a glossary of terms used within the report;
- Annex C provides summaries of the responses received from Member States;
- Annex D summarises the validation of consumer evolution trends;
- Annex E provides summaries of responses from stakeholders; and
- Annex F summarises the output of the project workshop.

Note that, for the purposes of brevity, '~' is taken to mean 'approximately' for the entirety of this report.

1.3 Background

The sub-700 MHz band (470-694 MHz) is currently reserved in the EU for digital terrestrial television (DTT) and wireless audio equipment for programme making and special events (PMSE) use. It was historically part of the larger 470-862 MHz band which, in most Member States, was used for broadcasting services including PMSE almost entirely. However, technological innovations and advancements, especially a switch from analogue to digital terrestrial television broadcasting, increased the spectrum efficiency of broadcasting services. This in turn, made it possible to release spectrum for other purposes which led to their repurposing for wireless broadband services (the so-called 800 MHz and 700 MHz EU-harmonised frequency bands, as shown in Table 1), to enable the opportunity for cost-efficient deployment of wireless broadband networks with good indoor and outdoor coverage.

UHF Channel	Centre Frequency (MHz)	UHF Channel	Centre Frequency (MHz)	UHF Channel	Centre Frequency (MHz)
21	474	37	602	53	730
22	482	38	610	54	738
23	490	39	618	55	746
24	498	40	626	56	754
25	506	41	634	57	762
26	514	42	642	58	770
27	522	43	650	59	778
28	530	44	658	60	786
29	538	45	666	61	794
30	546	46	674	62	802
31	554	47	682	63	810
32	562	48	690	64	818
33	570	49	698	65	826
34	578	50	706	66	834
35	586	51	714	67	842
36	594	52	722	68	850

Table 1 – UHF TV channels, showing the channel number and centre frequency. The channels in blue represent the 700MHz band, those in yellow the 800 MHz band both now cleared of digital terrestrial television (DTT) for mobile use within the EU.

The Lamy report, published in August 2014 on the future use of the UHF band (470-790 MHz) based its results on the work of a High Level Group involving top executives from Europe's broadcasters, network operators, mobile companies and technical associations, and proposed to:

- Dedicate the 700 MHz band to wireless broadband across Europe by 2020 (±2 years);
- Ensure regulatory security and stability for terrestrial broadcasters in the remaining UHF spectrum below 700 MHz until 2030; and
- Assess technology and market developments by 2025.

Based on the above report, the UHF Decision[19] provided long-term investment predictability and stimulated innovation by safeguarding, under Article 4, the availability of the sub-700 MHz band for DTT and PMSE services until at least 2030 in all Member States while taking into account the principle of technological neutrality. It allowed, in addition, alternative use in the territory of a Member State,

[19] Decision (EU) 2017/899 of the European Parliament and of the Council of 17 May 2017 on the use of the 470-790 MHz frequency band in the Union

provided that such use is compatible with the Member State's national broadcasting needs and the provision of broadcasting services in the neighbouring countries.

Under Article 7 of the UHF Decision, the Commission is required to report to the European Parliament and the Council on developments in the use of the sub-700 MHz frequency band. In doing so, it should take into account the social, economic, cultural and international aspects affecting the use of the sub-700 MHz band, further technological developments, changes in consumer behaviour and the requirements in connectivity to foster growth and innovation in the Union. This report represents the output of the project as required by Article 7, undertaken on behalf on the Commission by LS telcom and VVA, investigating the developments in the use of the sub-700MHz UHF band.

The key objectives of this project are to:

- Provide a sound overview of the latest trends and developments that are relevant for the current and future use of the sub-700 MHz band, taking into account:
  - Technological developments and future trends (considered in section 2 for DTT and section 5 for PMSE);
  - Consumer behaviour evolution (considered in section 3);
  - Public service media mission requirements (considered in section 4); and
  - Current and future use of the sub-700 MHz band in third countries (considered in section 6).
- Help to fulfil the reporting task that the Commission has in relation to the sub-700 MHz band under Article 7 of the Decision (EU) 2017/899 on the UHF band and in eventual policy making decisions;
- Contribute to EU preparation for the WRC-23 where the discussion about the future of the sub-700 MHz band in the ITU Region 1[20] within the broader review of the 470-960 MHz band, under Agenda Item 1.5, might lead to further policy actions in the sub-700 MHz band in Europe; and
- Examine the opportunities for the use of the sub-700 MHz band to contribute to the attainment of the 2030 Digital Compass[21] and Digital Decade Policy Programme[22] targets regarding digital infrastructure and connectivity.

[20] Europe, Africa, Middle East without Iran, Armenia, Azerbaijan, the Russian Federation, Georgia, Kazakhstan, Mongolia, Uzbekistan, Kyrgyzstan, Tajikistan, Turkmenistan, Turkey and Ukraine

[21] https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A52021DC0118

[22] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0574

2 Latest technological developments and future trends in the areas of DTT and 5G broadcasting

2.1 Technological Developments and Future Trends in DTT

The remaining spectrum available to terrestrial broadcasting in the UHF band (470-694MHz) has been allocated to broadcasting on a primary basis for a prolonged period of time (as early as the 1930s in some countries) and, in a number of EU Member States (MS), is stable and has mature and heavily relied upon networks. Digital broadcasting standards are not, however, standing still, with more recent technology advancements offering improvements such as enhanced capacity, spectral efficiency and video quality. This section considers the technological developments and future trends occurring within digital terrestrial television (DTT).

This section will include high level impact assessments of the trends identified, looking at changes to spectral efficiency and the ability of terrestrial broadcasting to remain relevant and competitive compared to other platforms. Furthermore, it will also consider costs and benefits to broadcasters, other stakeholders, and the economy as a whole.

The technological developments identified are grouped into three main areas:

- **Capacity improvements:** developments that increase the capacity available within the DTT platform or that decrease the capacity required by services on the platform;
- **Network topology modifications**: developments that allow for greater spectral efficiency to be achieved; and
- **Service improvements**: developments that are noticeable from the perspective of an end user, such that the quality of their experience is improved.

Note that a small number of the developments identified could be classified under more than one of these categories. For the sake of brevity, they will be considered under a single category. Capacities quoted are intended to be representative, and a range of capacities are achievable given the flexibility included within the standards. In addition, techniques such as statistical multiplexing and multiple pass encoding (not usually applicable to live material) allow for effective reductions in the capacity required per service, however as the benefit of these varies on a case-by-case basis, they will not be considered in detail.

2.1.1 Capacity Improvements

2.1.1.1 DVB-T2

First generation digital television networks in Europe utilised DVB-T (Digital Video Broadcasting – Terrestrial). In a number of countries, DVB-T replaced existing analogue TV services, offering improvements in capacity, for example ~8 services (assuming ~24Mbps capacity on a DVB-T multiplex, and a standard definition service requiring ~3Mbps of capacity) could be carried in the same 8MHz channel via digital means as opposed to the single service carried under analogue. DVB-T relies on the use of a multiplex, whereby multiple services are combined into a single stream which is then transmitted across a number of carriers. The use of digital brought other benefits too, for example improved reception performance in the presence of reflections and multipath, and also the possibility for enhanced services such as electronic programme guides (EPG).

Subsequent generations of transmission technology have been able to offer further improvements. DVB-T2, the further developed DVB standard, offers an additional 50-100% spectral efficiency over DVB-T (ITU-R, 2021). For the same standard definition (SD) service as considered earlier, a DVB-T2 multiplex (with assumed capacity of ~40Mbps) could carry ~13 services (again assuming a 3Mbps capacity requirement). Additional capacity can be used for more than just a greater number of services however, with higher quality high-definition (HD) content now regularly transmitted over DVB-T2 multiplexes. Note that HD services can be transmitted using DVB-T, however the higher capacity requirements of an HD service (assumed ~8Mbps using MPEG4) require a greater proportion of the capacity available, such that a DVB-T multiplex is only able to carry ~3 HD services.

In all cases, the exact transmission parameters of the multiplex, the required resolution of the service and the video compression scheme used determine the exact capacity requirements and hence the number of services that can be carried. Beyond the improvement in capacity that is offered by DVB-T2, greater flexibility within the standards allows for a wider range of transmission parameters. For example, the use of more robust transmission modes to allow reception in larger areas, or the use of longer guard intervals to enable more widespread use of single frequency networks (SFN), as explored in section 2.1.2.2.

The use of DVB-T2 as opposed to DVB-T requires some modification to transmission equipment, however. Whilst an aim of the development of DVB-T2 was for extensive re-use of existing DVB-T infrastructure (antennas, combiners, feeders) (Fraile, et al., 2011), there is a requirement for updated, DVB-T2 compatible transmitters and multiplexers to be used. In addition, unless great care is taken to choose transmission modes that exactly replicate the required signal to noise ratio utilised by the existing DVB-T system, some amount of network replanning is likely to be required as well.

The scale of any infrastructure replacement and network replanning is subject to a number of factors, most notably the size and scale of the DTT transmission network. Estimates produced for a previous European Commission study found that across the, as of 2016, 28 EU Member States, transition to DVB-T2 MPEG4 would cost a total of between €607 million and €888 million (between €585 million and €856 million for the current 27 EU Member States). Transition to DVB-T2 HEVC (High Efficiency Video Coding) was estimated to cost a total of between €456 million and €659 million (between €439 million and €635 million for the current 27 EU Member States) (LS telcom, VVA, 2015). Note that these represent costs as of 2016 and as such inflation, and transitions within Member States to DVB-T2, would affect the costs if incurred today.

In addition to upgrades to transmission equipment, viewers will require DVB-T2 capable receivers, noting that dependent on the scale of replacements needed, this could represent a significant cost. A previous European Commission study estimated the cost to upgrade receivers not replaced through the standard television replacement cycle in 28 EU Member States as shown in Table 2. For the purposes of the previous study, it was assumed that consumers replace their television sets on average once per 7 years and that any publicised switchover data may accelerate this (by an assumed 20%), but that any publicised government support scheme may delay this (by an assumed -20%). The cost was found to reduce as time progresses through a combination of a reduction in both the cost of a receiver (assumed to be -5% per year) and the proportion of receivers not having been replaced through the normal replacement cycle.

Year	2018	2019	2020	2021	2022
Cost (€ million), Eurobarometer Penetration Figures					
-20% Acceleration	1564	1316	1108	932	784
Neutral	1418	1155	940	766	623
20% Acceleration	1281	1008	794	625	492

Table 2 – Estimated costs for DVB-T2 receiver replacement across 28 EU Member States.

Source: LS telcom and VVA, 2015

The same study finds 75% of the costs would be incurred in four countries: Spain, France, Italy and the UK, noting that costs within the UK are no longer relevant to this report. Considering the neutral replacement scenario, removing the costs associated with the UK yields the results shown in Table 3, noting that ~74% of the cost will still be incurred in Spain (~€120 million in 2022), France (~€130 million in 2022) and Italy (~€170 million in 2022).

Year	2018	2020	2022
Cost (€ million), Eurobarometer Penetration Figures			
Neutral	1306	865	573

Table 3 - Estimated costs for DVB-T2 receiver replacement across 27 EU Member States.

Source: LS telcom and VVA, 2015

The cost per household is €6.68 in 2018, €4.43 in 2020 and €2.93 in 2022, assuming 195.4 million households within the 27 EU Member States (Eurostat, 2021).

2.1.1.2 Compression Improvements: H.264 MPEG4, H.265 HEVC and H.266 VVC

Where an upgrade from DVB-T to DVB-T2 can increase the capacity available to the DTT platform within a Member State, improvements in video compression technologies serve to reduce the capacity required by a service, such that a greater number of services can be carried within a given capacity. Initial digital television networks typically made use of MPEG2, a video compression technology standardised in 1995. A move to the more efficient MPEG4 (also known as H.264) can reduce the bitrate required by up to 50%. H.265 HEVC presents a similar improvement over H.264 MPEG4, with a quoted reduction in the required capacity of 42-50% (EBU, 2016). H.266 VVC is expected to deliver a similar improvement again over HEVC, i.e. a further 50% reduction in the required capacity (Fraunhofer HHI, 2022).

The use of updated compression equipment requires updated transmission equipment. Assuming no change in transmission standards, the existing transmission and multiplexing equipment can be used, although equipment will need to be updated at the content production and playout facilities. Estimates produced for a previous European Commission study found that across the, as of 2016, 28 EU Member States, transition to DVB-T2 HEVC (from DVB-T MPEG2/4) would cost a total of between

€456 million and €659 million (LS telcom, VVA, 2015). Recalculated to exclude values for the UK, the study finds that such a transition would cost between €439 million and €635 million for the current 27 EU Member States, noting that only ~€8 million of the cost is made up of encoder costs.

These higher compression standards can allow for the use of higher resolution services without consuming prohibitively large amounts of the available capacity, for example HD or 4K (ultra high definition, UHD), or allow other service improvements such as high frame rate (HFR) and high dynamic range (HDR). As with the move from DVB-T to DVB-T2, a change in compression requires replacement of consumer equipment to that which is capable of decoding the newer standards.

A previous European Commission study estimated the costs of this replacement for DVB-T2 HEVC in 28 EU Member States as shown in Table 4. For the purposes of the previous study, it was assumed that consumers replace their television sets on average once per 7 years and that any publicised switchover data may accelerate this (by an assumed 20%), but that any publicised government support scheme may delay this (by an assumed -20%). The cost was found to reduce as time progresses through a combination of a reduction in both the cost of a receiver (assumed to be -10% per year) and the proportion of receivers not having been replaced through the normal replacement cycle.

Year	2018	2019	2020	2021	2022
Cost (€ million), Eurobarometer Penetration Figures					
-20% Acceleration	4169	3324	2649	2112	1684
Neutral	4034	3113	2401	1852	1429
20% Acceleration	3900	2909	2169	1617	1206

Table 4 - Estimated costs for DVB-T2 HEVC receiver replacement across 28 EU Member States.

Source: LS telcom and VVA, 2015

2.1.2 Network Topology Modifications

2.1.2.1 Use of Low Power, Low Tower Networks

One method of increasing spectral efficiency in broadcasting networks is the use of low power, low tower (LPLT), or even medium power, medium tower (MPMT), networks. Historically, many networks have deployed high tower transmitter structures (often located on high terrain), utilising very high transmit powers (high power high tower, HPHT) to cover large areas with minimal amounts of transmission equipment and hence cost. Often, these have been supplemented by smaller sites filling in shadowed areas, or to cater to areas where reception is not possible due to interference to signals from the 'main' site. This example topology is shown in Figure 1.

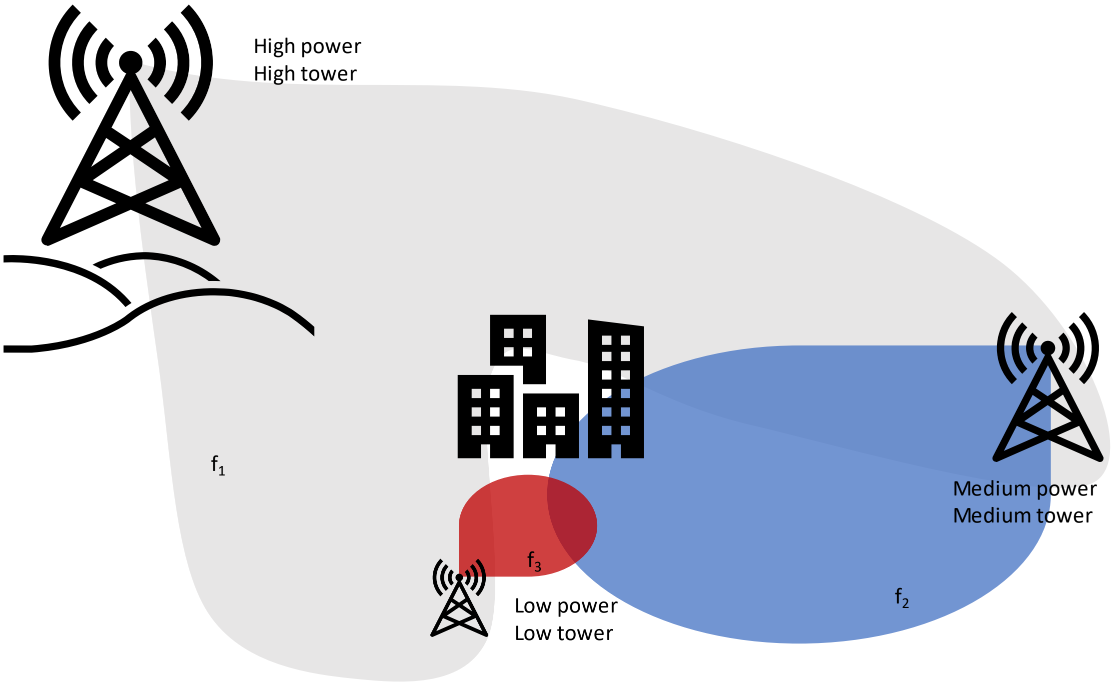


Figure 1 - DTT network topology, showing an example HPHT (high power, high tower), MPMT (medium power, medium tower) and LPLT (low power, low tower) site and the corresponding comparative ranges.

Moving from HPHT to LPLT reduces the transmission area per site, as shown in Figure 2, in theory reducing the area over which the frequency cannot be reused due to interference constraints (in particular if the lower tower network is now more shadowed by terrain features), thereby increasing frequency reuse in a given area and hence spectral efficiency.

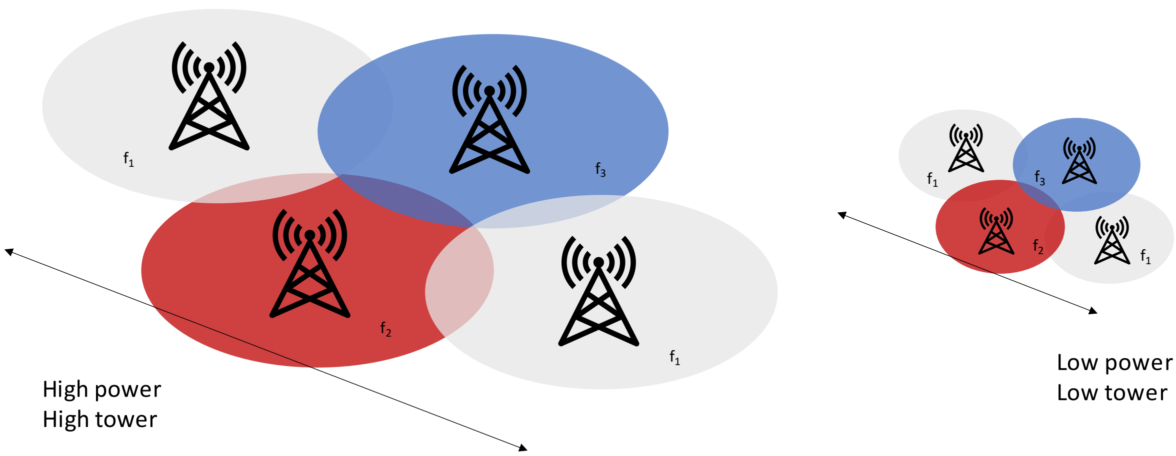


Figure 2 – Example HPHT and LPLT regular networks, showing the shorter reuse distance for an example frequency f_1 achieved with an LPLT network.

This requires the addition of more sites to account for reduced signal levels, although can result in a denser network more reminiscent of a mobile (IMT) network. A particular example of this approach being utilised is in Portugal, where the migration from analogue to digital terrestrial television was also marked with a move from HPHT to LPLT transmission. Instead of 18 high towers (plus gap fillers[23]) being used for transmission, around 230 low towers were used. This change permitted the network to be operated primarily as an SFN thus providing national coverage with a single television frequency channel. This is seen to demonstrate the high degree of spectrum efficiency that can be achieved through the combined use of low power, low tower networks and SFNs.

One study considering the issue of the increased cost associated with LPLT networks looked at the number of LPLT sites required to match fixed rooftop coverage from an HPHT broadcast network (Meabe, et al., 2015) within the Basque region in Spain. The study found that approximately 3.2x as many LPLT sites were required as HPHT sites to provide coverage to the area. The study estimated that this would amount to approximately 3x the cost of the existing broadcast network. Of course, the scale of densification required will depend on the area considered and the existing density of the HPHT network, but this study does show that the costs associated with moving to an LPLT network could be quite significantly higher than for an HPHT network.

From a user viewpoint, there is not necessarily a requirement to obtain additional reception equipment if network topologies are changed, assuming no changes are made to the transmission or compression technologies. There may be a requirement for users to retune if the frequencies utilised are changed however.

2.1.2.2 Use of Single Frequency Networks

Reception of the DTT signal at a particular location relies on a suitably high DTT signal field strength and the absence of high levels of interference (typically the wanted signed needs to be 20dB higher than interference for DTT, although this is dependent on the transmission and reception mode considered). Within a single frequency network (SFN), two or more transmitters are configured such that the co-channel signals received in the target coverage area are sufficiently similar for minimal levels of destructive interference to occur, as shown in Figure 3. For this to occur, the transmissions must contain identical content, be on the same frequency and be synchronised in the time domain such that the difference in the time of the arrival of the two signals at the receiver is consistent and within the guard interval.

[23] Small sites providing coverage in areas shadowed to the HPHT network.

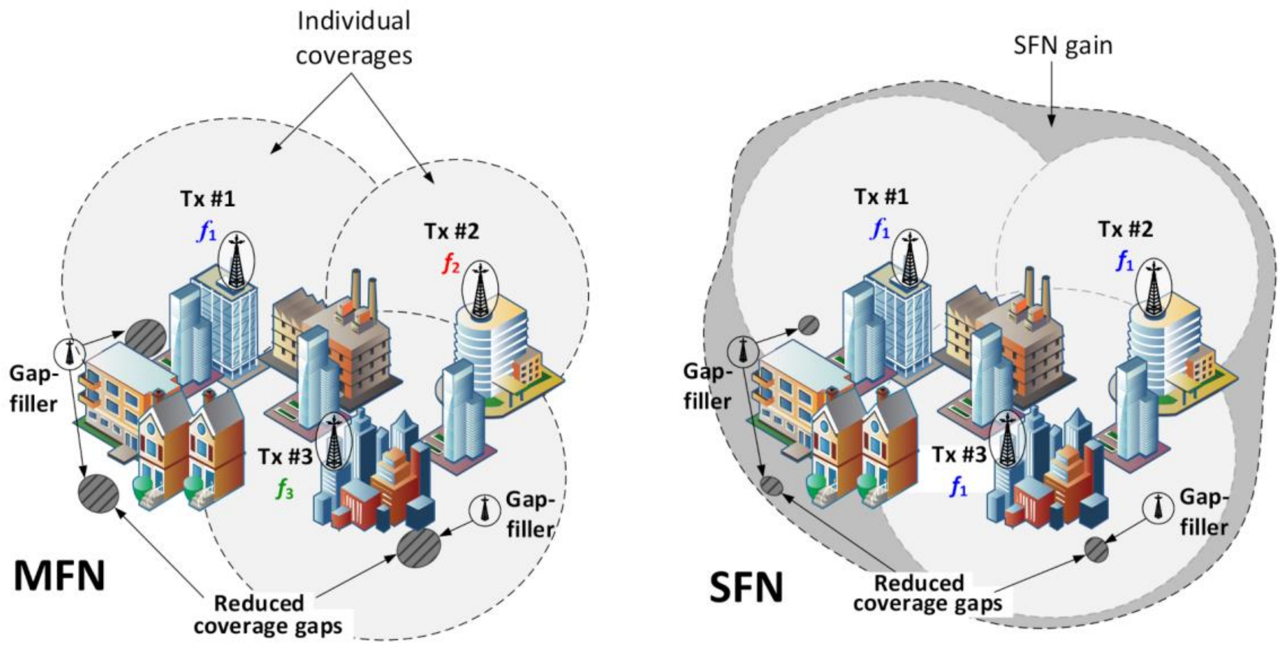


Figure 3 – Example SFN topology versus MFN topology.

Source: Staniec, 2021

In this way, the spectral efficiency of DTT can be increased, as coverage is laid down over a greater area (i.e. transmission from a greater number of sites) with fewer frequencies utilised than in a traditional multi-frequency network (MFN). EBU for instance finds that, for DVB-T2, a national SFN can in some instances be 25% more spectrally efficient than MFNs, and 15% more spectrally efficient than regional SFNs, noting that there are limitations on regionality requirements and international co-ordination (EBU, 2014).

However, operating SFNs is significantly more complex than MFNs, both in terms of infrastructure deployment and network planning. Tolerances on frequency and time of transmission need to be much more carefully managed, with external time references required. Similarly, distribution options for SFN networks are much more limited with, for example, off-air reception to feed transmitters made significantly more complicated. In addition, the consequences of incorrectly operating SFNs are potentially much more significant than in the case of MFNs. Co-frequency stations are likely to be much closer together when operating as an SFN which can prove very damaging for coverage in the event that correct synchronisation is not achieved. In addition, the operation of SFNs over wide areas requires large guard intervals, thereby reducing the multiplex's available capacity.

There is limited publicly available information regarding the cost to deploy SFNs within a broadcast network, often because they are adopted at the same time as other improvements. Additional transmission equipment is required to enable the SFN, for example to ensure the required time synchronisation across multiple transmitters (ITU, 2012). However, a number of studies note that the cost of this additional equipment is typically smaller than that associated with supporting the additional distribution requirements (EBU, 2012). Distribution of content to SFN sites is often achieved through use of line feeds or microwave links, rather than through off air reception, although alternative methods using off air reception of a site outside of the SFN have seen success more recently, potentially helping to reduce the cost associated with distribution.

Little information has been published on the capital expenditure required to migrate to an SFN topology. Instead, the operational expenditure required for an SFN has been compared to an equivalent MFN, in terms of the cost required to achieve an increase in spectral efficiency. Studies find that for an increase of 25% in spectral efficiency, i.e. an optimistic estimate for the spectral efficiency increase of a national SFN, transmission costs are approximately double the MFN approach (Bettancourt & Peha, 2015).

From a user viewpoint, there is no requirement to obtain additional reception equipment or retune if network topologies are changed to include more SFNs, assuming no changes are made to the transmission or compression technologies, or the frequencies utilised. There is the potential for increased quality of reception due to the presence of multiple signals constructively interfering, for example improving the received signal by up to 3dB for two appropriately configured transmitters in some locations (EBU, 2005), with coverage potentially laid down over slightly larger areas.

In addition, due to the larger composite coverage areas that are achieved through the use of SFNs, receivers travelling through the coverage areas of multiple co-frequency transmitters will not need to retune throughout the SFN area. In addition, the improved location diversity of the received signals can help to improve received signal strength by increasing the likelihood at a given location that at least one signal is not shadowed by obstacles. The extent to which this benefits reception is hard to generalise however as it is dependent on the signal paths and receiver location. In any case, the use of single frequency networks can help to improve support for mobile and portable reception modes.

2.1.3 Service Improvements

2.1.3.1 Alternative Reception Modes

In addition to the network modifications to increase spectral efficiency, either through more widespread use of SFNs or using LPLT topologies, network topologies could also be modified such that alternative reception modes are possible. This could include for example portable (i.e. handheld), mobile (i.e. in a vehicle) or indoor reception (i.e. without the need for a fixed rooftop antenna), as opposed to the more traditional fixed rooftop reception. Achieving portable, mobile or indoor reception requires increased field strengths however, owing primarily to the lower gain antennas and less favourable reception locations associated with these reception modes.

The Geneva 2006 DTT Planning Agreement states that a minimum median field strength of 56dBµV/m is required for fixed reception, increasing to 88dBµV/m for portable indoor reception. A 32 dB increase, or roughly 1,500x the field strength, equates to a much denser network, likely of an MPMT or LPLT configuration. It is also important to note that the assumed standard deviation associated with portable indoor reception is ~2dB higher than fixed reception (ITU, 2006). As such, in order to offer these alternative reception modes to viewers, operators would need to deploy much denser networks than have been used for the more common fixed rooftop reception.

One study considered the costs associated with moving from fixed rooftop reception to mobile or portable reception (Meabe, et al., 2015) within the Basque region of Spain. The study found that mobile reception could be achieved through either an exclusively LPLT network or a mixed LPLT HPHT network. In the LPLT network case, 4.45x as many LPLT sites were required as HPHT sites to provide mobile reception, equating to approximately 4.29x the cost of the existing HPHT network. If a mixed LPLT HPHT network was used, the cost was reduced by approximately 11%, equating to 3.81x the cost of the existing HPHT network. Of course, the scale of densification required will depend on the area considered and the existing density of the HPHT network, but this study does show that costs to achieve mobile reception could be quite significantly higher than fixed rooftop reception.

From a user viewpoint, there is not necessarily a requirement to obtain additional reception equipment if network topologies are changed, assuming no changes are made to the transmission or compression technologies. If users wish to take advantage of the potential for the new reception modes however, there may be a requirement to obtain alternative reception equipment, for example a mobile phone capable of DVB-T/2 reception, or a portable television. In addition, there may be a requirement for users to retune if frequencies utilised are changed.

2.1.3.2 HD, 4K, 8K

Traditionally most content has been broadcast in standard definition (SD), although many countries have moved, or are in the process of moving, to higher resolution standards. SD video (MPEG2 encoding) requires ~3Mbps of capacity, increasing to ~8Mbps for HD (MPEG4 encoding, ~5Mbps for HEVC encoding). Standards beyond HD, for example 4K and 8K, are available although these are typically less frequently used on DTT, being found more frequently via other distribution methods, such as streaming, cable or satellite. DVB anticipates that 4K services over DTT (HEVC encoding) would occupy 10-13Mbps of capacity (DVB, 2020), and recent trials by RTVE found that 8K required ~33Mbps of capacity (TVB Europe, 2020), essentially occupying a whole multiplex and marking a return of the single-frequency means single-programme era of the analogue days. Representative capacity requirements for various picture resolution standards are shown in Table 5.

Picture Resolution	Encoding Standard		
	MPEG2	MPEG4	HEVC
SD	3 Mbps	1.5 Mbps	
HD	>15 Mbps	8 Mbps	5 Mbps
4K			15 Mbps
8K			33 Mbps

Table 5 - Representative capacity requirement for the different encoding and video standards

The use of these updated standards requires updated consumer reception equipment, with receivers capable of decoding the updated standards, but also viewing equipment capable of displaying the higher resolution content. In addition, content production and contribution equipment will also be required to be capable of delivering content in these enhanced resolutions. Adoption of these new standards will therefore come with expense to content producers. Information regarding the costs associated with migration to these newer standards is not widely published, however.

2.1.3.3 WCG, HDR, HFR

Use of enhanced services such as wide colour gamut (WCG), high dynamic range (HDR) and high frame rate (HFR) offer further improvements beyond just resolution, including smoother video and more accurate representation of colour and brightness. Use of these improvements further increases the capacity required per service, as shown in Table 6.

Resolution	Standard (HEVC)	+HFR	+HDR	+WCG	+HDR+WCG	+HFR+HDR+WCG
HD	5.0Mbps	6.2Mbps	5.9Mbps	5.4Mbps	6.4Mbps	7.7Mbps
4K	15.0Mbps	18.6Mbps	17.8Mbps	16.3Mbps	19.3Mbps	23.0Mbps

Table 6 – Data rate increases required for enhanced video quality

The use of these updated standards requires updated consumer reception equipment, with receivers capable of decoding the updated standards, but also viewing equipment capable of displaying the enhanced content. In addition, content production and contribution equipment will also be required to be capable of delivering content in these enhanced resolutions. Adoption of these new standards will therefore come with expense to content producers. Information regarding the costs associated with migration to these newer standards is not widely published however.

2.1.3.4 Interactive Broadcast Broadband

Technologies aiming to offer enhanced content carried over alternative means to DTT include hybrid TV standards such as DVB-I (Digital Video Broadcasting – Internet) and HbbTV (Hybrid Broadcast Broadband TV) which aim to supplement existing broadcast content with on-demand content obtained through broadband. In contrast, standards such as DVB-HB (Digital Video Broadcasting - Home Broadcast) aim to utilise the readily available broadcast signal to make content available to all IP-enabled devices within the home. These standards are in varying degrees of adoption but serve to increase choice available to the consumer.

A number of these interactive, hybrid services allow viewers access to linear free to view content, including that from PSM providers, whilst also allowing other content to be viewed easily on the same devices and within the same interface. This has the benefit that no viewers are disenfranchised, for example those not connected to the internet or those not interested in learning how to operate an alternative platform. It also ensures that DTT does not fall behind other competitors in the market, for example streaming services, with regards to allowing on demand access to a wide variety of services, both those available via traditional linear viewing and those only available online. In addition, the bundling of these multiple services into a single package means that viewers are directed towards the DTT option when watching linear free to view content. Not only does this save internet bandwidth for other applications but also serves to maintain usage of DTT.

2.1.4 Implications

The technological developments identified increase the amount of capacity available to the DTT platform within a Member State, whilst also reducing the capacity required for a given service. In addition, the increased capacity and compression levels offered by the developments also provide the opportunity for enhanced services, such that viewers are able to receive richer services through DTT (i.e. through the addition of interactivity). In turn, the DTT platform is better able to compete with other distribution platforms where these types of enhanced services are more commonplace. Network topology changes do not themselves offer additional total platform capacity or enhanced services, but they do offer the potential for enhanced spectral efficiency, and hence potentially a greater number of services, as well as the possibility for alternative reception modes. Considering just the developments that affect capacity on the platform, Figure 4 shows the number of services that can be carried on a representative DVB-T/T2 multiplex assuming the different encoding technologies and service requirements.

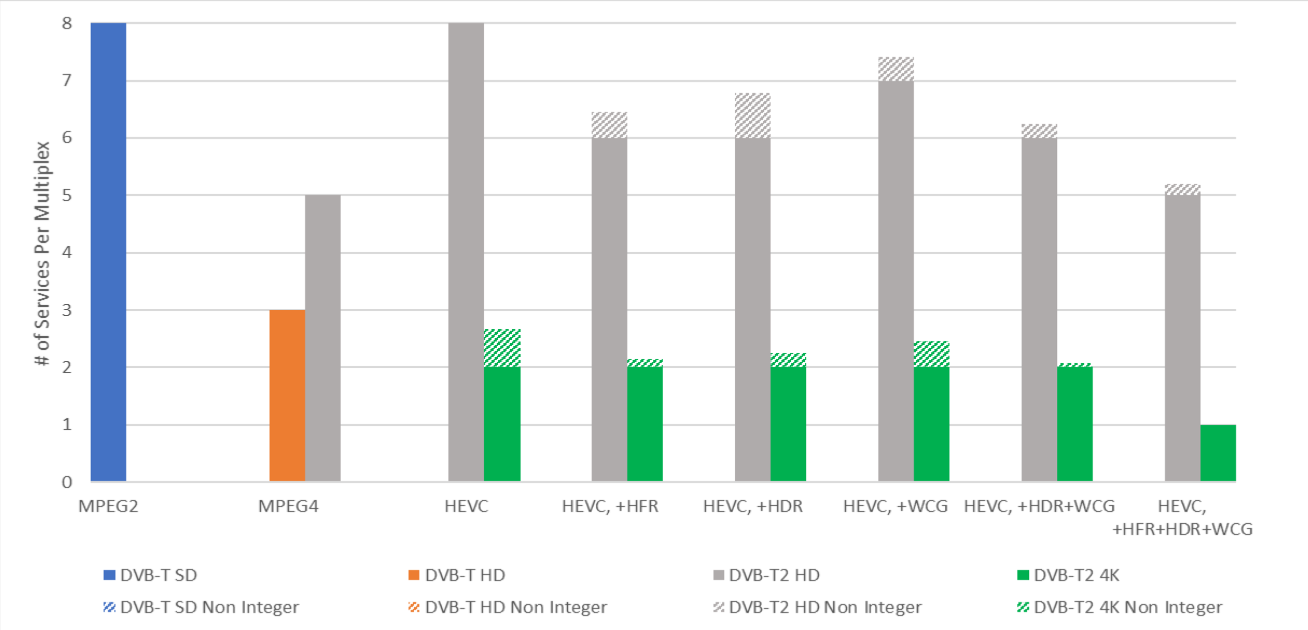


Figure 4 – Representative number of services achievable per multiplex for the different transmission, encoding and video standards (with surplus capacity not sufficient to carry a service shown as a hatched pattern).

# of Services for Encoding Standard								
Transmission Standard and Picture Resolution	**MPEG2**	**MPEG4**	**HEVC**	**HEVC +HFR**	**HEVC +HDR**	**HEVC +WCG**	**HEVC +HDR +WCG**	**HEVC +HFR +HDR +WCG**
DVB-T SD	8	0	0	0	0	0	0	0
DVB-T HD	0	3	0	0	0	0	0	0
DVB-T2 HD	0	5	8	6	6	7	6	5
DVB-T2 4K	0	0	2	2	2	2	2	1

Table 7 - Representative whole number of services per multiplex for the different encoding and video standards.

It can be seen that moving from DVB-T MPEG2 SD to DVB-T2 HEVC HD allows a broadly equivalent number of services per multiplex (~8). As such, each Member State's DTT platform could potentially offer a significant proportion of services in HD, but only if using DVB-T2 and HEVC. This allows for increased competition with other delivery technologies, as HD is becoming increasingly common. The same is true for higher resolution standards such as 4K, where demand for these types of services is growing also. Figures regarding consumer expectation of content are limited, however users of OTT content are beginning to expect 4K content, as demonstrated by a third of Netflix subscribers paying higher rates for the 'Premium 4K' plan (IBC365, 2021). However, if 4K is required over DTT, considerably fewer services will be available per multiplex (~2). As such, it is likely that Member States will not be able to offer all existing services in 4K.

The number of services achievable per multiplex when using one or two of HDR, HFR and WCG is broadly similar (~2), although the 'spare' capacity available that could be used for other services is reduced. Delivering services in WCG, HFR and HDR simultaneously would achieve just a single service per multiplex however, severely limiting the breadth of content available on the platform. VVC could be deployed to improve matters, however as a number of Member States have relatively recently undergone upgrade programmes, e.g. moving to DVB-T2 and HEVC, it could be expected that appetite to undergo additional upgrade programmes might be limited. In any case, the availability of VVC capable receivers is currently unclear (ITU-R, 2021).

The cost of these upgrades is likely to be significant. Estimates place the cost of upgrades to DVB-T2 in the hundreds of millions of euros across the EU27, with a similar amount estimated to replace consumer receivers. Other estimates place the cost of operating an SFN at double the cost to operate an equivalent MFN, increasing to approximately three times the cost when operating an LPLT network, and approximately four times the cost when moving to a network capable of achieving mobile reception. As such, any widespread adoption of these more modern standards would require a significant investment in the platform, the appetite for which is likely to be limited if there is not continued regulatory certainty regarding access to the spectrum required.

2.2 DTT Developments in the EU Member States

2.2.1 Member State Developments Summary

All 27 EU Member States provided responses to the questionnaire, full details of which are included in Annex C. The number of multiplexes per Member State is shown in Figure 5 and Table 8. Note that in all analysis within this summary, unless stated otherwise, the **final state within each Member State is considered**, i.e. after any current planned upgrade programmes have been completed[24]. In addition, if multiple standards are quoted as used on the platform, unless exact values have been provided in the response, even splits between the standards are assumed for the analysis. Note that France's quoted single local multiplex is assumed to represent a layer of local multiplexes, i.e. more than 1, although as details of the number of separate multiplexes have not been provided, a value of 1 is taken for the analysis.

[24] Note that for Italy the upgrade of the system to DVB-T2 HEVC is scheduled to occur, by law, no earlier than 2023.

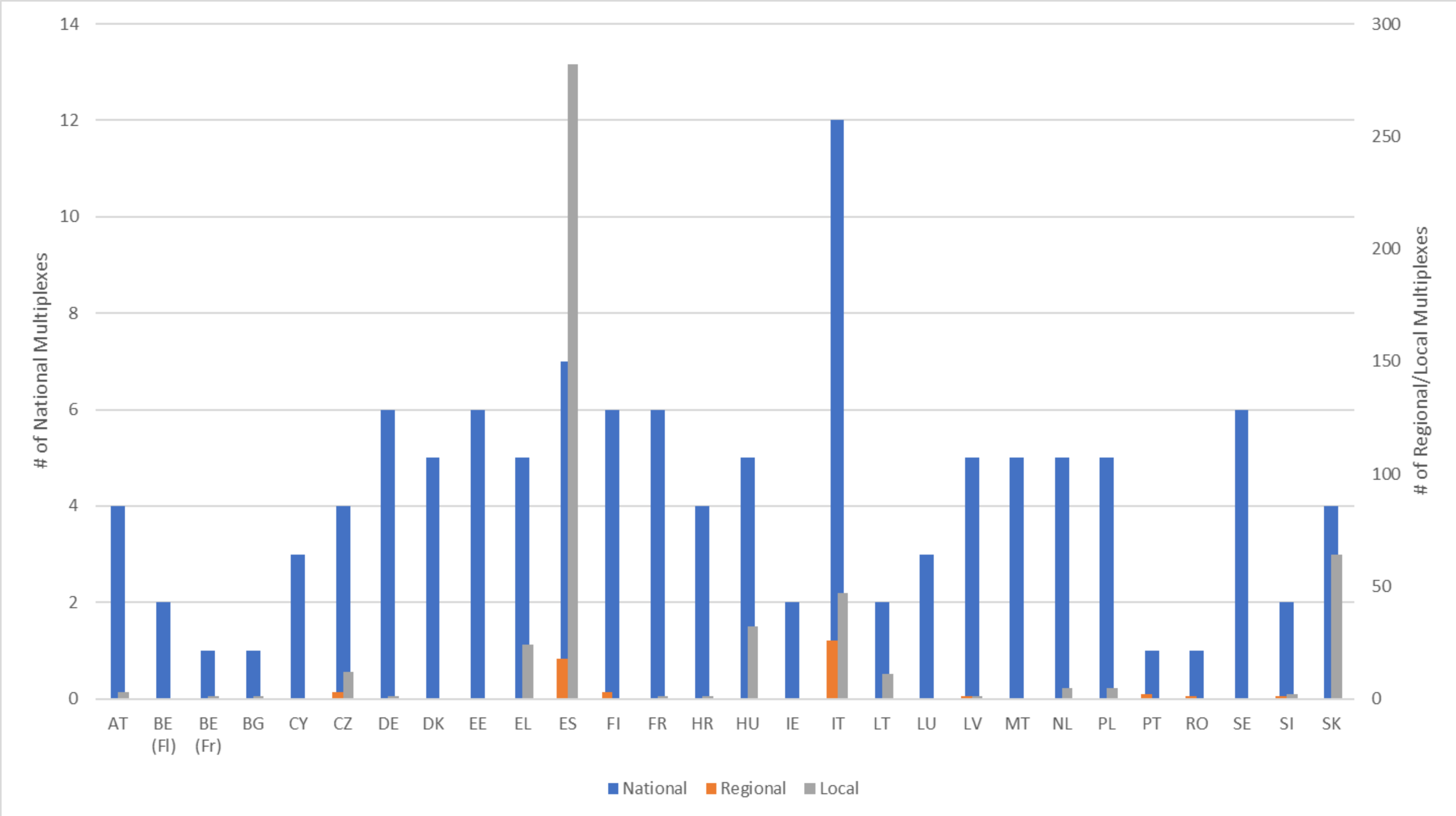


Figure 5 – Number of national (left axis, blue), regional (right axis, orange) and local (right axis, grey) multiplexes for Member States.

No. of Multiplexes	National	Regional	Local
AT	4		3
BE (Fl)	2		
BE (Fr)	1		1
BG	1		1
CY	3		
CZ	4	3	12
DE	6		1
DK	5		
EE	6		
EL	5		24
ES	7	18	282
FI	6	3	
FR	6		1
HR	4		1
HU	5		32
IE	2		
IT	12	26	47
LT	2		11
LU	3		
LV	5	1	1
MT	5		
NL	5		5
PL	5		5
PT	1	2	
RO	1	1	
SE	6		
SI	2	1	2
SK	4		64

Table 8 - Number of national, regional and local multiplexes for Member States.

Across the Member States, there is an average of 4 national, 7 regional and 29 local multiplexes, although as the numbers of regional and local multiplexes vary significantly across the Member States (standard deviation, σ, of 9.61 and 67.8 for regional and local respectively), the average is not particularly useful in the case of regional and local multiplexes. Considering instead the median, Member States have a median of 5 national multiplexes, 3 regional multiplexes and 5 local multiplexes.

Across the Member States, ~40% of the total number of national multiplexes are operating DVB-T, with ~60% operating DVB-T2. 11 Member States utilise just DVB-T2, 11 utilise just DVB-T, and 5 utilise a mixture of the two at the national layer level. Considering regional multiplexes, approximately 45% of the total number of multiplexes utilise DVB-T, with ~55% utilising DVB-T2. Of the 8 Member States who operate regional multiplexes, 1 uses both DVB-T and DVB-T2, 4 use just DVB-T, and 3 use just DVB-T2 at the regional layer level. For local multiplexes, approximately 87% are operating DVB-T, with ~13% operating DVB-T2. Of the 17 Member States who operate local multiplexes, 10 utilise just DVB-T, 4 utilise just DVB-T2, and 3 utilise both DVB-T and DVB-T2 at the local layer level.

For compression technologies, across the Member States, 8% of the national multiplexes utilise MPEG2, 53% utilise MPEG4, and 39% utilise HEVC. Of the Member States, 2 utilise just MPEG2, 15 utilise just MPEG4, 6 utilise just HEVC, 1 utilises both MPEG2 and MPEG4, and 3 utilise both MPEG4 and HEVC at the national layer level. For the 8 Member States operating regional multiplexes, ~47% of the total number of multiplexes use MPEG4 and ~53% use HEVC. Of the Member States, 2 use just HEVC, and 6 use just MPEG4 at the regional layer level. For local multiplexes, ~11% of the total number of multiplexes represented use MPEG2, ~75% use MPEG4 and ~14% use HEVC. Of the 16 Member States who operate local multiplexes, 2 Member States use just MPEG2, 7 operate just MPEG4, 5 Member States use just HEVC, 2 use both MPEG2 and MPEG4, and 1 uses both MPEG4 and HEVC at the local layer level.

This is shown graphically in Figure 6 and Figure 7.

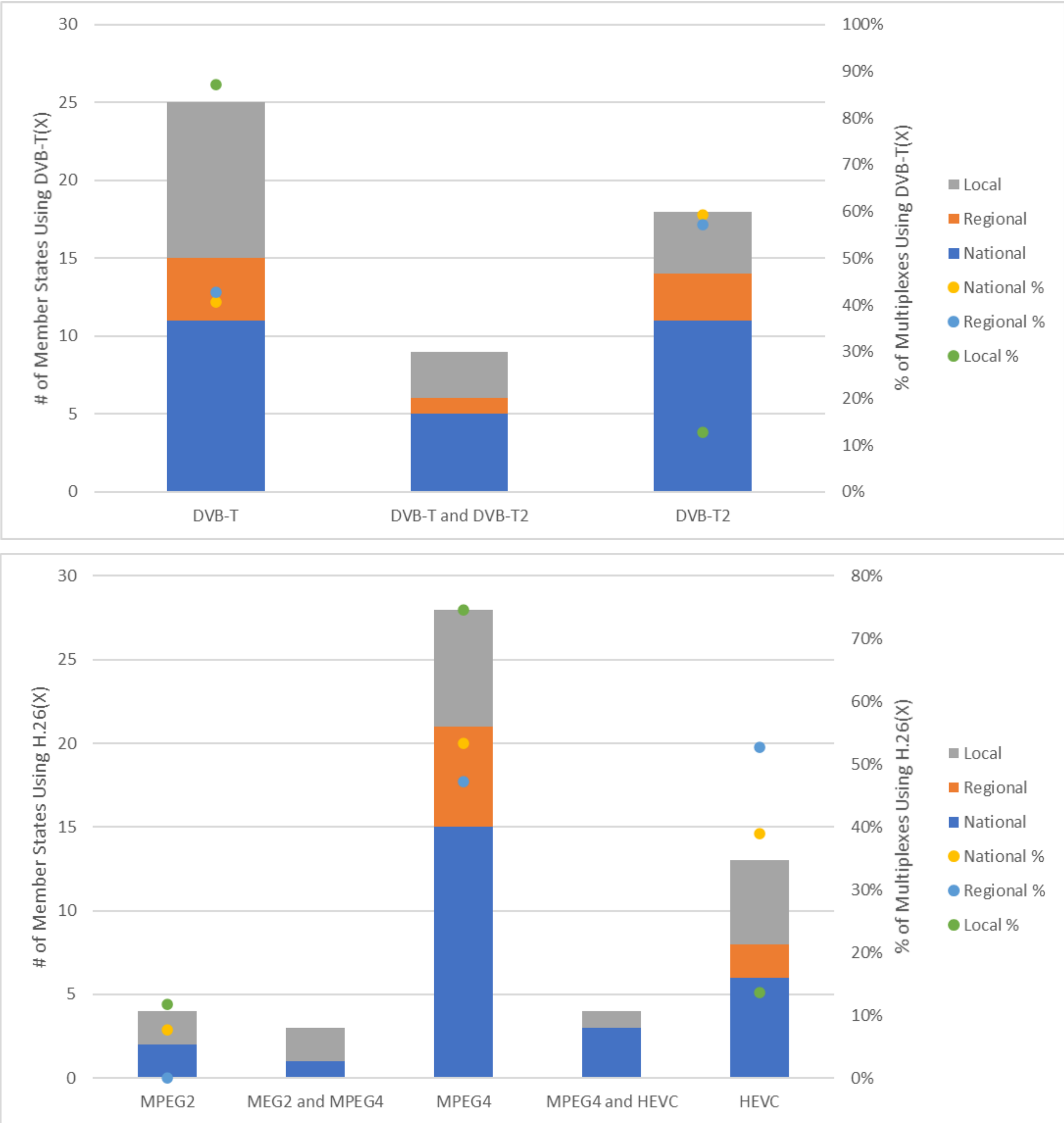


Figure 6 – (TOP) Number of Member States (left axis) and proportion of represented multiplexes (right axis) using DVB-T and DVB-T2. (BOTTOM) Number of Member States (left axis) and proportion of represented multiplexes (right axis) using MPEG2, MPEG4 and HEVC.

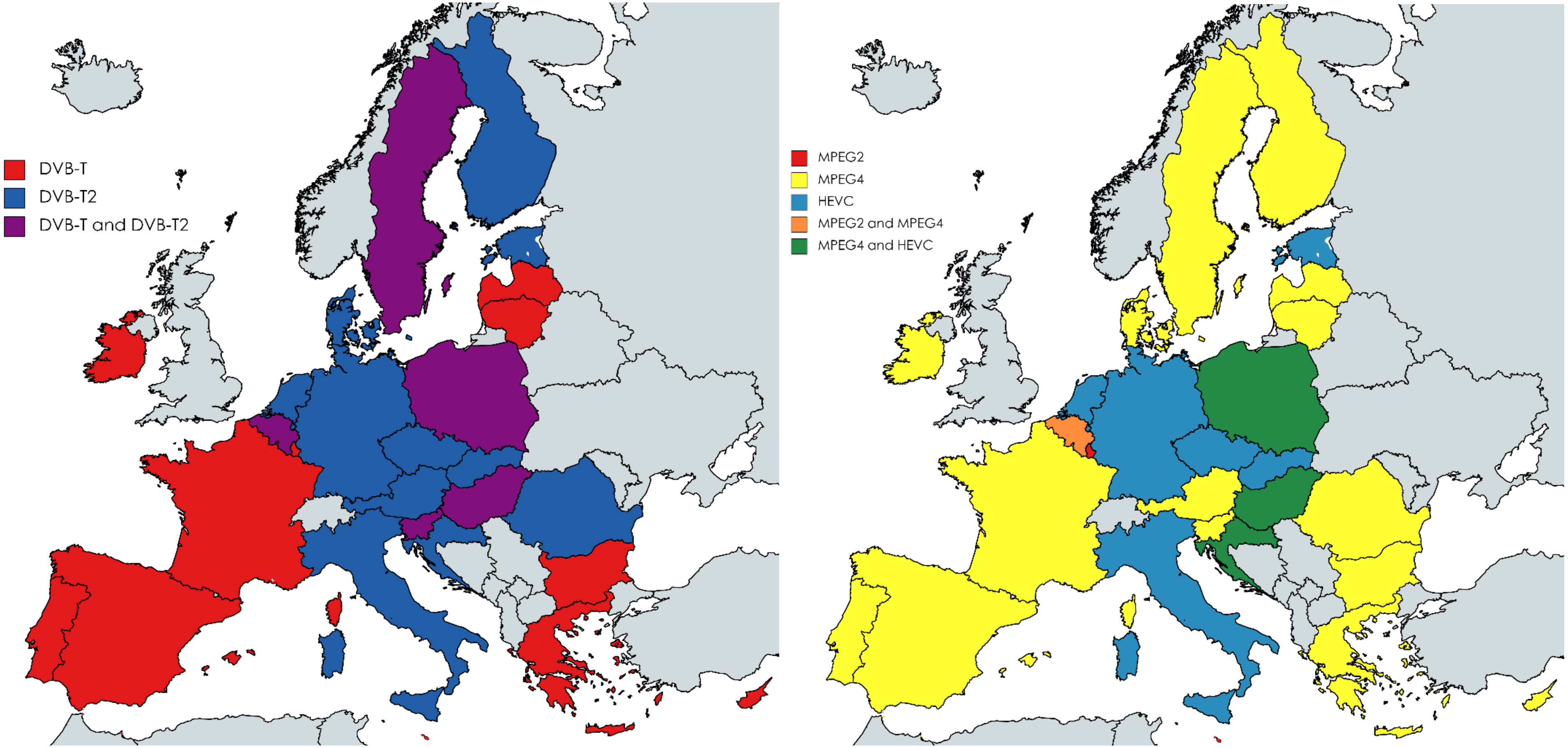


Figure 7 – (LEFT) Member States using DVB-T, DVB-T2 or both DVB-T and DVB-T2 for their national multiplexes. (RIGHT) Member States using MPEG2, MPEG4, HEVC, MPEG2 and MPEG4 or MPEG4 and HEVC for their national multiplexes.

The split between transmission standards within Member States is relatively even, with the same number of Member States using just DVB-T2 (11) as just DVB-T (11) for their national multiplexes. The proportions of represented multiplexes using DVB-T and DVB-T2 show larger levels of variation, however, with a ~40% DVB-T and ~60% DVB-T2 split at a national layer level. This would suggest that a number of Member States with higher numbers of national multiplexes, for example Italy with 12, are using the more recent standards, thereby pulling up the totals.

Considering compression, use of the newer standards (MPEG4 or HEVC) is much more widespread (92% of national multiplexes represented), with 24 Member States using at least MPEG4 for their national multiplexes. 39% of national multiplexes represented use HEVC, with lower proportions for local multiplexes (14%), and higher proportions (53%) for regional multiplexes.

Whilst a number of Member States are in the process of upgrading their DTT platforms, thereby increasing the proportion of Member States operating the more recent standards, there are still some Member States operating older standards (11 Member States at a national layer level using just DVB-T, with DVB-T multiplexes representing ~75% of the total number of multiplexes in Member States). It is worth noting however that there are of course reasons why Member States make use of older standards that this analysis does not consider, for example to ensure compatibility with older sets or because low uptake of DTT limits the commercial viability of any upgrades.

For Member States, the percentage of multiplexes using DVB-T and DVB-T2 is shown for the national layer in Figure 8, the regional layer in Figure 9, and the local layer in Figure 10. The percentage of represented multiplexes using MPEG2, MPEG4 and HEVC is shown also for the national layer in Figure 11, for the regional layer in Figure 12, and for the local layer in Figure 13. A summary of the totals is shown in Table 9. Note that where responses have stated that a layer of multiplexes uses a mixture of standards, an equal split between the various standards has been assumed.

MS	No. of National Multiplexes	DVB-T	DVB-T2	MPEG2	MPEG4	HEVC	No. of Regional Multiplexes	DVB-T	DVB-T2	MPEG2	MPEG4	HEVC	No. of Local Multiplexes	DVB-T	DVB-T2	MPEG2	MPEG4	HEVC
AT	4		4		4								3	1	2	1	2	
BE	3	1	2	1	2								1	1		1		
BG	1	1			1								1	1			1	
CY	3	3			3													
CZ	4		4			4	3	1.5	1.5			3	12	6	6			12
DK	5		5		5													
DE	6		6			6							1		1			1
EE	6		6			6												
EL	5	5			5								24	24		24		
ES	7	7			7		18	18			18		282	282			282	
FI	6		6		6		3		3		3							
FR	6	6			6								1	1			1	
HR	4		4		2	2							1		1			1
HU	5	2	3		2	3							32	32			32	
IE	2	2			2													
IT	12		12			12	26		26			26	47		47			47
LV	5	5			5		1	1			1		1	1			1	
LT	2	2			2								11	11			11	
LU	3	3		3														
MT	5	5		5														
NL	5		5			5							5		5			5
PL	5	1	4		1	4							5	4	1		4	1

MS	No. of National Multiplexes	DVB-T	DVB-T2	MPEG2	MPEG4	HEVC	No. of Regional Multiplexes	DVB-T	DVB-T2	MPEG2	MPEG4	HEVC	No. of Local Multiplexes	DVB-T	DVB-T2	MPEG2	MPEG4	HEVC
PT	1	1			1		2	2			2							
RO	1		1		1		1		1		1							
SE	6	3	3		6													
SI	2	1	1		2		1	1			1		2	2			2	
SK	4		4			4							64	64		32	32	
Total	114	41%	59%	9%	52%	39%	55	43%	57%	0%	47%	53%	461	86%	14%	13%	73%	15%

Table 9 – Percentage of national, regional and local multiplexes in Member States using DVB-T or DVB-T2, and using MPEG2, MPEG4 or HEVC.

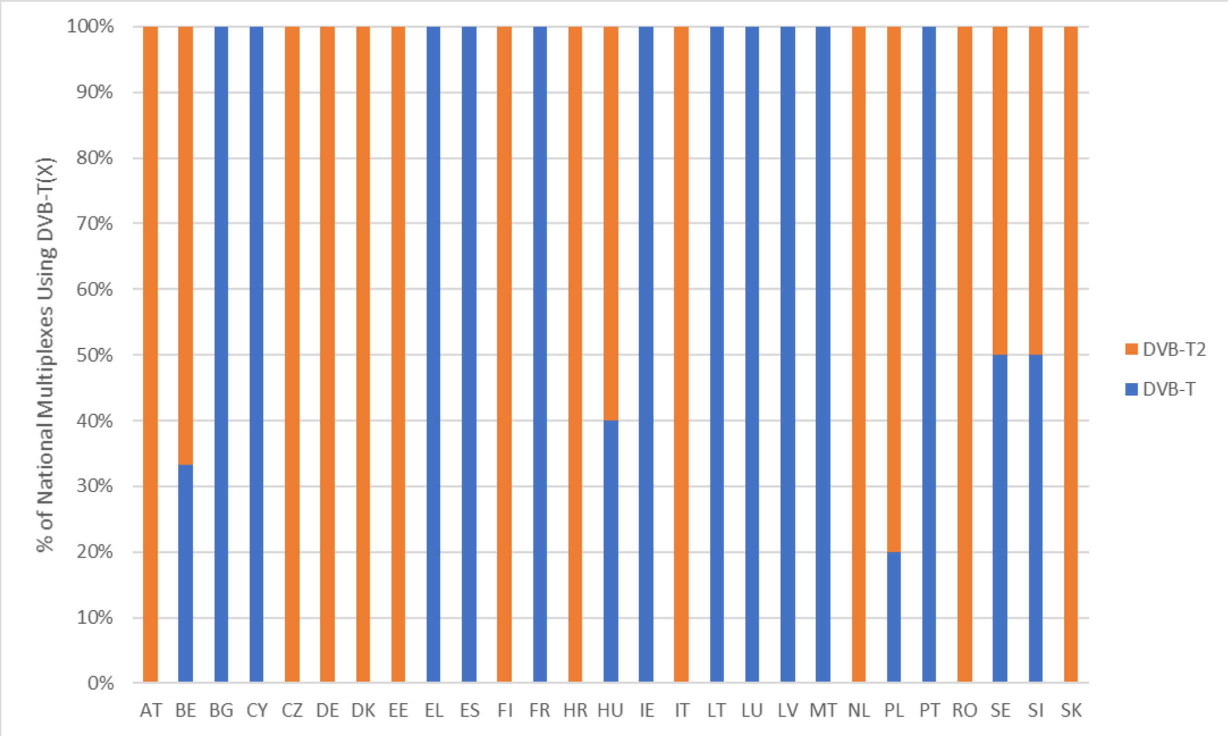


Figure 8 – Percentage of national multiplexes within Member States making use of DVB-T and DVB-T2.

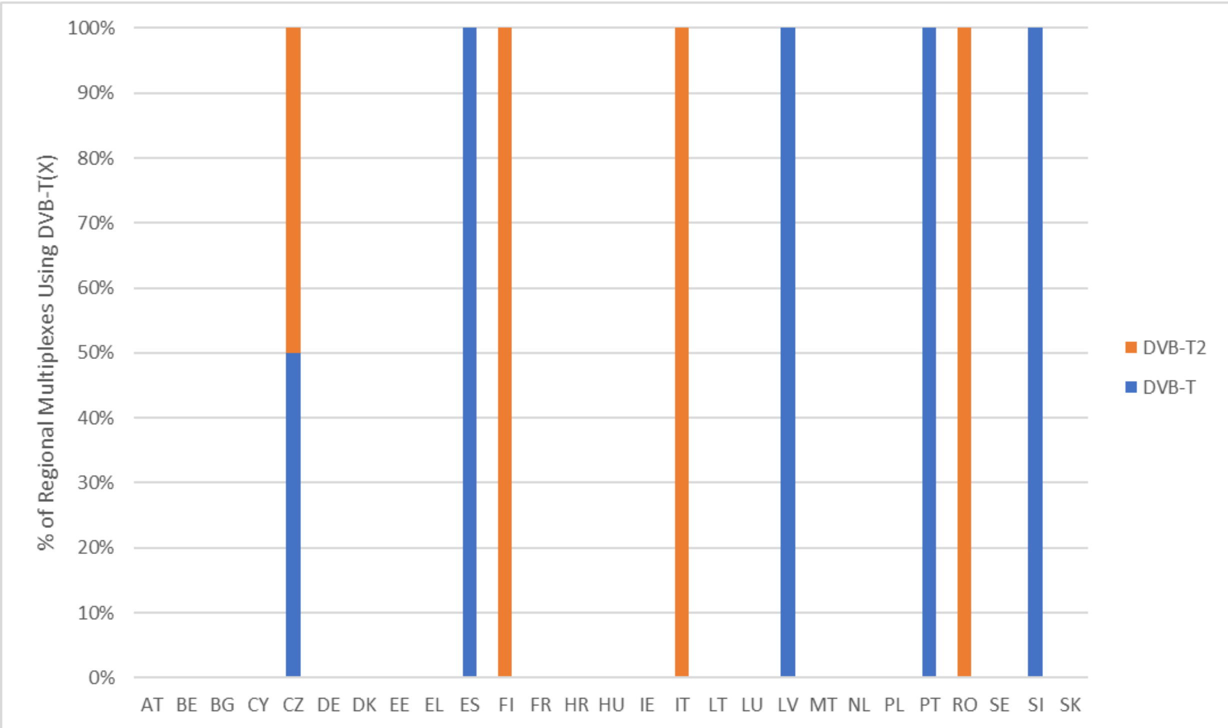


Figure 9 - Percentage of regional multiplexes within Member States making use of DVB-T and DVB-T2.

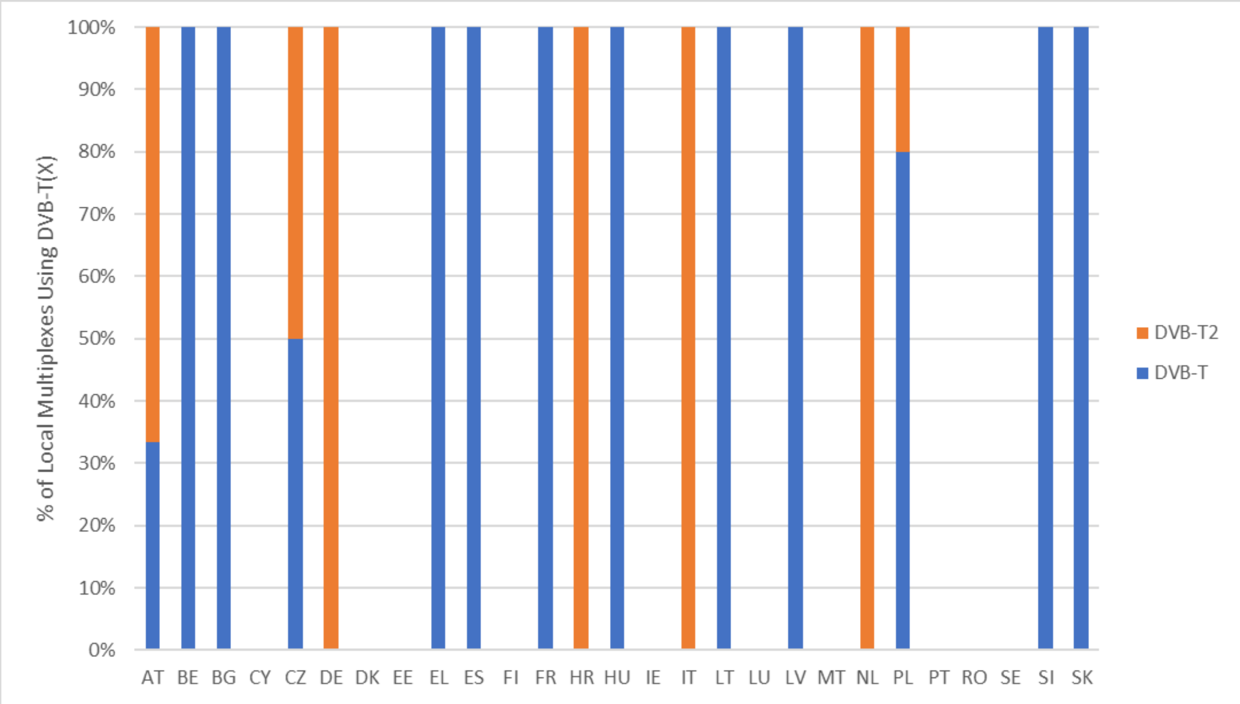


Figure 10 - Percentage of local multiplexes within Member States making use of DVB-T and DVB-T2.

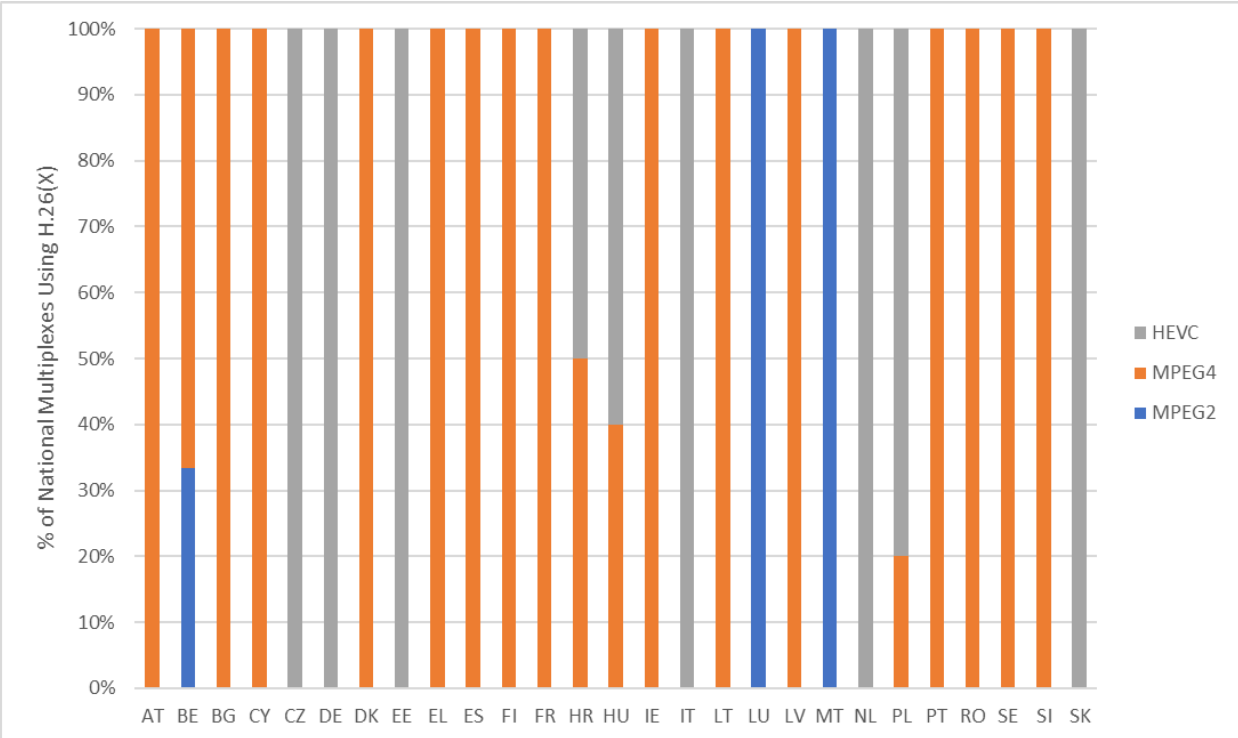


Figure 11 - Percentage of national multiplexes within Member States making use of MPEG2, MPEG4 and HEVC.

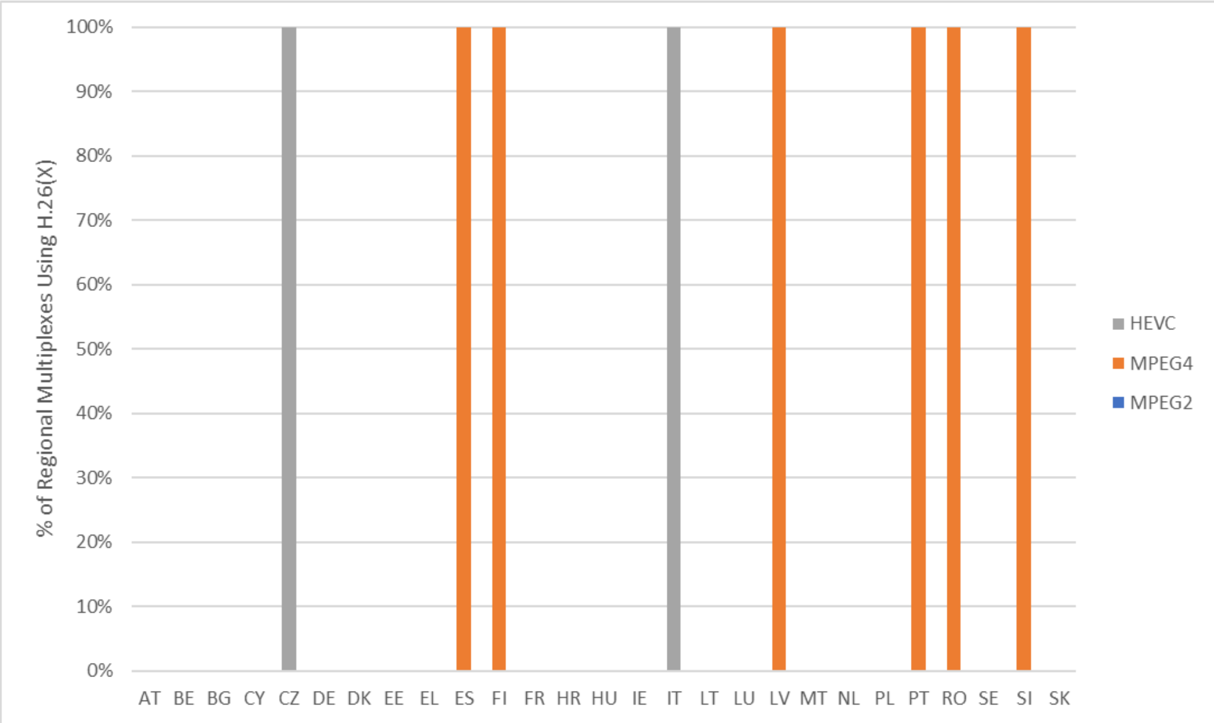


Figure 12 - Percentage of regional multiplexes within Member States making use of MPEG2, MPEG4 and HEVC.

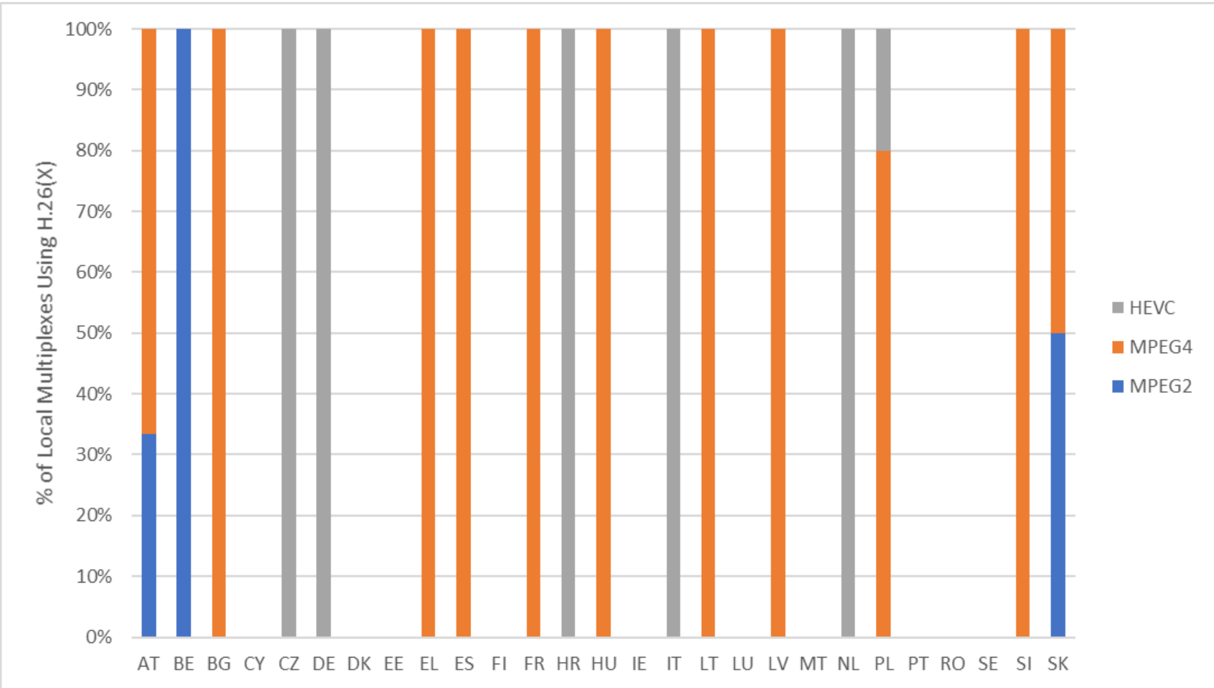


Figure 13 - Percentage of local multiplexes within Member States making use of MPEG2, MPEG4 and HEVC.

Figure 14, Figure 15 and Figure 16 show the split of services (or channels) across national, regional and local multiplexes respectively in Member States. Note that the response from the Czech Republic indicated its platform would include ‘several’ services on the regional multiplexes (for which a value of 4 has been assumed) and ‘some’ services on the local multiplexes (for which a value of 10 has been assumed). Germany indicated that the majority of services on its platform were in HD, for which a value of approximately 90% HD content has been assumed.

We have further broken down the information provided into Pay-TV services and those which are Free-To-Air (FTA), which is to say that no subscription or other payment is required in order to receive them.

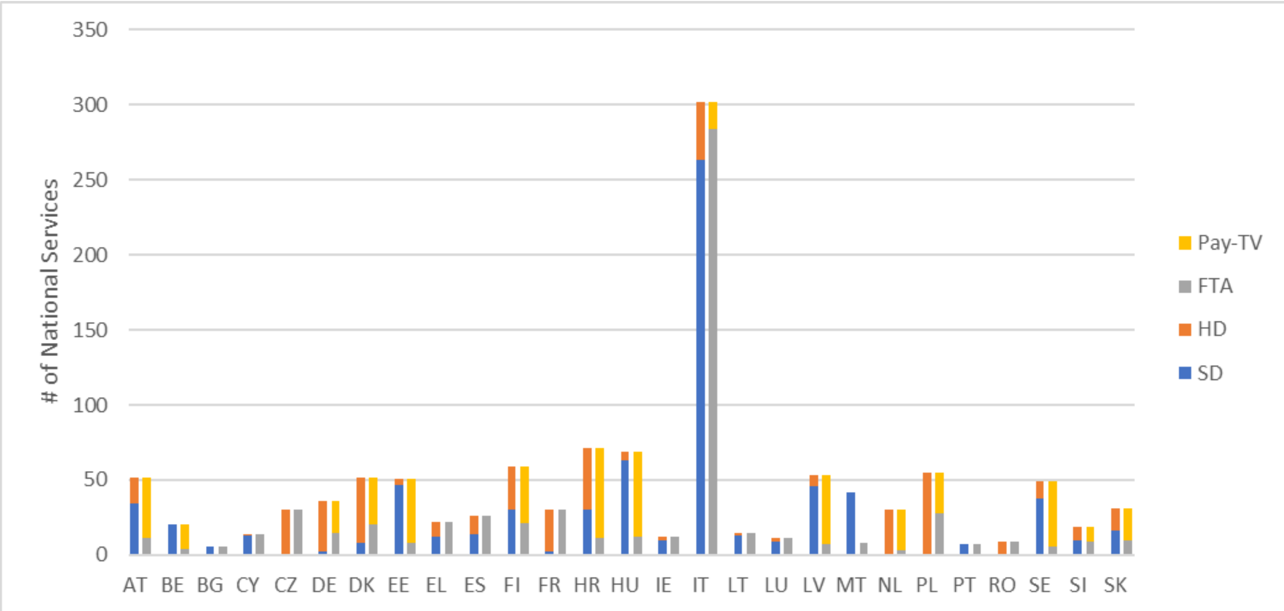


Figure 14 – Number of national services on Member States’ DTT platform, showing the split between HD and SD, and FTA (free-to-air) and Pay-TV.

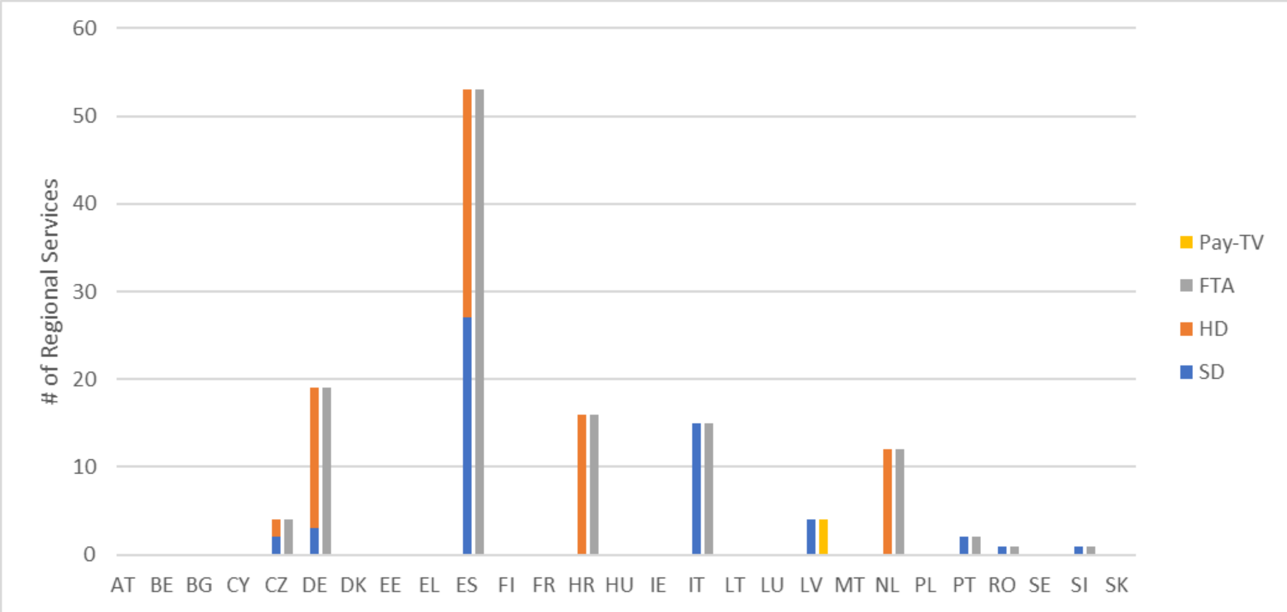


Figure 15 - Number of regional services on Member States' DTT platform, showing the split between HD and SD, and FTA and Pay-TV.

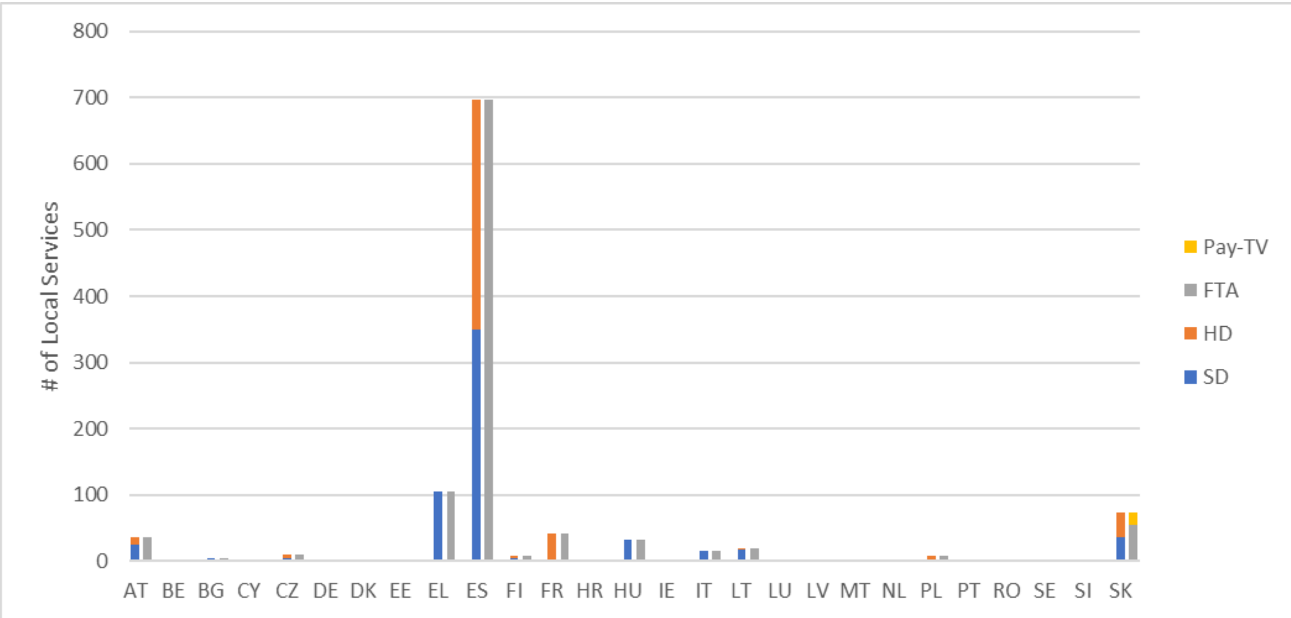


Figure 16 - Number of local services on Member States' DTT platform, showing the split between HD and SD, and FTA and Pay-TV.

	National				Regional				Local			
MS	SD	HD	FTA	Pay-TV	SD	HD	FTA	Pay-TV	SD	HD	FTA	Pay-TV
AT	34	18	11	41	0	0	0	0	25	12	37	0
BE	20	0	4	16	0	0	0	0	1	0	1	0
BG	6	0	6	0	0	0	0	0	5	0	5	0
CY	13	1	14	0	0	0	0	0	0	0	0	0
CZ	0	30	30	0	2	2	4	0	5	5	10	0
DK	8	44	20	32	0	0	0	0	0	0	0	0
DE	2	34	15	21	3	16	19	0	0	0	0	0
EE	47	4	8	43	0	0	0	0	0	0	0	0
EL	12	10	22	0	0	0	0	0	106	0	106	0
ES	14	12	26	0	27	26	53	0	350	347	697	0
FI	30	29	21	38	0	0	0	0	5	4	9	0
FR	2	28	30	0	0	0	0	0	2	40	42	0
HR	30	41	11	60	0	16	16	0	0	3	3	0
HU	63	6	12	57	0	0	0	0	32	0	32	0
IE	10	2	12	0	0	0	0	0	0	0	0	0
IT	263	39	284	18	15	0	15	0	15	0	15	0
LV	46	7	7	46	4	0	0	4	1	0	1	0
LT	13	2	15	0	0	0	0	0	18	2	20	0
LU	9	2	11	0	0	0	0	0	0	0	0	0
MT	42	0	8	34	0	0	0	0	0	0	0	0
NL	0	30	3	27	0	12	12	0	0	0	0	0
PL	0	55	28	27	0	0	0	0	0	8	8	0
PT	7	0	7	0	2	0	2	0	0	0	0	0
RO	0	9	9	0	1	0	1	0	0	0	0	0
SE	38	11	6	43	0	0	0	0	0	0	0	0
SI	10	9	9	10	1	0	1	0	2	0	2	0
SK	16	15	10	21	0	0	0	0	37	36	55	18

Table 10 - Number of services on Member States' DTT platform, showing the split between HD and SD, and FTA and Pay-TV.

Italy has the highest number of national services (~300), whilst Spain has the highest number of regional services (53) and the highest number of local services (>100). This is considered on a video resolution basis in Figure 17 and on an access arrangements basis, i.e. FTA or pay-TV, in Figure 18.

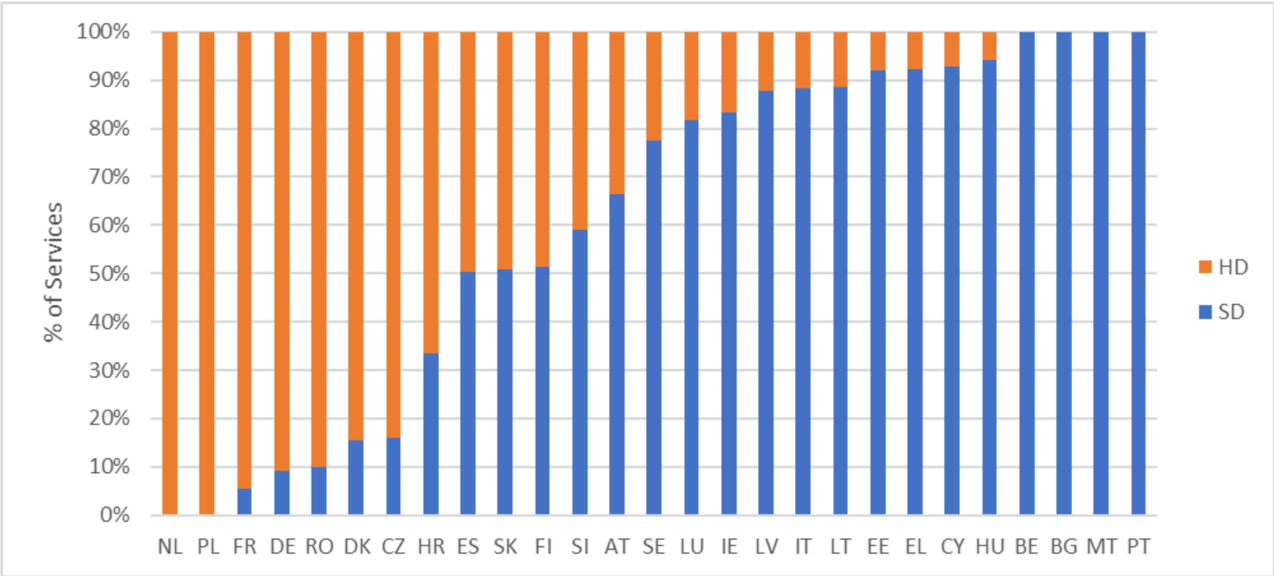


Figure 17 – Percentage of services available in SD and HD on Member States' DTT platforms.

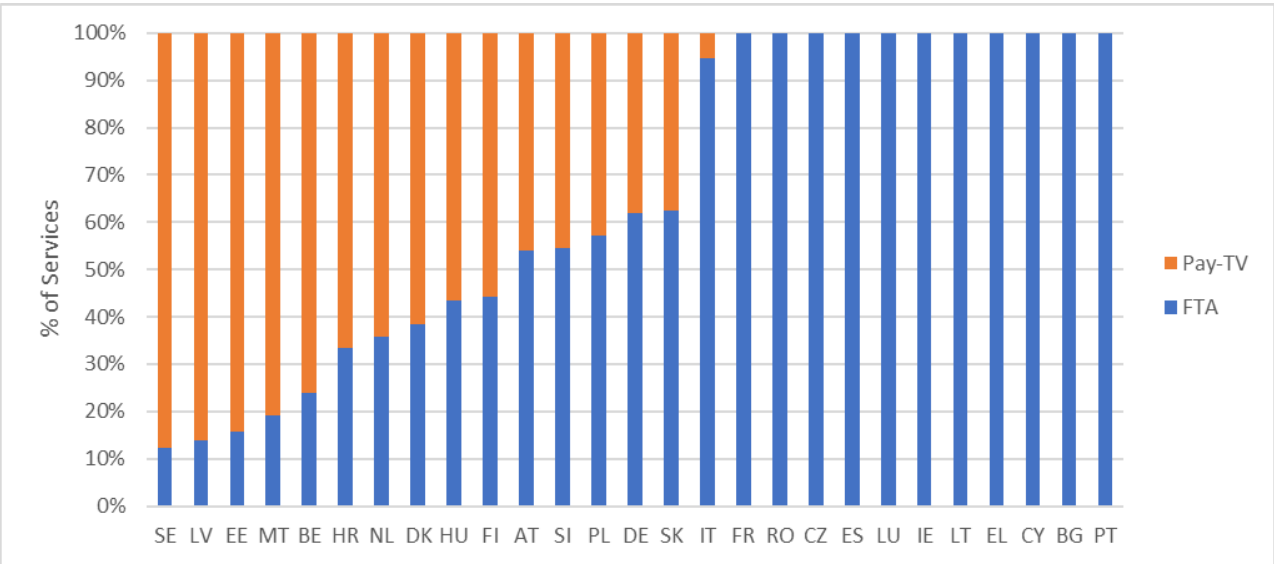


Figure 18 – Percentage of services available FTA and Pay-TV on Member States' DTT platforms.

Poland and The Netherlands are seen to have the highest proportions of services available on HD, with France, Germany, Romania, Denmark and Czech Republic also offering high proportions via HD (>80%). Belgium, Bulgaria, Malta and Portugal offer exclusively SD services, whilst Hungary, Cyprus, Greece and Estonia also offer large proportions of their services in SD (>90%). Bulgaria, Portugal, Cyprus, Greece, Lithuania, Ireland, Luxembourg, Spain, Czech Republic, Romania and France offer exclusively FTA content, whilst Latvia, Sweden, Estonia and Malta offer large amounts of Pay-TV content (>80%).

16 Member States provided information regarding the expiry date of their current DTT licences within the questionnaire response, and expiry dates for another 6 Member States were estimated based on

research of regulator websites, as shown in Figure 19. Note that in the case where multiplexes within a Member State have different expiry dates, the latest expiry date has been taken for simplicity.

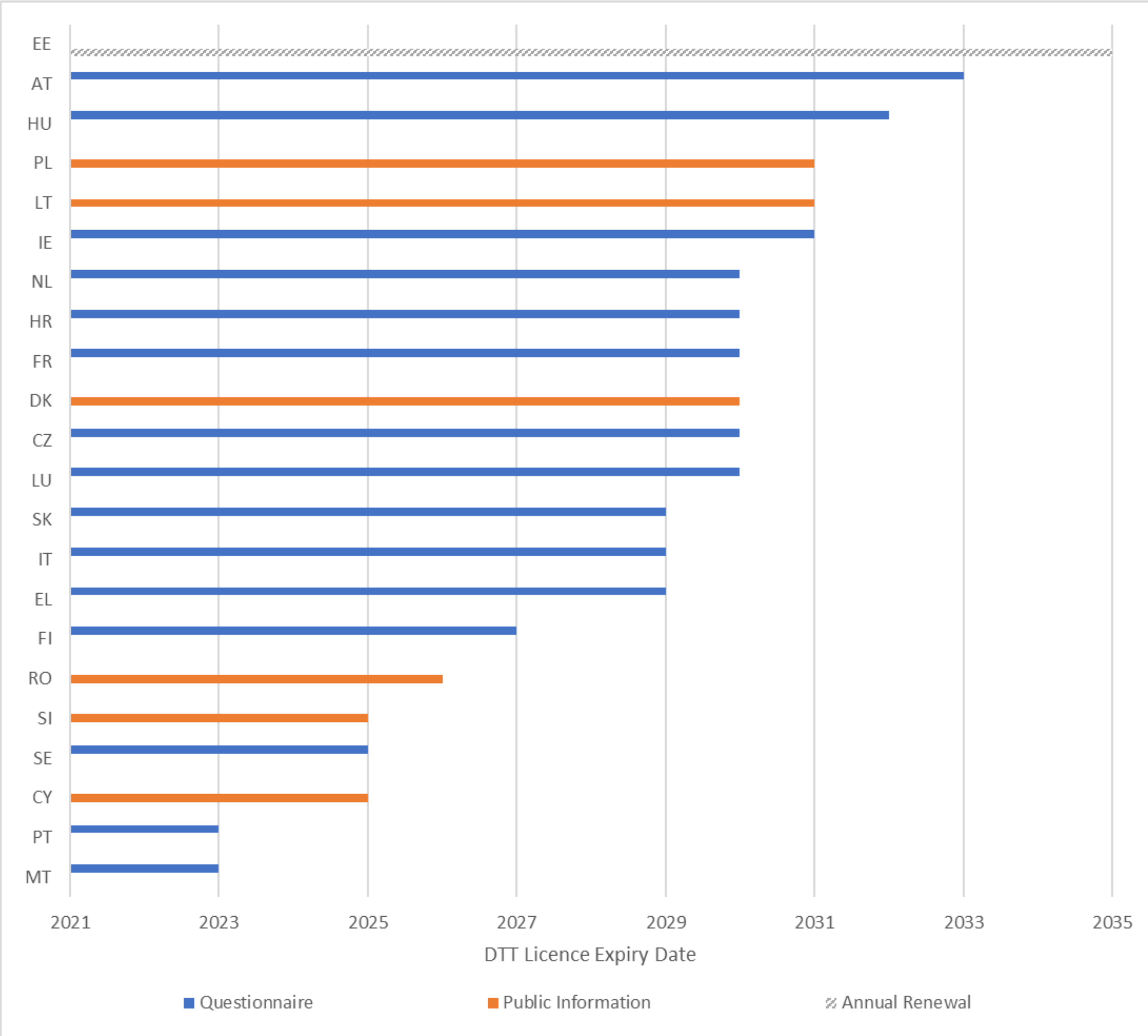


Figure 19 – DTT licence expiry dates in various EU Member States with information from questionnaire responses shown in blue, and information from research of regulator websites shown in orange.

Malta and Portugal have much shorter expiry dates (2023) when compared to other Member States. However, responses from MCA and ANACOM indicate that DTT usage in these Member States is low (0.8% and ~5% of households reliant on FTA DTT in Malta and Portugal respectively). For Malta, the commercial DTT operator is in the process of migrating away from the DTT platform to an IPTV platform and has not expressed interest in renewing the licence beyond February 2023. The DTT licence holder in Portugal has not yet indicated whether or not it will renew the licence beyond 2023.

For the other Member States that provided information regarding expiry dates:

- DTT licences in 3 Member State expire in 2025;
- DTT licences in 1 Member State expire in 2026;
- DTT licences in 1 Member State expire in 2027;
- DTT licences in 3 Member States expire in 2029;
- DTT licences in 6 Member States expire in 2030 (noting that France provided information regarding its law guaranteeing the band for DTT until 2030 rather than an explicit expiry date);
- DTT licences in 3 Member State expire in 2031;
- DTT licences in 1 Member State expire in 2032;
- DTT licences in 1 Member State expire in 2033; and
- DTT licences in 1 Member State are subject to annual renewal until cancelled (shown arbitrarily within the graphic as until 2035).

In summary, usage of the newer technologies is fairly high (~40% of represented national multiplexes are DVB-T and ~60% are DVB-T2, ~40% of represented national multiplexes use HEVC), but there are still developments that could be made. Expiry of current multiplexes is in most Member States around 2030 or beyond.

2.2.2 Possible Future Upgrade Path

Whilst a number of Member States are currently making use of the most up to date standards, there is still a fairly significant amount of development that could occur within the DTT platform. This section briefly considers the extent to which upgrades to newer standards may support a move to exclusively high definition content. In order to generate estimates for the potential capacity for upgrades, the representative data rates considered previously for the capacity available on a DVB-T/2 multiplex have been used, as well as the representative data rates required for an SD/HD service on MPEG2/4/HEVC.

However, the DVB standards allow for a much wider selection of transmission and encoding standards than the representative values assumed here. As such any Member State whose current service offering requires a greater level of capacity than the assumed values allow, for example through the use of lower quality video, statistical multiplexing or higher order modulation schemes, is assumed to be able to achieve a similarly improved performance under any upgraded standards. For example, a Member State carrying 6 HD services on a DVB-T2 multiplex using MPEG4 encoding achieves better performance than assumed in the representative values (6 services at 8Mbps totalling 48Mbps carried on a multiplex assumed to be capable of achieving just 40Mbps), and as such would be assumed to be able to achieve between 9 and 10 services when using HEVC, i.e. 1.2 times the number of services that may be expected using the representative values (8 services at 5Mbps).

On this basis, only 6 of the Member States would be estimated to be able to carry all unique, i.e. not simulcasted, national services in HD, assuming use of DVB-T2 and MPEG4. This increases to 18 Member States if HEVC is assumed to be used. As such, it is estimated that a significant portion of

Member States would be able to migrate to a fully HD service offering if the newest standards were adopted. Further, it may be that the more widespread use of SFNs, more widespread use of statistical multiplexing, or the use of higher order modulation schemes could help other Member States to deliver all services in HD also.

An alternative consideration is the extent to which the current number of services could be supported within a smaller amount of spectrum. The amount of available spectrum does not map exactly to the number of multiplexes that can be supported as a number of complex factors affect the effective spectral efficiency of DTT, not least that detailed analysis and clever replanning of a network could help to support a greater number of multiplexes in a given portion of spectrum. However, for this analysis, it will be assumed that the amount of spectrum directly relates to the number of multiplexes that can be supported, on the basis that detailed network replanning and modification would require significant capital expenditure and a potentially significant viewer support exercise.

As such, a reduction in spectrum of ~40%, as would be represented by removal of access to the 600MHz band, is assumed to reduce the number of multiplexes that can be supported by 40% as well. Even when rounding up the number of multiplexes that can be supported in all cases, i.e. 2.2 multiplexes is rounded to 3, just 10 of the Member States would be able to carry the same number of services as currently (even in the same SD/HD split as currently) using MPEG4, increasing to 13 of the Member States when considering HEVC (again maintaining the current SD/HD split). Of course, this represents an oversimplification, as it does not take into consideration how detailed network planning may mitigate the loss of spectrum as has occurred in, for example, the clearance of the 700MHz band. However, the high level analysis does show clearly that a loss of spectrum would mean, for a number of the Member States, a reduction in the number of services that could be carried, and likely a reduced ability to upgrade services to higher video resolutions, or other enhancements, in the future.

Note however that the high level approach to this analysis means that the conclusions considered here are only representative, and a detailed planning study would need to be conducted in order to determine more accurately the potential for upgrades.

2.2.3 Spectral Efficiency Estimates

The spectral efficiency of a given link is possible to calculate relatively straightforwardly. At a system level this is more difficult, particularly in the case of a system such as broadcast where all services are transmitted to all users but only one service is viewed by each user at a given time. This is further complicated by viewers only consuming content at certain times, but the content being transmitted regardless. In order to compare the usage of spectrum between Member States, this section estimates the spectral efficiency of the DTT platform in each Member State with the current state (including currently planned upgrades), and under a scenario where all multiplexes are moved to DVB-T2, HEVC and HD.

The estimates are based on the questionnaire responses, and produce a transmitted spectral efficiency, i.e. the bit rate transmitted across all national multiplexes in a given amount of spectrum, and a received spectral efficiency, i.e. taking into account the average viewing time per person (noting that values were not available for Luxembourg, Greece and Malta), the bitrate for an average national service in each Member State and again the spectrum used. In each case, all 224MHz of spectrum is assumed to be in use unless the questionnaire response explicitly stated otherwise. The same scaling approach as used in section 2.2.2 is used also. If the representative values assumed for capacity and bitrate do not allow for the 'upgraded' scenario, i.e. all services in HD, then the number of services is assumed to reduce such that it can be supported. An estimate of the received spectral efficiency (for national services) is shown in Figure 20, and an estimate of the transmitted spectral efficiency (for national services) is shown in Figure 21.

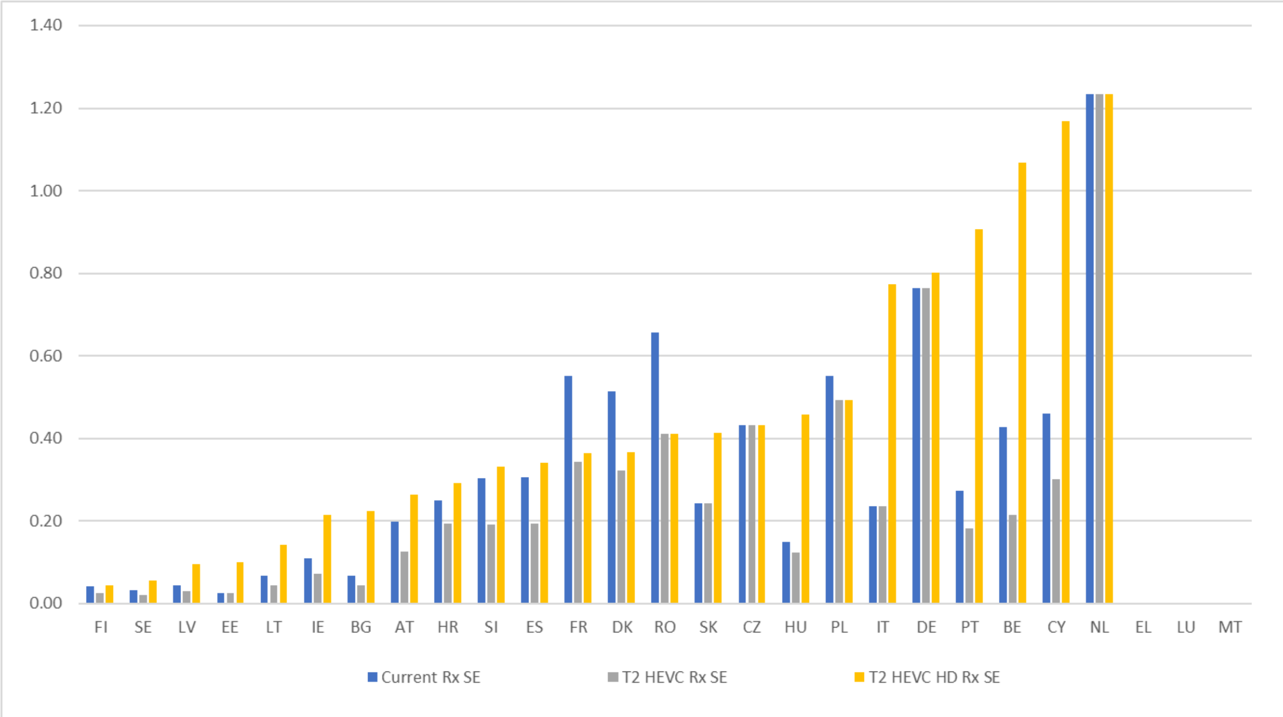


Figure 20 – Received spectral efficiency estimates.

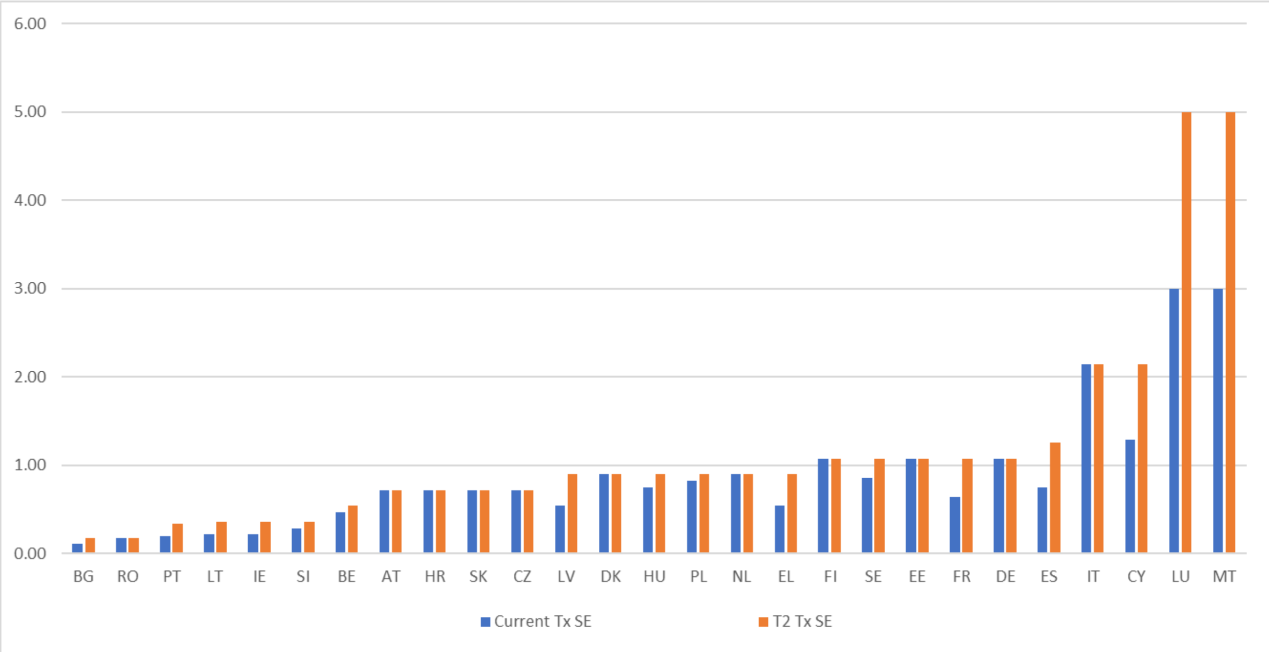


Figure 21 – Transmitted spectral efficiency estimates.

It is worth noting that a move to improved compression standards reduces the estimated received spectral efficiency. This is because the bit rate being transmitted is reduced. It can be seen that the estimated received spectral efficiency varies considerably across Member States, primarily because of differences in the amount of time spent watching television and the population density. Considering the transmitted spectral efficiency, this varies somewhat less as it is determined by the number of multiplexes, transmission standard and the amount of spectrum in use, noting that in most Member States this is assumed to be the full 224MHz. It is apparent in both cases, however, that upgrades to improved transmission, encoding and video resolution standards would be estimated to improve the spectral efficiency in a number of Member States, for example by a factor of 3.8 in the case of Estonia's received spectral efficiency (as most of its current services are transmitted in SD) and a factor of ~1.7 in the case of Member States moving from DVB-T to DVB-T2.

2.3 5G Broadcasting

Whilst the upgrades considered in the previous sections constitute improvements to the existing DVB standards, there are alternative standards in development that could supplement or indeed replace the role of DVB. One such development is that of 5G Broadcasting.

DTT broadcasting has traditionally targeted fixed reception, i.e. a dedicated aerial positioned so as to receive the highest quality signal, noting that some Member States do target other reception modes in their planning. Fixed reception is designed to enable efficient delivery of content to large television screens. Content consumption is found increasingly to be moving away from exclusively utilising television screens to a mixture of devices, for example large screens as well as smartphones, tablets and laptops, and in a mix of locations, both in and outside of the home. As such, the requirement for fixed reception potentially limits the capability of broadcasters to deliver content to some end users in locations and formats that work for them.

Targeting other reception modes, whilst possible, requires an ecosystem of devices capable of incorporating the necessary antennas and decoders. Some such devices do exist, for example portable televisions with built in tuners, phones containing built-in DVB tuners and accessories capable of decoding the signal that can be plugged into phones. However, these devices are by no means widespread. As such, many broadcasters have turned to fixed and mobile broadband as a means of delivering content to end users in a more flexible manner. Consumption of broadcast content via these methods has grown significantly in recent years but does come with its own set of challenges.

Content delivery over broadcast networks represents spectrally efficient distribution of content, as any given content is transmitted on a single channel within a geographical area. This contrasts with mobile broadband however, where the unicast system requires that the content to be delivered to each user be transmitted separately, regardless of whether two users are requesting the same content, as shown in Figure 22. On a network experiencing little congestion this may not be an issue, but with networks subject to increasing levels of data consumption, the high data requirements that video consumption brings may cause issues.

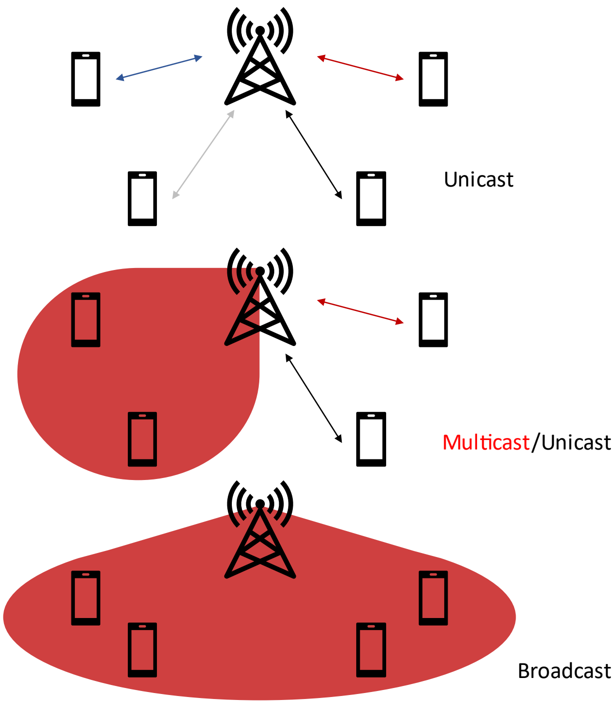


Figure 22 – Examples of unicast, multicast and broadcast transmissions within a mobile cell. For each, the same colour represents the same content, and a bidirectional arrow represents both uplink and downlink.

A potential solution offering both higher levels of spectral efficiency than unicast delivery of identical content and the possibility for broadcast content to reach new reception modes and devices is 5G Broadcast. 5G Broadcast offers the opportunity to deliver broadcast content over 5G (using either a broadcast or IMT network), as defined within the relevant 3GPP standards. Broadcasters have been heavily involved in the development of these standards, actively contributing individually and through bodies, such as the EBU, to ensure inclusion of characteristics suitable for broadcast. This section will investigate the characteristics of 5G Broadcast, how this solution compares to DTT, and the foreseen costs and challenges in deploying 5G Broadcast.

2.3.1 Characteristics

This section briefly investigates the characteristics of 5G Broadcast, and how these compare to DTT (in particular DVB-T2). Considering first propagation; as DTT and 5G Broadcast are generally envisaged to operate in the same frequency range, i.e. sub-700MHz UHF band, propagation of the two will be comparable with a number of notable differences.

DTT typically targets fixed rooftop reception and propagation is for the most part line of sight with relatively little clutter surrounding the receive antenna (generally 10m above ground level). 5G Broadcast targeting handheld portable reception (typically 1.5m above ground level) is instead subject to much higher levels of clutter surrounding the receiver. As a result, high levels of signal loss are likely for the 5G Broadcast case (32.5dB higher loss for portable outdoor than fixed rooftop (EBU, 2020)). In addition, mobile devices envisaged for reception of 5G Broadcast signals will also have lower antenna gains than fixed rooftop antennas. As a result, higher incoming signal levels are expected to be required for reception of 5G Broadcast on mobile devices than DVB-T/T2 on fixed rooftop antennas.

A recent trial in Austria (ORS, 2021) found that a similar capacity (~30Mbps for a single multiplex) was achievable using 5G Broadcast as DVB-T2 (for fixed reception), although required a 6dB greater SINR (signal to interference and noise ratio) for reception of 5G Broadcast. This is lower than is often achieved with DVB-T2 however (~40Mbps). Work by the EBU (EBU, 2021) finds that existing broadcast networks could provide a 25dB SINR in a 5MHz channel, sufficient to achieve greater than 15Mbps capacity. Note that EBU finds that a similar SINR (with 1.6dB) is required by fixed and portable reception, although assumes diversity reception in the portable case.

In any case, whilst promising performance may be attainable under certain circumstances, the trials and analysis to date have not reached the levels of capacity that can be achieved using fixed rooftop reception for DVB-T2. Taking the maximum levels observed, i.e. ~30Mbps, this represents a 25% reduction on the capacity of a representative DVB-T2 multiplex (40Mbps). Given an exact mapping of the DVB-T2 transmission network to 5G Broadcast, this could represent a 25% reduction in the available capacity on the platform.

Modelling analysis conducted by the EBU (EBU, 2021) finds that networks comprising just HPHT or MPMT sites are capable of delivering good fixed rooftop reception, but do not provide good mobile coverage in all environments. Conversely LPLT is capable of providing good mobile reception but requires a high site density. Instead, EBU finds that hybrid networks consisting of ‘umbrella’ coverage laid down by HPHT sites, supplemented by MPMT sites in some rural and suburban areas, and LPLT sites in urban areas, offer the best compromise between good mobile coverage and reasonable site density. As such, whilst coverage of 5G Broadcast to fixed reception could be assumed to be broadly similar to DVB-T2, coverage to mobile devices will be worse without additional site deployment.

In summary, early trials have found 5G Broadcast can deliver similar capacity and coverage to example DVB-T2 multiplexes for fixed rooftop reception, but these are still below the higher capacity levels that are achievable using DVB-T2. Reception on mobile devices is found to be possible, both on the basis of simulations and trials, but reception to these devices requires much higher signal levels (as much as 32.5dB in some analysis (EBU, 2020)), suggesting that in order to reach mobile devices, 5G Broadcast will require the deployment of additional sites, likely in the form of a hybrid network architecture, i.e. a mixture of HPHT, MPMT and LPLT sites.

2.3.2 Deployment Challenges and Costs

This section briefly considers the likely challenges and costs that might be associated with deployment of a 5G Broadcast network.

5G Broadcast, as defined in the current ETSI standard (ETSI, 2020), can operate on bandwidths of 1, 3, 4, 5, 10, 15 and 20MHz, with work ongoing in 3GPP to standardise use of 6, 7 and 8MHz bandwidths. No information is provided as to the envisaged frequency bands of operation, however many anticipate that 5G Broadcast would be deployed in current sub-700MHz UHF spectrum to facilitate reuse of existing broadcast transmission and domestic reception equipment. Due to the lack of standardised frequencies currently within the standard however, the technology could be deployed in other frequency bands.

Potential issues arise however with co-existence with other services in the band. If 5G Broadcast were to co-exist with existing DTT Broadcasting, EBU finds that use of 5MHz or 8MHz bandwidths would be required so as to align with the requirements of the Geneva 2006 Agreement (GE06), noting that use of an 8MHz channel would achieve higher capacity and spectral efficiency (EBU, 2021). In addition, spectrum usage would be limited to existing entries within GE06, else co-ordination may be required. Furthermore, user equipment would need to have suitable Radio Frequency (RF) characteristics for operation in the presence of high levels of DTT signals on adjacent spectrum.

EBU analysis (EBU, 2021) finds that existing broadcast networks may be insufficient to deliver the levels of coverage that would be required for good mobile reception of 5G Broadcast. Given the density of mobile networks this is perhaps not surprising, but would require that broadcasters either further develop their own networks (with an associated cost) or make arrangements with existing mobile network operators. This raises further questions as to the business models that will help to support 5G Broadcast. The traditional broadcast model has featured broadcasters either operating their own transmission networks or, as is the case in many Member States, paying dedicated network operators to manage the network on their behalf. If broadcasters are required to densify their existing networks, there is a question as to how economically viable this may be. With linear viewing found to be shrinking, the burden on broadcasters to finance additional network rollouts could be prohibitive. Similarly, any additional cost to finance mobile deployments may also be prohibitive.

A further requirement for any broadcast service is high levels of reliability and sustained operation during periods of power disruption. Broadcasters currently place strict service level agreements (SLA) on network operators to achieve these requirements. However, the application of such requirements to a greater number of sites likely further increases the burden to broadcasters and may limit the extent to which non broadcast specialised sites can be used.

There is work underway within 3GPP Release 17 to allow dynamic use of multicast/broadcast in existing small scale mobile network deployments, primarily over a single cell, with minimal infrastructure changes. Where broadcast targets all users in a cell, multicast would target a subset of them, as shown in Figure 22. The required mode is selected by the mobile network operator so as to achieve higher levels of spectral efficiency (EBU, 2020). This could potentially mitigate some of the issues explored previously. Network congestion arising from users consuming the same content multiple times could be lessened, and there would be limited requirement to deploy large amounts of additional network infrastructure.

However, a current issue that is seen with a multicast/broadcast mode is the lack of a receive only mode (ROM) (Shrivastava, et al., 2021), i.e. SIM free reception. It is expected that this will be addressed in future work, but currently use of this mode would not meet FTA requirements of broadcasters in all Member States. Similarly, the business models associated with delivery of content in this method are currently unclear. In any case, the dynamic use of multicast or broadcast within existing networks represents an option that, with future development, could offer a promising means of carrying live broadcast content over mobile networks in a more spectrally efficient manner.

The standard for 5G Broadcast does specify a requirement for devices to be capable of ROM. Whilst equipment vendors are showing interest in the development of 5G Broadcast capable equipment, as demonstrated both in the participation of these organisations in trials and published documents such as those from chip manufacturer Qualcomm (Qualcomm, 2021), it is unclear the extent to which such devices are available in the market. The average mobile phone replacement cycle is ~3 years (Phoenix Cellular, 2021), but this still requires widespread adoption of the technology by manufacturers and network operators. A further complication is delivering content through 5G Broadcast to televisions, for example for individuals who do not have a mobile phone. The typical TV replacement cycle is ~7 years (PRWEB, 2014), and as such even if TV manufacturers chose to integrate 5G Broadcast reception equipment into TVs, a distinct lag behind mobile devices would be expected.

Detailed analysis regarding the cost that might be associated with a 5G Broadcast network has not been published. Few studies consider relevant aspects to the field of 5G Broadcast or give much of an indication of the scale of the cost compared to current DTT networks. For example, an EBU study (EBU, 2014) considered the network density required to achieve a similar capacity with an LPLT LTE network for mobile or light indoor reception to the existing portable reception over an HPHT broadcast network within Germany.

A dense cellular network with a higher spectral efficiency than DVB-T2 would cost approximately 25-30x the current cost of the DTT offering within Germany, reducing to 7-8x the cost if a similar spectral efficiency to DVB-T2 was obtained. The exact cost was dependent on the proportion of new sites that would need to be constructed. It is worth noting however that as the DTT network considered within the study was designed to provide portable reception, i.e. a denser network than would be required for fixed rooftop reception, it can be assumed that in Member States targeting fixed reception, these costs could be somewhat lower. The study was based on older 3GPP standards, and as such may not represent the levels of spectral efficiency that can be achieved using more modern standards.

A further analysis by the EBU (EBU, 2019) compared estimated transmission and deployment costs for content distribution under a number of scenarios within a ‘normalised’ European country. The work considered the case where DTT continues as is, the case where content is carried exclusively over 5G mobile networks, and where content is shared between existing DTT infrastructure and 5G mobile networks, albeit with a majority share (75% of traffic) carried over DTT. The study considered only the total costs of each of the models, rather than apportionment of these costs, and as such it is difficult to extrapolate costs for any particular party. However, the study found that continuation of DTT as is would amount to ongoing annual costs of €0.28 per person, increasing to €7.32 per person for content shared over DTT and 5G, and €15.05 per person for content carried exclusively over 5G. The significant increase in costs amounts to the higher dimensioning required for 5G networks when carrying 100% of media traffic. The study assumes unicast delivery of content however, which makes its results less directly applicable to the current issue of 5G Broadcast.

In any case, the cost analyses that have been performed do at least provide some idea of the magnitude of any costs that may be associated with broadcast delivery over mobile networks. Development of an LTE network capable of broadcasting, even using existing retrofitted sites, is estimated to cost 7 to 25x the cost of a comparable DTT network. Carriage of traffic on 5G, albeit using unicast rather than multicast or broadcast, is estimated to cost between 26 and 53x the cost of existing DTT. Deployments using true broadcast or multicast, and the most recent standards, may achieve lower costs than explored here, however the range of values considered shows that further analysis of the issue is likely to be required. It can be expected that the experience and understanding that will be gained from ongoing 5G Broadcast trials may allow better estimates of the costs of the technology to be produced in future.

A study conducted by Rohde & Schwarz (Rohde & Schwarz, 2021) considered the effect on mobile network operator (MNO) capex and opex if certain amounts of traffic were offloaded to broadcast networks. The study assumes that broadcast network operators (BNO) will increase their capex spending on their existing broadcast networks by 15-20% in the coming years to upgrade to the newest technologies, i.e. adoption of 5G Broadcast/Multicast capable equipment. The study finds that if MNOs are able to offload 3 hours' worth of video content to the broadcast network, they would be able to reduce annual capex and opex by up to 20%. To finance the BNO investment, Rohde & Schwarz assumes that broadcasters are able to lease capacity 'slots' in a multicast as a service (MaaS) arrangement to MNOs, but also, for example, to various other services for example emergency services, VoD providers who wish to pre-load content to mobile devices overnight, and venues wishing to broadcast content to users' phones. The study assumes that BNOs would be able to increase revenues by ~15% per year by adopting this MaaS approach.

In summary, a key challenge facing the deployment of 5G Broadcast is the availability of reception equipment, in terms of the requirement for it to offer a ROM, be capable of reception with high field strength DTT signals in adjacent spectrum and the timescale it will take for such equipment to become widely available. Studies find that the cost to development a 5G Broadcast network are significant and, whilst some potential business models are beginning to emerge, the extent to which these would be feasible for broadcasters in all Member States is currently unclear.

2.3.3 Developments and Trials

2.3.3.1 5G Broadcast Trial in Vienna, Austria

The initial phase of this trial was conducted in 2020-2021, with the following partners contributing (5GMAG, 2021):

- Austrian PSM provider ORF;
- Network operator ORS;
- TV content provider Servus TV;
- Radio content provider KroneHit; and
- Vienna University of Technology (TU), Institute for Telecommunications.

The primary aim of the trial was to compare performance of LTE-based 5G terrestrial broadcasting (as per ETSI TS 103 720 (ETSI, 2020)) with the existing DVB-T2 system. The trial made use of frequencies in the sub-700MHz UHF band (734 – 744MHz and 662 – 672MHz, utilising bandwidths of 5, 6, 7, 8 or 10MHz). Existing broadcast sites were used (one HPHT using an ERP of 40kW and an antenna height of 118m, one MPMT using an ERP of 20kW and an antenna height of 42m) with an inter site distance of ~16km. Equipment was sourced from a number of vendors (primarily Rohde & Schwarz and Kathrein for the transmission and reception equipment), with measurements taken under stationary, mobile, and portable conditions. Modelling was conducted by TU, such that a number of channel conditions and modulation and coding schemes could be considered. These simulations were then compared to field measurements conducted by ORS (ORS, 2021).

A comparison of the high level reported results of the trial is shown in Table 11.

System	Net Data Rate (Mbps)	Net Data Rate per MHz (Mbps/MHz)	Minimum C/N or CINR (dB)
DVB-T2	27.7	3.5	18.1
5G BC MCS16	15.4	1.5	17.4
5G BC MCS26	30.7	3.1	24.1

Table 11 - Comparison of DVB-T2 and 5G Broadcast efficiency (data rate and min. C/N or CINR).

Source: ORS, 2021

The key findings of the trial were:

- 5G Broadcast enabled devices can successfully be used for portable reception (pedestrian, slow velocities up to 30km/h and inner-city traffic up to 110km/h) to extend the number of potential users for terrestrial broadcasting;
- 5G Broadcast HPHT networks can supplement existing DVB-T2 HPHT networks (for fixed and portable indoor reception) and can coexist with DVB-T2 in the sub-700MHz UHF band;
- 5G Broadcast could achieve comparable performance with DVB-T2 in the future, noting that the standards are still under development.

A second phase of the trial, planned to continue until 2023, will aim to investigate the ecosystems and business models that might be possible with 5G Broadcast, particularly looking at the convergence of broadcast and mobile networks. In addition, due to the perceived lack of available reception equipment, ORS is developing an open source 5G Broadcast reception platform as a reference platform for upcoming mobile devices.

2.3.3.2 5G MEDIA2GO, Germany

This trial sought to investigate the possibility for media content to be provided to users whilst driving. The trial began in October 2020, and is intended to continue until September 2022, with the following partners contributing (5GMAG, 2021):

- German regional PSM provider SWR;
- Equipment vendor Kathrein Broadcast GmbH;
- Network provider DFMG Deutsche Funkturm GmbH;
- Car manufacturer Dr. Ing. h.c. F. Porsche AG;
- Equipment vendor Rohde & Schwarz GmbH & Co. KG;
- Technische Universität Braunschweig – Institut für Nachrichtentechnik; and
- Mobile network operator Telekom Deutschland GmbH.

The key aims of the project are to investigate the suitability of 5G Broadcast for supplying content for mobile use in vehicles, integrating both linear and non-linear broadcast content on the vehicle's infotainment system, along with geo-referenced recommendations (SWR, 2020). The trial makes use of 2 HPHT transmitter sites (in Stuttgart and Heilbronn), along with 7 LPLT transmitter sites (cosited with mobile base stations), operating under SFN conditions. A 5MHz carrier within UHF channel 40 (622 – 630MHz) is used for the trial (5GMAG, 2021).

Mobile measurements will be undertaken by the campaign to determine the coverage of the network topology that is being investigated, as well as the suitability of the proposed system for delivering content for mobile reception. The project is ongoing: limited information has yet been published regarding the results.

2.3.3.3 5G Today, Germany

This trial aimed to develop the 5G Broadcast components needed for an end-to-end solution, whilst evaluating 5G Broadcast as a system (noting that the trial used the earlier standard FeMBMS), studying the performance of the 5G Broadcast signal for mobile reception in a number of reception locations. The trial took place between July 2017 and February 2020, with the following partners contributing (5GMAG, 2021):

- German regional PSM BR;
- IRT;
- Equipment vendor Kathrein Broadcast GmbH;

- Equipment vendor Rohde & Schwarz; and
- Mobile network operator Telefónica Germany.

The trial made use of BR's HPHT transmitters at Wendelstein and Ismaning (100kW ERP), and frequencies provided by Telefonica in the 700MHz band (channel 56, 750 – 758MHz). The two transmitters were operated as an SFN (5G TODAY, 2021), making use of a newly developed circularly polarised transmit antenna (IRT, 2019). The new antenna was found to provide improvements in received field strength by up to 2dB in some environments due to a diversification of the transmitted signal (Kathrein, 2019).

Coverage was predicted in both 2D and 3D with IRT's FRANSY software, using the recommendations within EBU TR034 (EBU, 2015), taking reflections into account for increased accuracy. Mobile measurements were taken of the test setup to verify the predictions, with a high level of accuracy achieved. A reasonable level of SFN gain was obtained also, even with differing physical cell identities (PCIs) assigned to the two test transmitters. The cell acquisition subframe (CAS), responsible for signalling and control, had a shorter cyclic prefix than the data signal (MBSFN). Whilst individually both signals had sufficient field strength to be detected across the entire measurement route, the SINR was in some cases too low for mobile reception, suggesting that a mismatch in cyclic prefixes could be responsible (IRT, 2019). 3GPP Release 16 has included support for longer cyclic prefixes for the CAS that have aided in this respect however.

2.3.3.4 5G Rural First, Orkney Islands, UK

This trial aimed to understand the practicalities of using 5G Broadcast, as well as gaining insight into audience behaviour and perceptions. It ran from May 2018 to September 2019, with the following participants contributing (5GMAG, 2021):

- UK PSM BBC;
- Infrastructure provider Cisco;
- Infrastructure provider CloudNet;
- Infrastructure provider Lime Microsystems;
- University of Strathclyde; and
- UK local authority Orkney Islands Council.

The trial involved providing residents of the remote islands with dedicated handsets to determine the extent to which they made use of the service, and gain insights into how BBC's existing streaming platforms could be modified to handle the service. The trial reports positive feedback from users, who are reported to have seen the benefit in gaining access to more services (BBC, 2019). Little detailed information about the trial has been published, however.

2.3.3.5 Trials for 5G Distribution, Spain

This trial aimed to test the performance of FeMBMS (Release 14) in a real environment, whilst also testing the delivery of information services. The trial took place between February and April 2020, with the following partners contributing (5GMAG, 2021):

- Spanish PSM provider RTVE;
- Broadcast network operator Cellnex; and
- Equipment vendor Rodhe & Schwarz.

The trial used frequencies within the 700MHz band (750 – 755MHz), and a transmitter site at Collserola Tower, with an ERP of 1.5kW. 4K content, both live and non-live, was broadcast over the network (IBC, 2020), although little detailed information about the results of the trial has been published.

2.3.3.6 Aosta Valley, Italy

The main goals of this project were to implement a standalone LTE eMBMS network (Release 14) deployed on terrestrial broadcast infrastructure, distributing live TV content to mobile devices. The following partners contributed:

- Italian PSM provider RAI;
- Technische Universität Braunschweig (TUB); and
- European Broadcasting Union (EBU).

The trial took place in August 2018, in the Aosta Valley in Italy. The trial made use of two HPHT transmitter sites in SFN mode, utilising UHF channel 53 (726 – 734MHz). The trial aimed to test reception of the eMBMS signal under varying levels of mobility (EBU, 2018). Little detailed information about the outcomes of the trial has been published.

2.4 **Possible EU Actions**

Having considered the developments within the DTT sector, this section now considers a number of possible future scenarios for the sub-700MHz band. Four potential regulatory scenarios were considered and circulated to Member States as part of the questionnaire:

- Continued use of the band for broadcasting and PMSE, with the opportunity to use non-broadcast services in the band if they are compatible with existing DTT (Scenario a);
- The introduction of a dedicated 600MHz mobile band (aligned with international developments such as have taken place in ITU Region 2), and hence another reduction in DTT and PMSE spectrum (Scenario b);
- Potential reduction in spectrum for current DTT and PMSE, with the introduction of an optional sub-band (e.g. 600 MHz) for shared mobile use with equal rights to broadcast, subject to co-ordination and compatibility, or for converged business models (Scenario c); and
- Conversion of the frequency range 470–694 MHz to joint mobile/broadcasting with equal rights (Scenario d).

15 of the Member States included assessments of the impact of these scenarios on the potential future development of IMT, PMSE and DTT. For brevity, the full responses of each of the Member States will not be reproduced here, but a summary of the main points is shown in Table 12. The

percentage of Member States that provided an impact assessment that identified certain key points within their response is shown in Figure 23.

A number of the Member States identified negative impacts of scenarios b, c and d:

- Economic impacts to DTT (33% under scenario b, 7% under scenario c and 13% under scenario d);
- Potential issues with frequency co-ordination (27% under scenario b, 60% under scenarios c and d); and
- A reduced ability to offer a wide array of programming, meet pluralist media requirements or FTA requirements (40% under scenario b, 13% under scenario c and 27% under scenario d).

A comparatively smaller number highlighted positive impacts of these scenarios:

- Flexibility (7% for scenarios c and d);
- Economies of scale for mobile network operators (7% for scenarios b and c); and
- Socio-economic benefit (7% for scenarios b, c and d).

It is important to note that negative impacts were also highlighted for scenario a, in the form of inefficient use of spectrum (13%) and constrained or limited development of IMT (20%).

However, the small number of responses limits the applicability of these conclusions more widely. Similarly, a number of the Member States noted that they had not yet considered the impacts of these scenarios yet as DTT licences in many cases do not expire for a number of years.

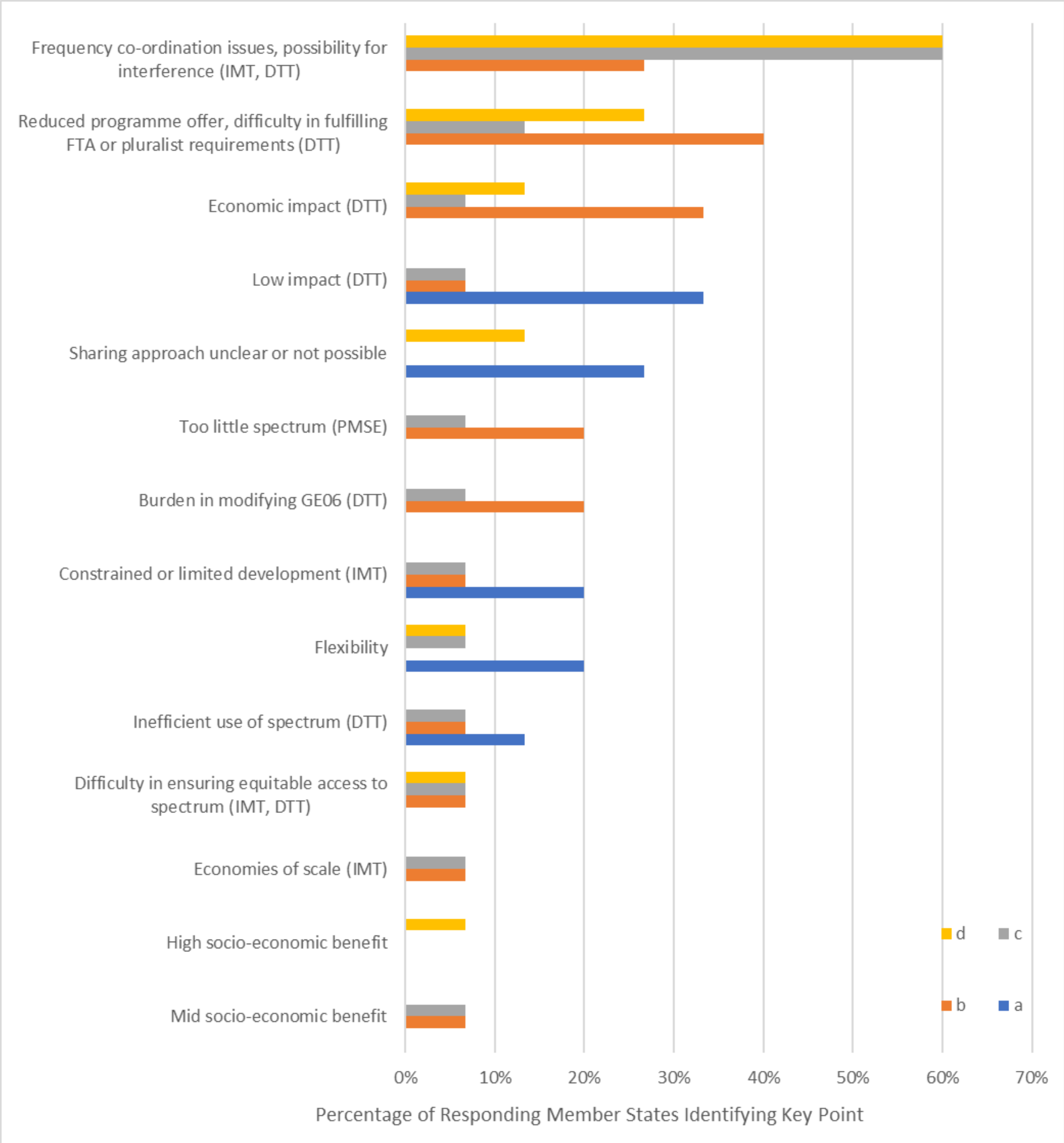


Figure 23 – Percentage of Member States identifying possible regulatory scenarios regarding the sub-700MHz UHF band.

MS	Scenario a	Scenario b	Scenario c	Scenario d
Austria	No major impact to DTT, but potentially limited benefit to IMT	Significant decrease in the number of programmes, major economic impact to DTT	Could support all different needs, co-ordination could be very difficult across Europe	Spectrum sharing methods and business models supporting this are still unclear
Belgium	N/A			
Bulgaria	N/A			
Croatia	Low impact to DTT	High impact, risks extinction of DTT	Low impact to DTT	High impact, risks extinction of DTT
Cyprus	N/A			
Czech Republic	N/A needs to be EU wide approach			
Denmark	N/A			
Estonia	If spectrum needs for DTT decrease, spectrum use will be inefficient	Needs should be balanced with IMT Insignificant addition on throughput of mobile networks		Development of DTT not harmonised across markets, so potential interference to DTT and potential restrictions on IMT
Finland	DTT cannot share with IMT, so parts of the band need to be cleared if there is such a need and spectrum available for mobile	Traficom expects IMT to need additional spectrum, but usage of 600MHz would heavily depend on usage in other countries	N/A	

MS	Scenario a	Scenario b	Scenario c	Scenario d
France	Unclear what non-broadcast services could share the spectrum	Significant restructure of DTT multiplexes, and a significant impact on ability to sustain a pluralist TV offer. Highly challenging scenario from democracy and pluralist point of view	Significant impact on ability to sustain a pluralist TV offer. Highly challenging scenario from democracy and pluralist point of view	
Germany	N/A			
Greece	Allows for retention of DTT services as required	This would require a transition to DVB-T2, but could potentially reduce the programming offer and introduce significant effort requirements to agree co-ordination with neighbouring countries	N/A	
Hungary	Unclear what non-broadcast services could share the spectrum, and potentially limited benefit to IMT	Frequency co-ordination issues, financial compensation and investment problems, loss of viewers, difficult to ensure equitable access to spectrum between neighbouring countries	Difficult to ensure equitable access to spectrum, long co-ordination procedure	
Ireland	N/A			

MS	Scenario a	Scenario b	Scenario c	Scenario d
Italy	Rights have been assigned to DTT operators for 10 years (starting in 2019). The state did not pay compensation to national operators for the reduction of multiplexes (a conventional conversion factor from DVB-T to DVB-T2 of 0.5 has been applied)	N/A		
Latvia	Flexible approach preserving possibility for DTT if required. Favourable with respect to co-ordination and application of radio regulations with respect to non-EU countries	No spectrum available for pay-DTT service and a major reduction in available PMSE spectrum that could not be made up elsewhere	Major co-ordination challenge, different scenarios compared to neighbours will introduce large co-ordination distances and a high possibility of interference situations	
Lithuania	DTT and SDL could potentially share the spectrum	There is the potential for broadcaster spectrum requirements to not be met, and there could be limited development opportunities for DTT. There could also be difficulties in ensuring harmonisation and sharing of the spectrum across the EU	Potential difficulties in sharing	Potential difficulties in sharing in many Member States, and potential difficulties in meeting the FTA PSM requirements

MS	Scenario a	Scenario b	Scenario c	Scenario d
Luxembourg	Unclear what non-broadcast services could share the spectrum	Administrative burden in modifying GE06, 3rd digital divided might not be an appropriate solution	Difficult to realise from a compatibility point of view	Difficult to realise from a compatibility point of view
Malta	No impact	Creates cross border coordination issues between MS and non-EU countries. Migration to sub-600MHz could be challenging for some MS, especially for those whose neighbours make heavy use of DTT or are outside of the EU		Availability of adequate spectrum or contiguous frequency blocks could be challenging due to cross border coordination
Netherlands	Possible inefficient use of band	Possible difficulty in fulfilling FTA obligation, possibly insufficient PMSE spectrum	Possible difficulty in fulfilling FTA obligation, possibly insufficient PMSE spectrum but IMT represents possibly a better usage of the band	Difficulty in achieving coexistence between IMT and DTT, possibly insufficient PMSE spectrum
Poland	N/A			
Portugal	N/A			
Romania	Low impact to DTT	DTT could be replanned with minimal impact, but PMSE usage would need to change significantly	Interference may be difficult to manage, and the flexibility of mobile operators to manage frequency assignments could be affected	Regulator ANCOM sees that dedicated bands would be more successful than a co-primary allocation
Slovakia	N/A			

MS	Scenario a	Scenario b	Scenario c	Scenario d
Slovenia	No socio-economic benefit, constrains the development of IMT	Mid-term socio-economic benefit, helping operators benefit from economies of scale, but introduces significant effort in modifying GE06		Greatest socio-economic benefit, allows most flexibility
Spain	Unlikely to occur given the high demand for DTT in Spain	Unlikely to occur given the high demand for DTT in Spain. Any changes would require significant network replanning and development	Possible difficulties in sharing	
Sweden	N/A			

Table 12 – Member States' main response points in considering four possible regulatory scenarios regarding the sub-700MHz UHF band.

More generally, the following considerations were raised for each of the scenarios.

- **Scenario a** represents the least amount of change for DTT, as it retains access to the spectrum for DTT if required, with the potential for usage by other services only in instances where coexistence can be managed or where the spectrum is not required for DTT. Of course, if usage of DTT is widespread this may preclude usage by other services in many areas due to the high separation distances often required for DTT-IMT coexistence. 4 Member States note that they are unclear as to which services could share the spectrum with DTT given its current usage, and 3 note that this could constrain or limit development of IMT going forward.
- **Scenario b**, the introduction of a dedicated mobile band in the 600MHz range, represents the scenario with Member States expecting the largest economic impact to DTT, presumably because a clearance of DTT from the new mobile band would be required under this scenario. 1 Member State notes the socio-economic benefit that the additional IMT spectrum would represent, and that a harmonised position across Europe would ensure economies of scale for mobile network operators. However, this would be countered by a reduced ability of DTT to meet FTA and pluralist requirements (6 Member States), as well as an administrative burden in modifying the GE06 agreement (3 Member States).
- **Scenario c**, the introduction of an optional mobile sub-band, represents an option with flexibility and the potential for socio-economic benefit, as noted by 1 Member State. However, having no single harmonised position potentially opens up co-ordination and interference issues (noted by 9 Member States). As with scenario a, the often large separation distances quoted for coexistence of DTT and IMT could potentially place significant limitations on the deployment of IMT technologies in Member States sharing borders with those still making significant use of DTT.
- **Scenario d**, the conversion of the full 470–694 MHz range to joint mobile/broadcasting with equal rights, is the scenario jointly most associated (9 Member States) with potential frequency co-ordination and interference issues, presumably for the same reason as scenario c but applying to the whole of the band rather than just a portion. 2 Member States also note a limited possibility for sharing, suggesting again the potential for IMT deployments being hindered in some areas due to the large separation distances required. 1 Member State notes that they believe this scenario would represent the greatest socio-economic benefit over the longer term however.

For each of these scenarios to be implemented, a number of steps would need to be taken. In the case of **Scenario a**, in the absence of a co-primary allocation of the 470-694MHz range to mobile in ITU Region 1 at WRC-23, an allocation by footnote would at least be required for those Member States wishing to use the spectrum for mobile services. In addition, the use of mobile services in some Member States would require international co-ordination and potentially amendments to GE06. In the case of **Scenario b**, a co-primary allocation to ITU Region 1 at WRC-23 would be required, as well as a European level regulatory decision enforcing the creation of a dedicated 600MHz band, as occurred with the 700MHz band. It is likely that this option would also require significant replanning of the remaining broadcast services, so as to ensure sufficient capacity remained to support the television platform as required. As a result, significant international co-ordination and amendments to GE06 would also likely be required.

In the case of **Scenario c**, either a co-primary allocation to mobile in ITU Region 1, or by footnote, at WRC-23 would be required. As with **Scenario b**, Member States wishing to take advantage of the optional sub-band would potentially need to conduct significant replanning of broadcast networks to facilitate clearing the spectrum. Similarly, as with **Scenario a**, the use of mobile services in some Member States would require international co-ordination and potentially amendments to GE06. In the case of **Scenario d**, a co-primary allocation to mobile in ITU Region 1 at WRC-23 would be required. As with **Scenario c**, significant international co-ordination and amendments to GE06 would be required in Member States wishing to take advantage of the co-primary allocation. For **Scenario d**, the extent of these efforts would likely be far greater than in **Scenario c** however.

In addition to providing an impact assessment of the regulatory scenarios, Member States were also asked to provide more information regarding the currently deployed mobile bands and whether demand for additional sub-1GHz spectrum had been identified. The number of Member States having deployed each of the 700, 800 and 900MHz bands is shown in Figure 24. It can be seen that all of the Member States have licensed the 900MHz band, all Member States except one have licensed the 800MHz band, and approximately 75% have licensed the 700MHz band.

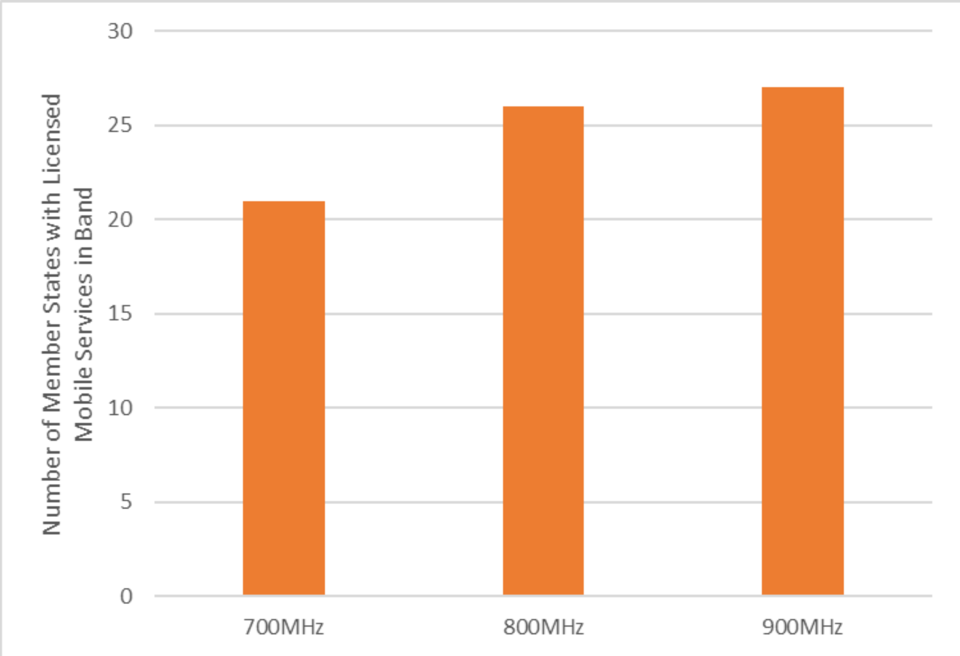


Figure 24 – Number of Member States that have licensed spectrum to mobile operators in the 700MHz, 800MHz and 900MHz bands.

The number of Member States who have identified demand for additional sub-1GHz mobile spectrum are shown in Figure 25. Whilst 2 Member States have identified demand and 4 Member States are aware that there may be potential demand, the majority of Member States (21) have either identified no additional demand or do not have enough information to comment. It is worth noting that in all Member States where additional demand has been identified (Czech Republic and Finland), the 700, 800 and 900MHz bands have all been licensed.

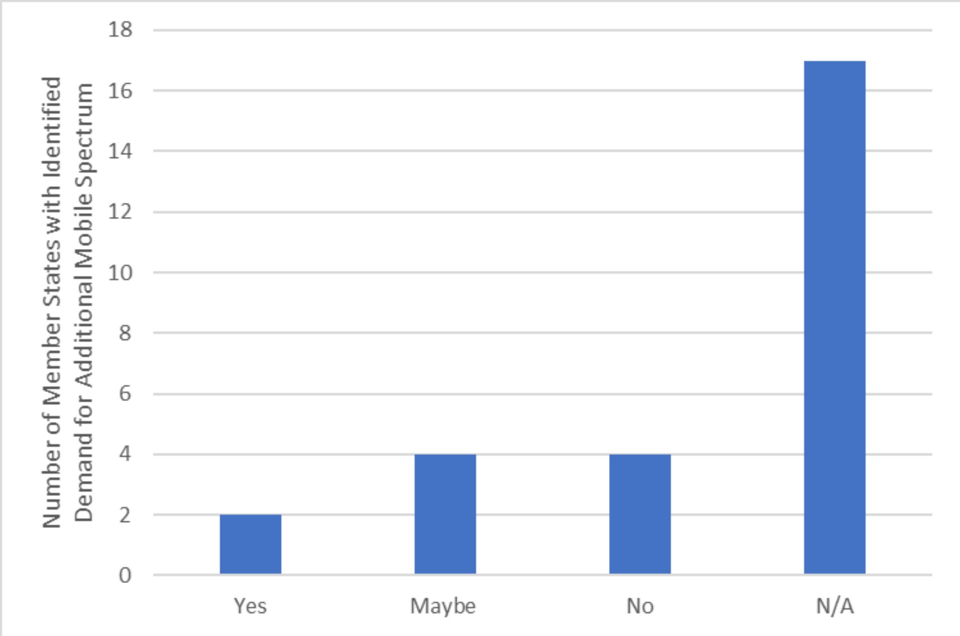


Figure 25 – Number of Member States that have identified demand for additional sub-1GHz mobile spectrum.

It is clear that across Member States, the views regarding each of these potential regulatory scenarios vary considerably. Some, typically those with higher DTT usage figures, appear to associate negative impacts more so with scenarios b, c and d, whilst those with lower DTT usage figures tend to associate more positive developments as a result of the increased spectrum for IMT. The differences in views also apply when considering the identified demand for additional mobile spectrum. A number of Member States have not yet considered the issue in great detail, focussing either currently on making spectrum available to mobile in other frequency ranges (for example the 5G pioneer bands), or instead preferring to see how DTT usage develops going forward and after any decisions made at WRC-23.

2.5 Summary

In summary, a number of technological developments in DTT, and a potential alternative in the form of 5G Broadcasting, have been investigated. DTT developments could potentially offer the same number of services in HD as SD (assuming a migration from DVB-T MPEG2 to DVB-T2 HEVC) or roughly one quarter the number of services in 4K as SD. Subsequent developments in HFR, HDR and WCG would allow fewer services to be carried. Across Member States, approximately ~60% of national multiplexes are using the most advanced transmission standards (DVB-T2) with ~40% of represented national multiplexes using the most advanced, widely available encoding standards (HEVC). As such, whilst there has been good progress in adopting the newer standards, there are still some improvements that can be made in a number of Member States. The same is true when considering the usage of SFNs, which can allow for up to 25% greater spectral efficiency than a multi frequency network. At least 12 of the Member States are already using SFNs to some extent in at least one layer within their DTT networks.

5G Broadcasting is seen to offer a potentially promising alternative to DTT, with early trials showing a similar capacity can be obtained over 5G Broadcast with a slightly more stringent reception threshold. However, what is unclear are the business models that could support 5G Broadcast, for example in how it is funded and who is responsible for the network. Similarly, the availability of equipment is currently minimal, although there is work ongoing in trials to encourage manufacturers to include support for the standard within devices.

Regarding Member State views on regulatory approaches to the band in the future, there is little consensus other than that significant changes to the band, as represented in scenarios b, c and d, are expected to require significant co-ordination effort. There are differing levels of agreement as to whether these changes are likely to cause significant impact to DTT (in the form of economic impacts and the platform’s ability to meet pluralist and FTA requirements) or generate significant socio-economic benefits through an increase of spectrum for IMT. The costs associated with any widespread upgrade of Member States’ DTT platforms are likely to be significant, and as such it may be that appetite to do so is limited without sufficient regulatory certainty regarding access to UHF spectrum.

The varied views from Member States are further highlighted when considering whether demand for additional sub-1GHz spectrum for mobile communications has been identified, and the extent of any such demand. The majority of Member States (21) do not have sufficient information to comment on the likelihood of additional sub-1GHz spectrum being required, potentially because the current focus for administrations is making the pioneer 5G spectrum bands (700 MHz, 3.6 GHz and 26 GHz) available to operators.

3 Consumer behaviour evolution

3.1 The European audiovisual market

The audio-visual (AV) sector plays a central role in European society. Its relevance has two dimensions: the economic, since film and television are large industries, and the social and cultural, since they are also common elements of everyday life (Crusafon, 2015). The audio-visual (AV) sector also makes an invaluable contribution to Europe's cultural diversity, unlocking its tremendous creative potential (Crusafon, 2015).

In 2020, the size of the European AV market amounted to slightly more than EUR 82,230 million (EAO, 2020). Revenues from audio-visual service providers (both linear and non-linear) accounted for ca. 70% of the total revenues (excluding public funding[25]).

Overall, from 2016 to 2020 in the European AV market there was a slight increase of about 1.9% in revenues. Of particular significance was the expansion of non-linear service providers in the period 2016-2020. On-demand service revenues experienced a compound annual growth rate (CAGR)[26] of about 38%.

	2016	2017	2018	2019	2020	2020/2019	CAGR (2020/2016)
Audiovisual services27	76,326	78,461	80,790	82,568	82,230	-0.4%	1.9%
Public funding28	20,955	21,040	21,165	21,418	21,559	0.7%	0.7%
Advertising TV	22,718	22,922	23,232	22,802	20,504	-10.1%	-2.5%
Advertising Radio	4,187.9	4,274.8	4,377.6	4,397.2	3,755.7	-14.6%	-2.7%
Pay-TV revenues	25,949	26,832	27,329	27,332	27,265	-0.2%	1.2%
On-demand revenues	2,516	3,391	4,687	6,619	9,146	38.2%	38.1%
Cinema gross box-office	5,536	5,565	5,323	5,769	1,790	-69.0%	-24.6%
Physical Video	2.393	2.048	1.736	1.492	1.138	-24%	-16,9%
Retail	2.170	1.889	1.628	1.416	1.103	-22,1%	-16%
Rental	223	159	108	76	35	-53,9%	-37%

[25] Adding public funding increases the share of audiovisual services to 96% of the total AV market.

[26] Compound annual growth rate, or CAGR, is the annual growth rate of an investment over a specified period of time longer than one year.

[27] As defined by the European Audiovisual Observatory (2020), the term "audiovisual" refers to all the media except the press: cinema, television, radio, video and the various on demand services (such as Video On Demand or Catch-up TV) are all sectors of the audiovisual industry.

[28] Public funding of the audiovisual sector mainly encompasses public financing of public service broadcasters, film funds and indirect production incentives.

	2016	2017	2018	2019	2020	2020/2019	CAGR (2020/2016)
TOTAL	84,255	86,074	87,850	89,828	85,158	-5.2%	0.3%
Growth		2.16%	2.06%	2.25%	-5.20%		

Table 13 - The audio-visual market in the EU (2016-2020), in mln €.

Source: European Audiovisual Observatory, 2021

3.2 Audiovisual consumption analysis

3.2.1 Linear TV consumption and trends

Television is one of the favourite ways of entertainment in Europe, reaching 85% of European citizens at least once a week. A TV set is present in nearly all (95%) European households. Linear TV broadcasting is the cornerstone of media consumption. However, data show that linear TV consumption looks much different compared to a few years ago. The average **overall** daily television viewing per person continues to decrease with a 216-minute daily average until 2019 a decline of 4% over five years (Figure 26). Nevertheless, the covid pandemic in 2020 is responsible for a spike in viewership which returned the EU27 average to the 2015 level.

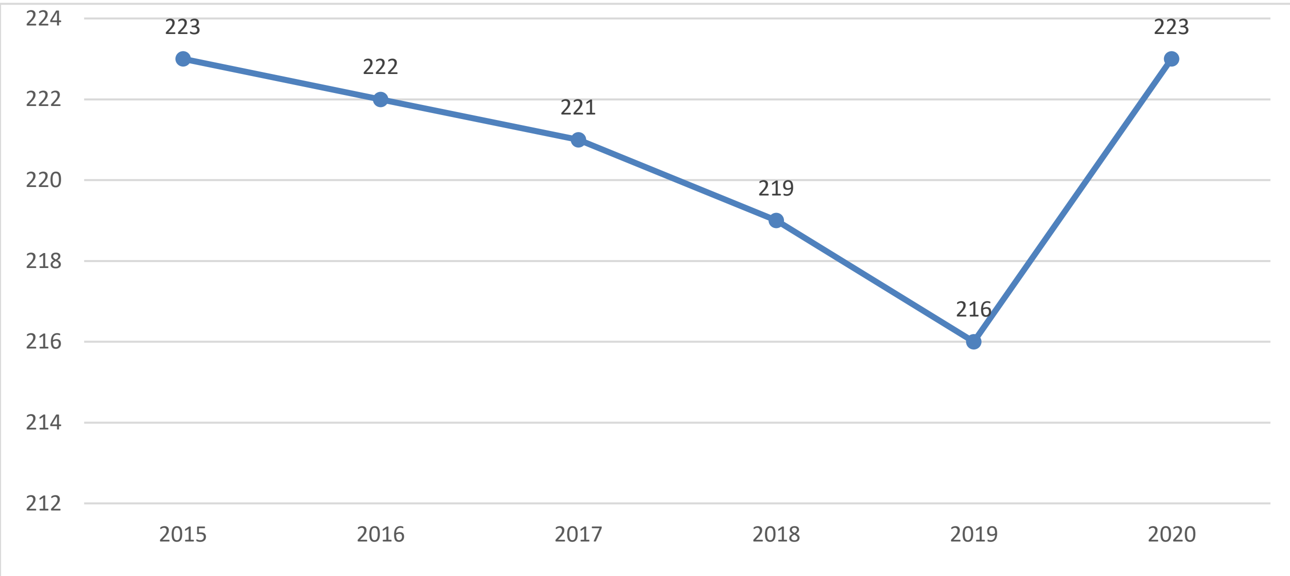


Figure 26 - Average time spent watching television daily in EU27 in 2015-2020 (in minutes).

Source: European Audiovisual Observatory, 2021

According to video market intelligence company Glance data based on television viewers in over 90 countries around the world, in 2020, an average of 2 hours 54 minutes per day was spent watching television (6 minutes more compared to 2019). This increase in TV consumption was also recorded for younger audiences, whereby young adults viewing time equalled an average of 1 hour 49 minutes a day (increased by 2 minutes) (Informitv, 2021) Based on the same source, in Europe, average viewing time grew by 15 minutes a day. The figure below provides comparison regarding the TV-AUD average television viewing per person in 2020 across certain countries and regions of the world, namely Island, Switzerland, China, Norway, Japan, UK, USA, Middle East and North Africa.

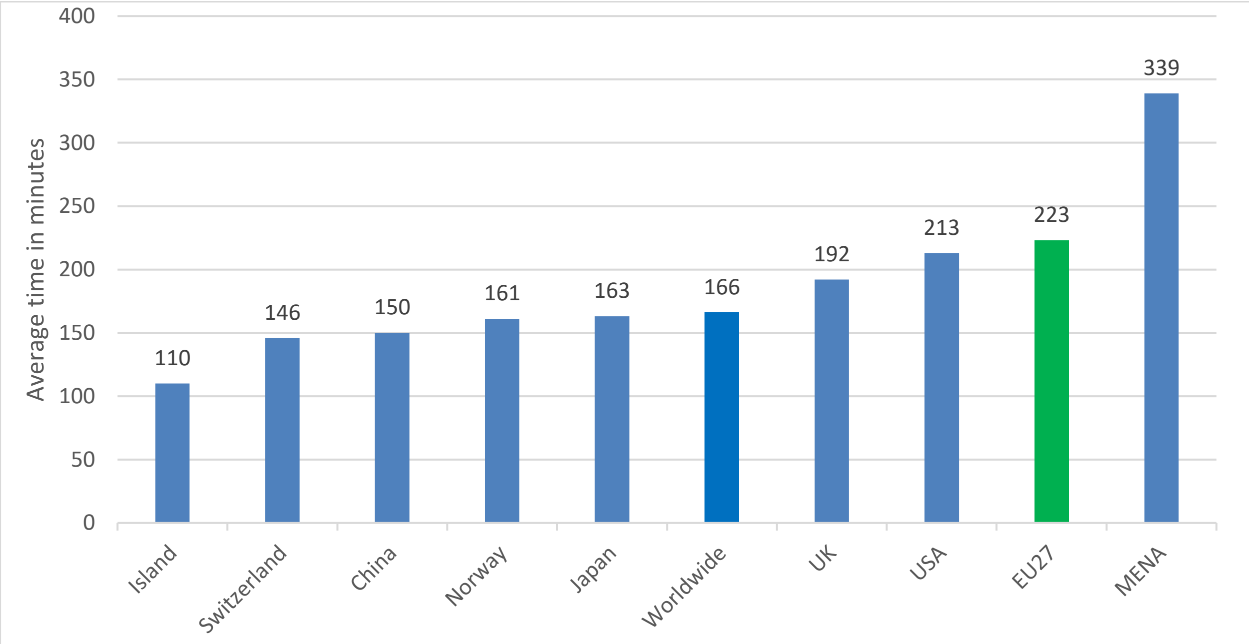


Figure 27 - Average time spent watching television daily in different regions of the world in 2020 (in minutes).

Source: European Audiovisual Observatory, Statista, 2021

As shown in the figure above, the EU27 registered a higher TV consumption average compared to the worldwide average, and also compared to certain countries and regions of the world. The pandemic on the one hand increased viewership due to interest in news coverage and at the same time introduced restrictions in terms of live sport and programme production. The same source estimates that global non-linear television viewing remained stable (average of 17 minutes a day) with highest figure in North America (26 minutes) and lowest average in Europe (13 minutes).

Focusing specifically on the impact of lockdowns on linear viewership, based on Omdia's analysis of cross-platform viewing time in France, Germany, Italy, Spain and the Netherlands, the share of linear TV watching increased across all Member States, albeit to a different extent. The most significant increase is evident in Italy (over 250 minutes and approximately 70% of overall viewing time across linear, online long-form, PVR time-shifted[29], Online short-form Social media and Pay TV VOD) (Informitv, 2021).

In the Nordic Member States, where the subscription video on demand (SVOD) market is booming (see section 3.2.2.1), people generally watched less TV than elsewhere in Europe and viewing figures

[29] Recording and storing information for later viewing, listening, or reading is known as timeshifting. Timeshifting in television can be accomplished with a personal video recorder (PVR) or a computer equipped with a TV tuner card.

there decreased faster than in other countries: Denmark, Finland and Sweden, which have already below-EU-average television consumption, have lost a further 22%, 18% and 5% respectively over five years (EAO, 2020).

The opposite trend is seen for Croatia, Greece, Hungary, Portugal and Romania, which in 2020 are placed at the top quartile for time spent watching television. In particular, Romania has always been the Member States top-ranking for average TV viewing in the EU in the period 2015-2020.

Member State	2015	2016	2017	2018	2019	2020
AT	**160**	167	175	179	183	160
BE	183	183	180	171	170	182
BE (CFB)	*194*	*199*	*195*	*183*	*179*	194
BE (VLG)	*174*	*172*	*171*	*164*	*163*	174
BG	231	235	252	254	251	231
CY	204	204	209	209	210	204
CZ	206	208	211	210	206	206
DE	222	223	221	217	210	222
DK	175	**160**	**150**	**142**	**137**	175
EE	222	225	243	229	225	222
ES	234	229	225	233	222	234
FI	171	171	168	165	162	171
FR	224	223	222	216	210	224
GR	269	257	261	266	**272**	269
HR	265	265	260	260	**268**	265
HU	**283**	**278**	**279**	**276**	**278**	283
IE	194	186	175	167	**157**	194
IT	254	247	243	248	244	254
LT	214	225	236	224	215	214
LV	211	194	177	176	177	211
NL	189	183	178	173	156	189
PL	263	261	259	257	256	263
PT	**283**	**286**	**284**	**283**	264	283
RO	**329**	**347**	**346**	**337**	**329**	**329**
SE	**153**	**148**	**140**	**133**	**127**	**153**
SI	205	215	215	218	227	205

Member State	2015	2016	2017	2018	2019	2020
SK	238	237	237	237	238	238
Avg. EU27	223	222	221	219	216	223
Avg. (EU27+UK)	223	222	221	218	214	223

Table 14 - Average time spent watching television daily in EU Member States in 2015-2020 (in minutes), breakdown by Member State. The Highest averages registered are outlined in the colour Red and the lowest in Green.

Source: Glance, 2021

The figure below provides data on cross-platform viewing time by country for the years 2019 and 2020 for some selected Member States and the US and Australia.

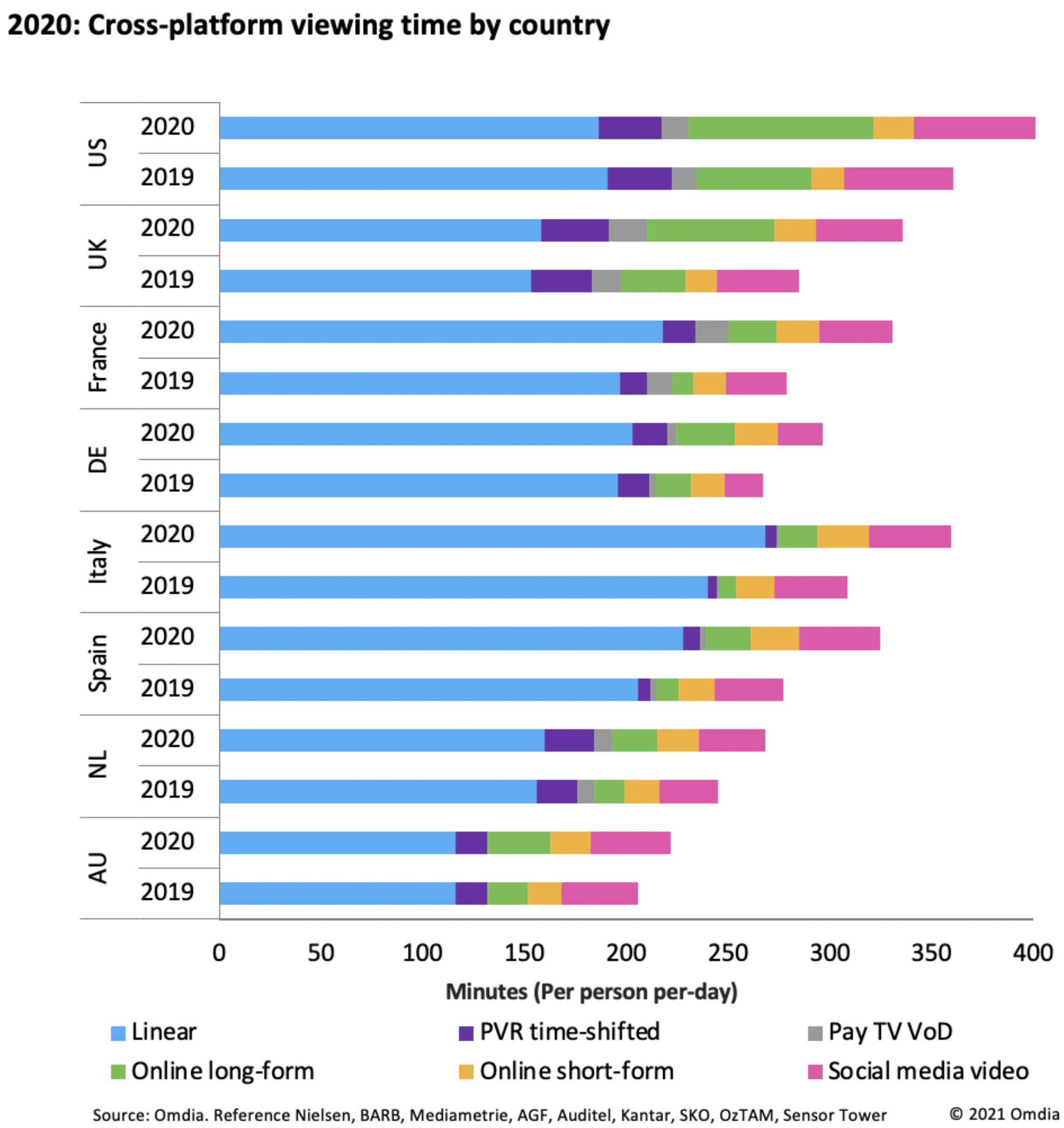


Figure 28 - Cross-platform viewing time by country.

Source: Omdia

The average time spent in front of TV screens also varies by age groups. As data from Germany, the Netherlands, Denmark, Italy, Poland and Hungary[30] display, the TV viewership is within the purview of older generations. While averages across age groups vary significantly in most countries, this is less obvious in Italy. In fact, viewers ages 60 and up, indeed, spend more minutes on average

[30] Jointly the six countries represent 48% of the EU27 population.

watching TV than their younger peers. This may suggest that the **linear TV industry is holding onto this demographic a lot more successfully than younger Europeans**.

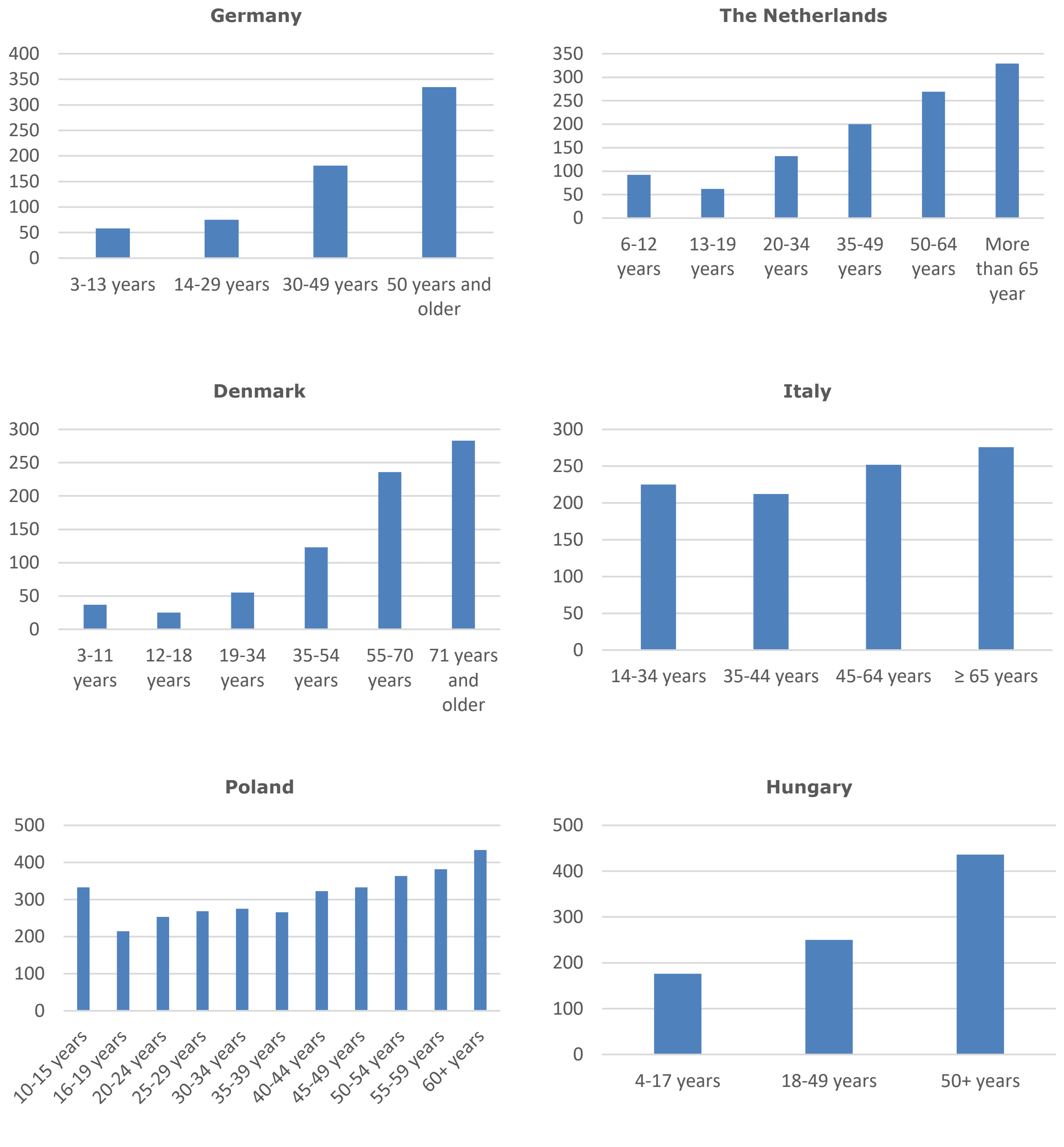


Figure 29 - Daily television viewing time (in minutes) in Denmark, Germany, Hungary, Poland and the Netherlands in 2020 and in Italy in 2018, by age group.

Source: AGF; GfK (DE), Stichting Kijkonderzoek; Screenforce (NL), Kantar Gallup; Slots- og Kulturstyrelsen (DK), AGCOM (IT), spidersweb.pl; Krajowa Rada Radiofonii i Telewizji; Nielsen (PL), Nielsen; Márkamonitor (HU)

Another general trend encompassing linear TV is that there has been a **general decrease in the concentration of the European audience market** due to a continued loss of share by market leaders over time. Over a five-year period from 2016 to 2020, average audience market shares of the four leading TV channels in Europe's national markets contracted by -4.6% in the EU as a whole (EAO, 2021).

There are major differences among Member States:

- Cyprus and Poland displaying a sharp decrease, -23.2% and -19.9%, respectively;
- Denmark, Ireland and Sweden show an increase in the concentration level, 9.5%, 11.6% and 7.1% respectively.

Member State	2016	2017	2018	2019	2020	Variation 2020/2019	CAGR 2020/2016
AT	41.2	39.4	37.7	36.6	37.7	*3.0%*	*-8,5%*
BE (CFB)	57.6	56.8	56.4	56.2	58.4	*3.9%*	*1,4%*
BE (VLG)	65.3	62.5	62.7	62.0	63.0	*1.6%*	*-3,5%*
BG	64.4	55.5	55.2	54.6	53.4	*-2.2%*	*-17,1%*
CY	59.1	54.4	49.0	46.5	45.4	***-2.4%***	***-23,2%***
CZ	53.9	53.5	51.2	52.4	52.4	*0.0%*	*-2,8%*
DE	46.9	46.3	46.4	46.0	46.7	*1.5%*	*-0,4%*
DK	59.0	56.9	58.3	59.2	64.6	***9.1%***	*9,5%*
EE	46.5	42.7	43.4	41.8	42.0	*0.5%*	*-9,7%*
ES	44.4	42.8	43.4	42.6	42.4	*-0.5%*	*-4,5%*
FI	66.4	66.4	65.9	64.8	65.1	*0.5%*	*-2,0%*
FR	53.1	51.6	52.2	51.6	51.7	*0.2%*	*-2,6%*
GR	51.8	55.8	56.2	57.5	53.0	*-7.8%*	*2,3%*
HR	59.6	59.7	59.3	57.0	55.2	*-3.2%*	*-7,4%*
HU	32.8	28.4	26.9	26.8	26.7	*-0.4%*	*-18,6%*
IE	36.3	38.8	40.0	39.8	40.5	***1.8%***	*11,6%*
IT	45.3	44.7	44.7	44.1	43.4	*-1.6%*	*-4,2%*
LT	44.1	46.5	47.4	48.6	46.5	*-4.3%*	*5,4%*
LV	40.2	37.2	33.9	33.9	35.2	*3.8%*	*-12,4%*
MT	63.1	60.0	55.0	63.6	61.3	*-3.6%*	*-2,9%*
NL	50.3	48.5	46.4	49.5	52.9	*6.9%*	*5,2%*
PL	41.3	38.3	37.5	36.4	33.1	***-9.1%***	***-19,9%***

Member State	2016	2017	2018	2019	2020	Variation 2020/2019	CAGR 2020/2016
PT	55.0	52.9	52.2	51.4	49.1	*-4.5%*	*-10,7%*
RO	43.3	41.8	42.9	44.7	45.9	*2.7%*	*6,0%*
SE	57.7	58.4	60.5	60.6	61.8	***2.0%***	*7,1%*
SI	46.5	45.2	44.5	42.8	42.2	*-1.4%*	*-9,2%*
SK	50.2	48.9	47.7	47.7	44.8	*-6.1%*	*-10,8%*
EUR 26 (Avg)[31]	*50.5*	*49.0*	*48.4*	*48.4*	*48.2*	*-0.5%*	*-4,6%*

Table 15 - TV daily audience market shares of the four leading TV channels and TV groups (2016-2020).

Source: European Audiovisual Observatory, 2021

Similarly, the weight of public service broadcasting (PSB) groups in national audience markets is also in decline. The PSB refers to programs on television and radio that are aired to provide information, advice, or entertainment to the public without trying to make a profit.

PSB groups benefited from the positive viewing patterns in national audience markets. The average audience market share of European[32] PSBs increased by 4% in 2020 compared to 2019. One of the explanations causing this increase is likely to be the increased demand for news since the pandemic began. Several PSB figure among the top 50 audiovisual companies worldwide[33] and many more among the top 100 audiovisual companies operating in Europe. However, the resources of the private sector competition are bigger than those of the PSBs. Although PSBs made up nearly half of the top 100 European television and radio networks, their revenue share was just 35% in 2020[34]. Moreover, the six PSBs included in the top 50 audiovisual companies list only represented 5% of total revenues.

From 2015 to 2020, the average audience market share of European PSBs contracted by 2%. Also in this case, there are major differences among Member States:

- In Denmark, Lithuania and the Netherlands, the weight of public service broadcasting increased by 14%, 46% and 16%, respectively;
- In Spain, Bulgaria, Cyprus and Hungary, the weight of public service broadcasting decrease ranged from -29% to -36%.

[31] Dataset missing for Luxembourg

[32] Includes the EU27 (without Luxembourg and Malta), Armenia, Bosnia and Herzegovina, Switzerland, Georgia, Iceland, North Macedonia, Norway, Turkey and the United Kingdom.

[33] Yearbook 2021; table PLAY-GLOB - The worldwide 50 leading audiovisual companies by audiovisual turnover

[34] Yearbook 2021; table PLAY-EU - The 100 leading European television and radio groups.

Member State	2015	2016	2017	2018	2019	2020
AT (1)	34.1%	34.4%	32.9%	31.9%	30.5%	31.8%
BE (CFB) (2)	21.9%	24.3%	23.2%	24.8%	24.7%	26.6%
BE (VLG)	**36.7%**	**39.3%**	**37.1%**	**38.7%**	**38.0%**	**37.5%**
BG	**8.1%**	**9.5%**	**5.5%**	**6.7%**	**5.8%**	**5.5%**
CY	16.9%	17.1%	**12.6%**	**13.3%**	**12.9%**	**12.0%**
CZ (1)	30.4%	31.2%	29.4%	30.2%	30.1%	30.1%
DE (1) (4)	**43.9%**	**45.1%**	**46.4%**	**47.8%**	**47.3%**	**48.4%**
DK (1)	**69.9%**	**74.4%**	**74.6%**	**76.0%**	**76.4%**	**79.9%**
EE	18.2%	16.8%	16.4%	19.2%	20.4%	23.1%
ES (1) (4)	23.8%	23.9%	24.0%	23.7%	15.5%	15.3%
FI	**43.0%**	**44.8%**	**43.3%**	**43.7%**	**43.5%**	**43.1%**
FR (3)	30.8%	30.9%	30.6%	31.3%	31.8%	32.0%
GR	**7.7%**	**8.6%**	**7.9%**	**9.1%**	**8.7%**	**8.9%**
HR	28.4%	29.2%	27.4%	28.1%	27.1%	n.a.
HU	**14.9%**	17.1%	15.1%	**12.7%**	**10.8%**	**9.8%**
IE	26.6%	28.4%	27.9%	27.4%	27.2%	28.8
IT	**37.2%**	**36.8%**	**36.7%**	**36.2%**	**35.8%**	**35.5%**
LT	**10.3%**	**9.8%**	**10.7%**	**12.6%**	**14.9%**	**15.0%**
LV	**12.4%**	**13.0%**	**12.3%**	**12.4%**	**12.5%**	**13.1%**
NL (4)	30.6%	32.1%	31.6%	32.0%	34.5%	35.5
PL (1)	29.4%	29.6%	28.0%	28.3%	28.6%	28.4
PT	18.1%	16.9%	15.2%	**14.6%**	**14.8%**	**14.0%**
RO	**4.7%**	**3.5%**	**3.6%**	**4.1%**	**3.5%**	**3.6%**
SE (2)	**35.9%**	**36.1%**	**37.0%**	34.9%	**35.7%**	**34.7%**
SI (4)	21.7%	22.3%	22.4%	21.9%	20.2%	20.8%
SK	**12.7%**	**13.8%**	**13.9%**	**14.0%**	**13.9%**	**13.1%**

Table 16 - Daily audience market share of public television in EU Member States in 2015-2020, breakdown by Member State.

(1) Includes complementary thematic public channels (TV2 channels counted as public in Denmark).

(2) TV5 Europe not included.

(3) Complementary thematic public channels not included.

(4) Includes regional public channels.

Data for LU and MT are not available. Market shares of foreign public channels not included. Highest percentages are outlined in Green and the lowest in Red.

Source: European Audiovisual Observatory, 2021

The figure below shows a public opinion survey in the EU (Eurobarometer 94)[35] regarding the level of trust in television in the EU Member States conducted in 2021. During the survey period, it was found that Europeans considered television to be a relatively reliable medium, with levels of trust ranging from 25% in Greece to 84% in Denmark. The average share of Europeans who tended to trust in television was 51%, a two per cent increase compared to 2019. By comparing the Figure below with Table 16, it is possible to notice a positive correlation between the two variables (correlation level of 0.58), indicating a possible positive relation between trust in media and weight of public service broadcasting (PSB) groups in national audience.

[35] https://europa.eu/eurobarometer/surveys/detail/2355

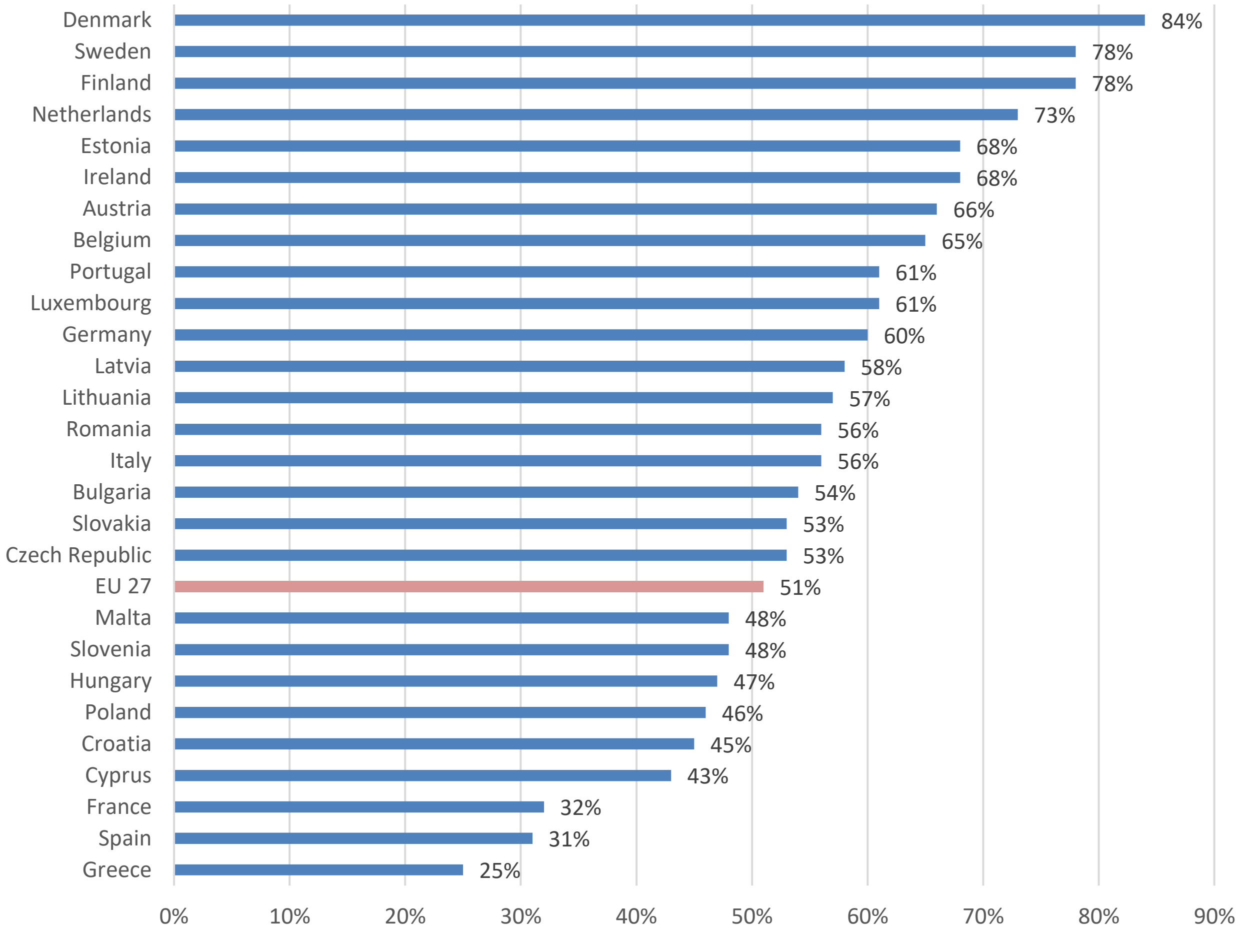


Figure 30 - Share of people who tended to trust in television in the EU Member States in 2021.

Source: Eurobaromoter, 2021

The decrease in the concentration is linked to the advent of Digital Terrestrial Television. In fact, the digitalisation brought a rapid expansion in the number of channels available to consumers, and a resulting loss of share of historic terrestrial services which dominated analogue distribution.

In relation to the number of TV channels, at the end of 2020, there were 5,528 TV channels established in Europe (excluding local channels), of which 3,628 were based in EU27 (EAO, 2021). Of the TV channels established in Europe, 91% belonged to a private company and 9% were owned by public service broadcasting organisations. Most recent data show 508 channels in EU27 are based on terrestrial transmission licences (15% of total, excluding local channels) and 130 public channels in EU27 are nationwide channels with terrestrial licences (EAO, 2021).

	Nationwide channels (with terrestrial licences)		Other nationwide channels (cable, satellite, IPTV, mobile)		Regional or territorial channels		Channels beyond national coverage		Total channels established in the country		
	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Total
AT	3	4	2	28	8	1	0	7	13	40	53
BE (CFB)	0	0	4	15	0	0	0	0	4	15	19
BE (DGB)	0	0	1	0	1	0	0	0	2	0	2
BE (VLG)	3	1	0	34	0	11	0	0	3	45	48
BG	3	0	1	93	0	13	0	13	4	119	123
CY	3	11	0	10	0	0	1	1	4	22	26
CZ	7	32	0	46	0	6	0	74	7	158	165
DE	11	3	0	212	9	56	5	63	25	334	359
DK	10	1	0	28	8	2	0	1	18	32	50
EE	3	0	0	19	0	0	0	3	3	22	25
ES	5	24	2	90	27	19	7	206	41	339	380
FI	3	23	0	0	0	0	0	0	3	23	26
FR	8	23	1	164	1	7	4	78	14	272	286
GR	5	10	0	37	0	108	1	3	6	158	164
HR	4	9	0	88	0	16	1	2	5	115	120
HU	6	0	0	9	0	38	1	0	7	47	54
IE	7	3	1	10	0	0	0	9	8	22	30
IT	13	134	3	81	0	12	1	12	17	239	256
LT	2	11	1	2	0	1	1	1	4	15	19
LU	0	0	0	1	0	0	0	127	0	128	128
LV	2	7	1	18	0	3	0	8	3	36	39
MT	3	5	0	17	0	0	0	2	3	24	27
NL	3	0	8	71	13	32	34	354	58	457	515
PL	7	19	9	75	0	1	2	5	18	100	118
PT	5	2	0	41	2	0	2	10	9	53	62
RO	3	0	0	94	0	60	1	19	4	173	177
SE	5	18	0	23	0	2	1	21	6	64	70
SI	3	20	0	28	3	10	0	0	6	58	64
SK	3	19	0	20	0	34	0	3	3	76	79

EU 27 (total)	**130**	**378**	**34**	**1354**	**72**	**432**	**62**	**1022**	**298**	**3186**	**3484**
EU 27 (%)	**4%**	**11%**	**1%**	**39%**	**2%**	**12%**	**2%**	**29%**	**9%**	**91%**	**100%**

Table 17 - TV channels established by Member State and by kind of transmission (2020)[36].

Source: EAO, 2021

The Figure below shows the share of foreign channels for each Member States: high percentages of foreign channels are present in Belgium, Denmark, Estonia, Finland, Hungary, Ireland, Latvia, Lithuania, Slovenia, Slovakia and Sweden with a number of foreign channels targeting the country higher than national ones.

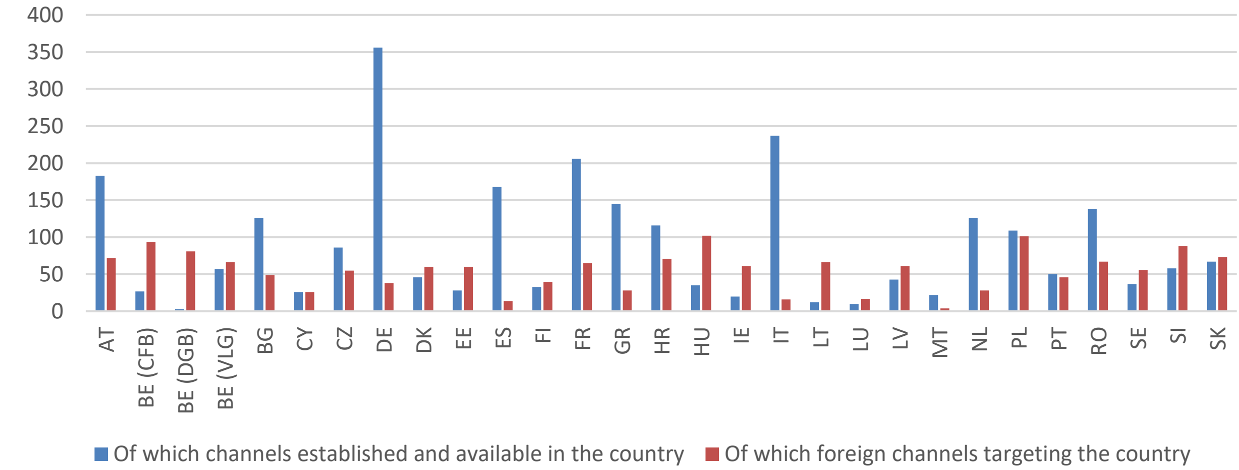


Figure 31 - TV channels available by nationality and by Member States (2019).

Source: European Audiovisual Observatory, 2020

By contrast, Austria, Germany, Greece, France, Italy, the Netherlands, Spain and Romania have less penetration of foreign channels. The low presence could be due to a predilection for national content among the viewers.

3.2.2 On demand consumption and trends

Video-on-Demand (VoD) is defined as a premium digital video content circulated over the Internet. A broad definition of the VoD platforms was provided by the International Telecommunication Union (ITU) in 2009, stating that video-on-demand represents: *“a service in which the end-user can, on demand, select and view a video content and where the end-user can control the temporal order in which the video content is viewed.”* (ITU, 2009)

In terms of market size, the consumer revenues for on-demand audio-visual services in the European Union presented a growth in the period between 2011 and 2020. In 2011, revenues reached around

[36] Local channels not included in 2020 EAO dataset

640 million euros, while nearly ten years after it amounted to approximately 11.6 billion euros, with a CAGR of 38% since 2011.

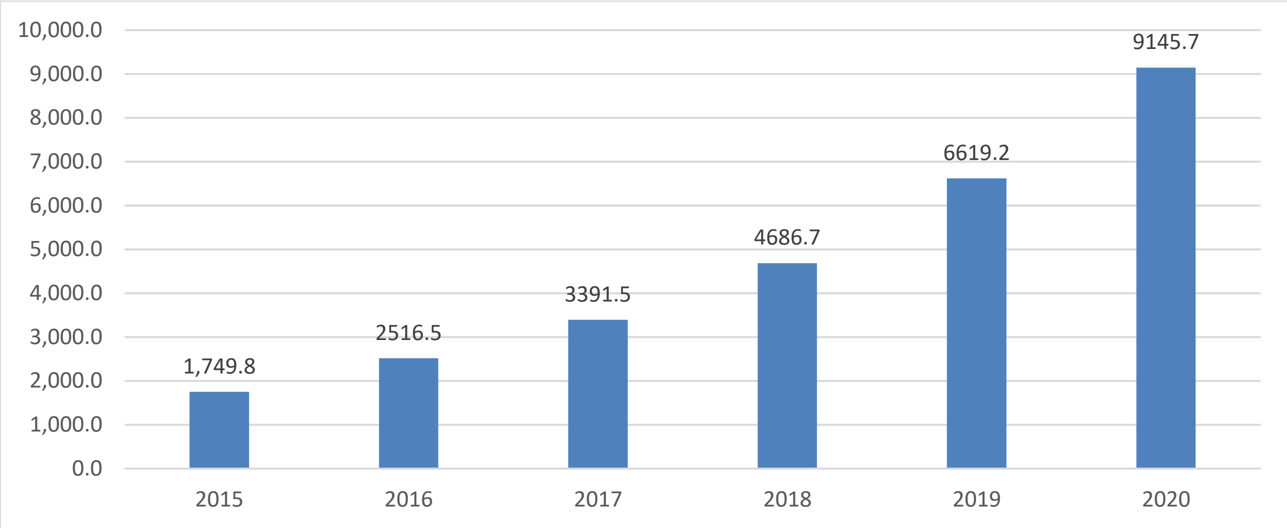


Figure 32 - Consumer revenues for on-demand audio-visual services in the European Union 2015-2020 (in million euros).

Source: European Audiovisual Observatory, 2021

In 2019, VOD only represented 7 percent of the 114.5 billion revenues generated on the EU27 + UK audiovisual market in 2019 (EAO, 2021). However, TVOD (transactional video on demand) and SVOD (Subscription video on demand) revenues were by far the fastest growing revenue segments in 2019, a trend that was also the case in 2020 in light of the difficulties of other segments, notably cinema box office and TV advertising, during the Covid-19 crisis (EAO, 2021). Most those other segments were either stagnant or declining (EAO, 2021).

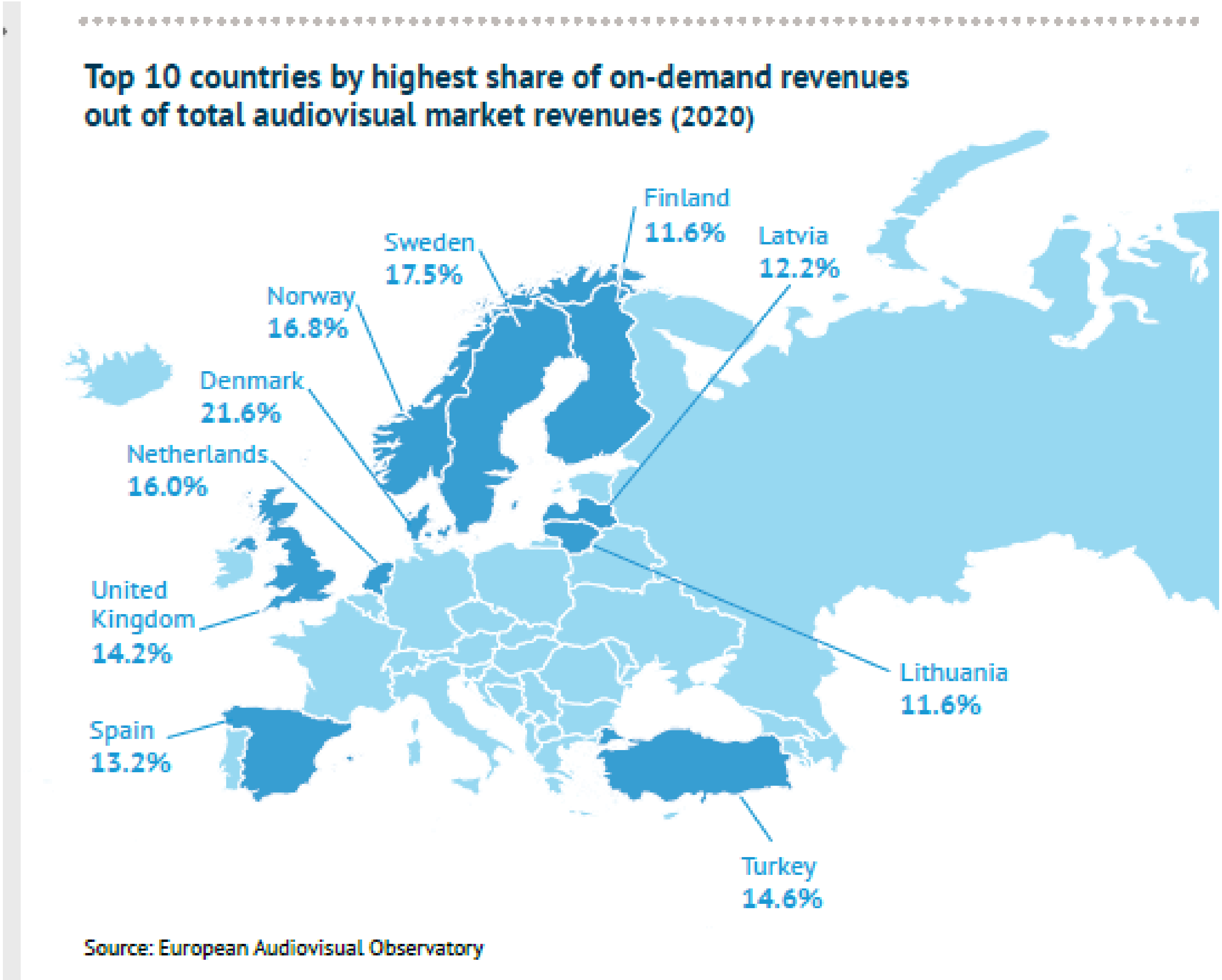


Figure 33 - Top 10 countries by highest share of on-demand revenues.

Source: EBU

The relative importance of each market segment varies widely between countries: high share of TV and radio advertising revenues out of total revenues in Bulgaria (where public funding accounts for a very limited share) and in Greece; significant weight of pay TV in Denmark (where one of the public service TV channels is subscription-based) and in Malta; comparatively high contribution of public funding to total revenues in Germany and in Croatia.

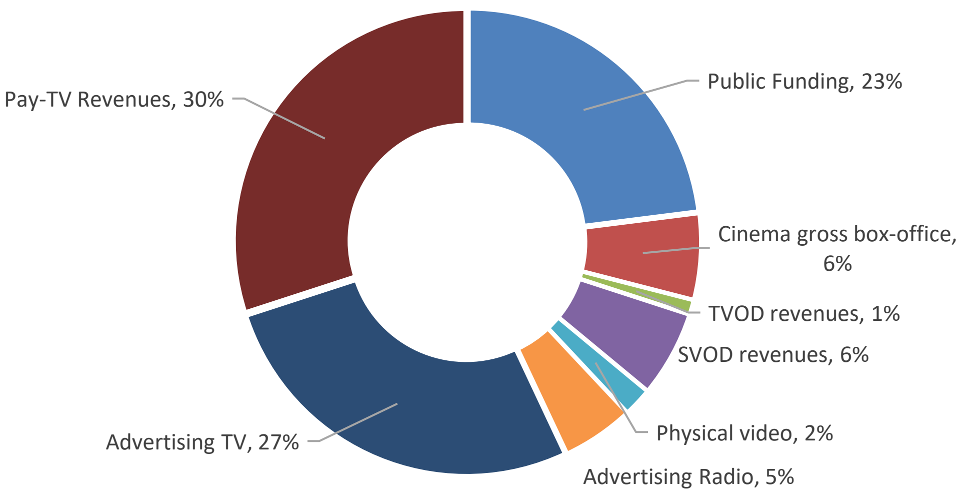


Figure 34 - EU27 + UK - Audiovisual market revenues by segment in 2019.

Source: European Audiovisual Observatory, 2020

Compared to TV viewership, **younger generations spend more minutes on average watching VOD**. In France, Germany, Italy and Spain, viewers aged 18-24 spend on average more time than their older peers watching media through on demand platforms (Figure 35 below). This result holds true also in Japan, whereas in the UK and in the USA, it is the group aged 25-34 which spends the most time.

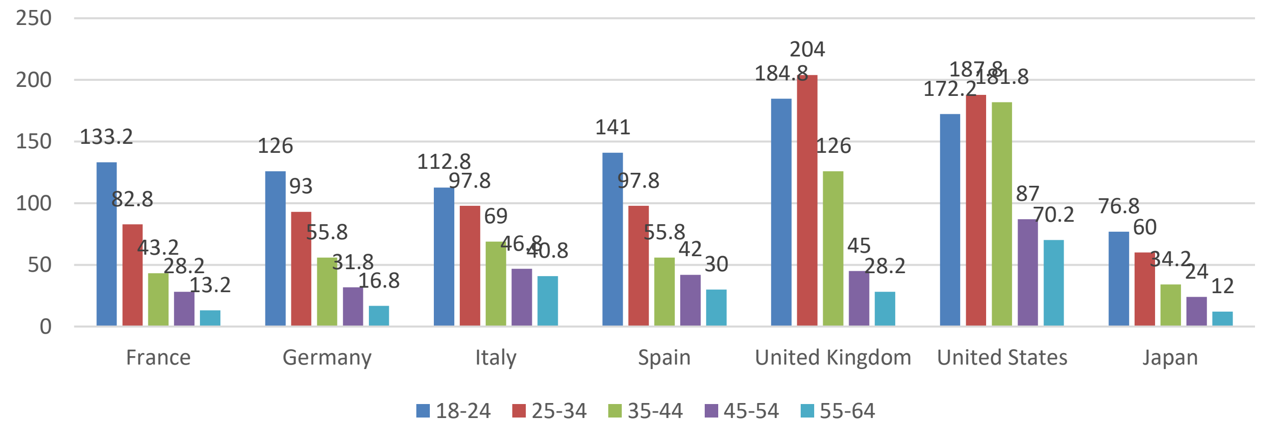


Figure 35 - Daily on-demand viewing time (in minutes) in selected countries worldwide 2018, by age group.

Source: Ampere Analysis, 2018

VOD can be categorized according to their business models.[37] There are three main types of VOD models:

- ***Subscription VoD – SVOD*** (Video Streaming) services offer access to a catalogue of films and television content in exchange of a subscription-fee, which can be monthly, weekly or daily (EAO, 2016). Through this method, the subscription grants access to a broad selection of different genres and titles which can be streamed on various devices with internet access.
- ***Transaction VoD – TVOD*** (pay-per-view) a transactional-on-demand service is a pay service renting or selling audiovisual works on a pay-per-view basis and represents rentals as a single transaction which has time-limited access to premium video content (i.e. movies, TV shows, series) (EAO, 2016). TVoD services replace DVD and Blu-Ray content sold in specialised physical stores and act rather as a digital store where consumers can pay for their purchase or rental fees (EAO, 2016). There are two sub-categories:
    - *Electronic-Sell-Through (EST)* or ***TVOD-Retail*** allows users to purchase unlimited usage right to a specific video file, accessible through both cloud-based or offline storage. Through EST, the video content can be purchased in a one-time transaction and remains permanently accessible after the purchase (EAO, 2016).
    - *Download to rent* (DTR) or ***TVOD-Rental***, where customers access a piece of content for a limited time for a fee.
- Advertising-based Video-on-Demand or ***AVOD*** is free on demand service to consumers. However, much like broadcast television, consumers need to sit through advertisements in exchange for free-content access. Advertisement revenue is used to offset production and hosting costs. AVOD is a broader definition which can include from User Generated Content (e.g. YouTube) to Catch-up TV or BVOD. ***BVOD*** stands for Broadcaster Video-On-Demand refers to content created by TV broadcast media that is subsequently made available online and on-demand as a free service with adverts. In the Catch Up TV, live programs from broadcasters are watched in a later time.

3.2.2.1 SVOD

From the launch of Netflix and several other services in 2011 and 2012, SVOD started the uptake in subscriptions of EU consumers and their shift in content consumption (EAO, 2021). SVOD services profited from rapid consumer adoption, as their value proposition for consumers quickly changed consumer expectations: being able to consume (premium) content anytime, anywhere and on any devices, with no interruptions such as TV advertising or a week-long wait for the next episode of TV series, at a much lower cost point than traditional pay TV, with an easy-to-use interface and a good user experience (EAO, 2021). All this provoked a shift for subscribers in their perceived value of traditional media services and their offerings (EAO, 2021).

In the past eight years, pay TV, commercial TV, telecom and tech players furthermore increased this trend by launching their services. This has led to reach 140 million subscriptions to SVOD services at the end of 2020 in the EU27 and in the UK (EAO, 2021). As SVOD is becoming mainstream and other

[37] Statista (2016), Digital Media: Video-on-Demand

players are preparing launches of services, the market will continue to grow over the next years (EAO, 2021).

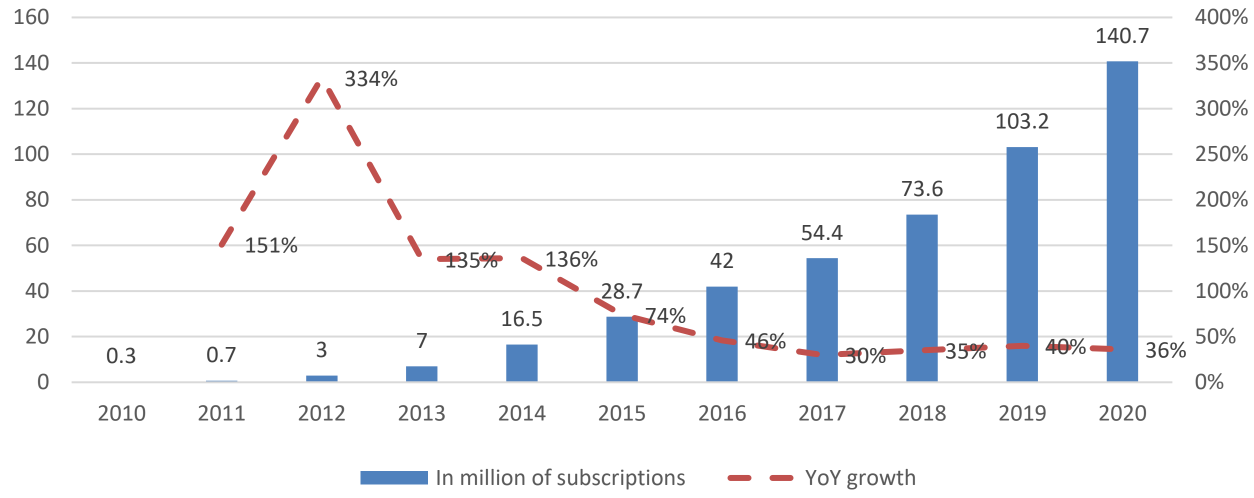


Figure 36 - EU27 + UK - Subscriptions to OTT SVOD.

Source: European Audiovisual Observatory, 2020

The rapid rise in revenues and subscribers was mainly driven by Western EU markets in which SVOD penetration rapidly increased, benefiting from higher broadband availability and higher consumer media budgets.

The figure below shows how five Member States qualify as maturing/mature SVOD markets (i.e. Denmark, Sweden, Finland, Germany and the Netherlands) in which SVOD has been adopted by more than 50% of households. These markets are qualified by households subscribing often to more than one SVOD service, strong local services in addition to global services and SVOD services beginning to be adopted by the so-called late majority[38] (EAO, 2021). 11 Member States (i.e. Austria, Ireland, Spain, Luxembourg, Italy, Belgium, France, Poland, Portugal, Slovenia and Malta) are in a phase in which SVOD services are becoming mainstream in the media consumption of audiences and SVOD services are rapidly adding subscribers (EAO, 2021). 11 Member States, mostly in Central and Eastern Europe (CEE)[39], are characterised by high pay TV penetration and comparable prices to SVOD services. Here the price advantage of SVOD services compared to pay TV is weak. A lower than EU27 broadband penetration is also a characteristic of this market (EC, 2021).[40] SVOD services face still a challenge to enter the mainstream in these countries (EAO, 2021).

[38] Beginning to adapt global services and SVOD services, and maturing SVOD markets, only after the majority Member States do.

[39] Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Romania, Slovakia, Greece and Cyprus.

[40] Based on the Digital Economy and Society Index (DESI) 2021:

- Bulgaria scores only 59% in overall broadband take-up of households subscribing (EU average: 77%) and is also lagging behind in the take-up of high-speed fixed broadband of at least 100 Mbps (15%, against an EU average of 34%).
- In Czech Republic, the roll-out of very high-capacity networks remains slow. 33% of households are covered by fixed very high-capacity networks (provided through FTTP), below the EU average (59.3%).

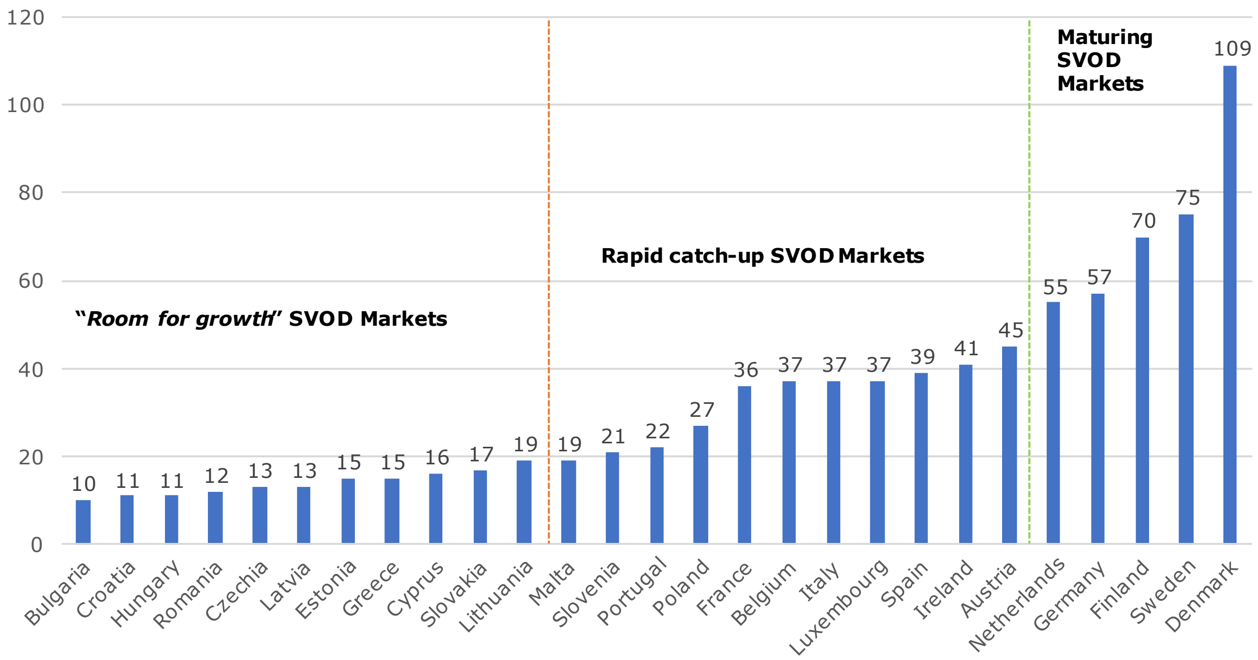


Figure 37 - SVOD penetration/100 households, 2019.

Source: European Audiovisual Observatory, 2021

The table below shows that Germany has by far the largest number of SVOD subscriptions in EU27, double these of comparable Member States in population numbers but, as the market is maturing, had the lowest (but still high) growth rate in EU27 (EAO, 2021). Nordic Member States, in which SVOD penetration is among the highest in EU27, had still an important growth rate in SVOD subscription in 2019 (EAO, 2021). CEE Member States, in which SVOD has still to further be adopted into the mainstream media consumption, experienced the fastest growth rate in EU27 (EAO, 2021).

- Estonia is characterised by an overall high coverage of fixed Very High Capacity Network (VHCN) connectivity, except in rural areas where additional investments are needed (in addition to lower than EU average take up of at least 100 Mbps fixed broadband and non-existent 1 Gbps broadband take up).
- In Hungary, VHCN coverage stands at 49%, below the EU average of 59%.
- Although many households are covered by fast broadband (NGA) 71% in Lithuania, in rural areas only 29.6% such access.
- In Latvia, overall fixed broadband take-up stands at 62% of all households (below the 77% EU average).
- For Poland, Fiber-to-the Premises (FTTP) coverage in rural areas remains at a lower level (only 24.1% of rural households covered in 2020, slightly below the EU average of 24.9%). Overall fixed broadband take-up is lower than EU average.
- Overall, fixed broadband take-up in Romania stalled around 67% of households (for the fourth year in a row).
- 25% of Slovakian households had a fixed broadband connection of at least 100 Mbps in 2020 (below the EU average of 34%). Although Slovakia is the 7th cheapest broadband market in the EU, consumers tend to choose lower broadband speeds.

Member State	2015	2016	2017	2018	2019	2020	CAGR 2015/2020
AT	593	794	1,037	1,311	1,731	2,226	28,6%
BE	257	470	703	1,101	1,766	3,229	82,8%
BG	24	38	65	121	240	389	62,3%
CY	n.a.	9	17	29	54	81	50,3%
CZ	34	94	163	298	556	872	56,6%
DE	9,467	11,972	15,177	18,761	23,303	31,587	35,5%
DK	855	1,243	1,508	1,955	2,913	3,928	34,8%
EE	n.a.	25	44	69	115	180	56,3%
ES	872	2,438	3,416	4,687	7,547	11,288	49,6%
FI	502	554	778	1,097	1,515	2,217	46,3%
FR	1,719	3,703	5,091	7,758	13,746	20,638	50,1%
GR	n.a.	104	184	310	586	904	54,4%
HR	11	34	55	86	131	174	32,8%
HU	n.a.	59	115	213	413	648	56,7%
IE	144	195	261	408	656	906	38,1%
IT	1,045	2,340	3,368	5,371	8,952	12,885	43,9%
LT	n.a.	51	84	129	222	341	53,4%
LU	11	21	33	55	92	143	56,1%
LV	n.a.	45	73	108	178	296	66,1%
MT	n.a.	5	11	20	37	56	52,9%
NL	671	988	1,452	2,442	4,255	6,113	43,7%
PL	973	1,172	1,714	2,461	3,530	4,575	29,6%
PT	57	152	254	456	888	1,582	78,2%
RO	225	196	256	394	576	856	48,6%
SE	1,114	1,510	1,803	2,548	4,061	5,490	35,2%
SI	44	55	65	91	142	209	47,6%
SK	33	47	75	134	250	405	62,1%
EU27	18,651.6	28,313.8	37,802.2	52,414.6	78,455.2	112,218.5	43,0%

Table 18 - Households subscribing to SVOD in EU27 (2015-2020), in thousands.

Source: European Audiovisual Observatory, 2021

Regarding the consumer revenues, the EU-4 (i.e. Germany, France, Italy and Spain) represent the majority of consumer revenues in the SVOD market, accounting for 68% of all revenues in 2020. However, maturing markets such as the Nordics, already generate, proportionally to their size, significant consumer revenues (EAO, 2021). SVOD revenues are growing at a fast pace in every EU Member State as consumers subscribe for the first time or add other SVOD subscriptions to supplement their content consumption (SVOD stacking). In some maturing markets (Germany, Sweden and Denmark), growth rates are below the EU average of 43% as markets are starting to mature and early adopters and early majority market levels are already reached (EAO, 2021). The aim for services in these markets is now to convince the late majority adopters, often the more aged part of the population to integrate SVOD services in their media consumption. In smaller audiovisual markets, SVOD is still on a quick expansion phase and revenues are set to grow (EAO, 2021).

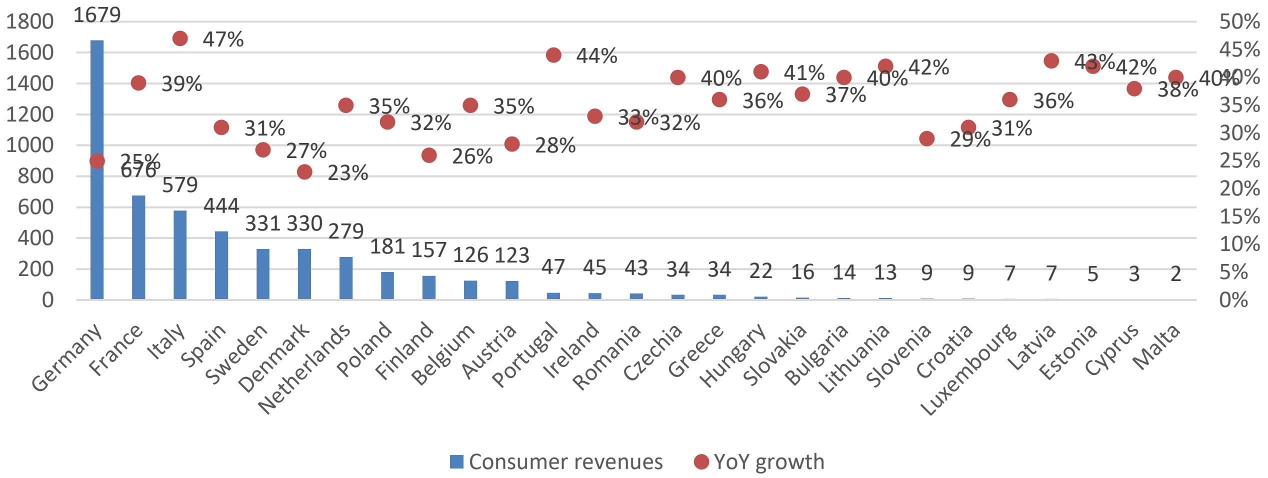


Figure 38: EU27 OTT SVOD consumer revenues by Member State 2019 and Year-on-Year growth 2018/19.

Source: European Audiovisual Observatory, 2020

In terms of distribution, OTT allows these services to reach consumers in other Member States, with 53% of the 460 services targeting another EU27 + UK of their market of establishment (EAO, 2021). This is due to country “hubs” of SVOD services, mostly in the UK (113 established services), Ireland (53), the Netherlands (40), Spain (38), France (37), Germany (20) and Sweden (20) and the Czech Republic (16) (EAO, 2021).

Jointly with the most known service providers, Netflix and Amazon, in all EU27 Member States, there are local services, ranging from entertainment to niche services, that also operate and compete for customers’ media budgets. These services are operated by national broadcasters, telecom players, distributors/producers or pure VOD players.

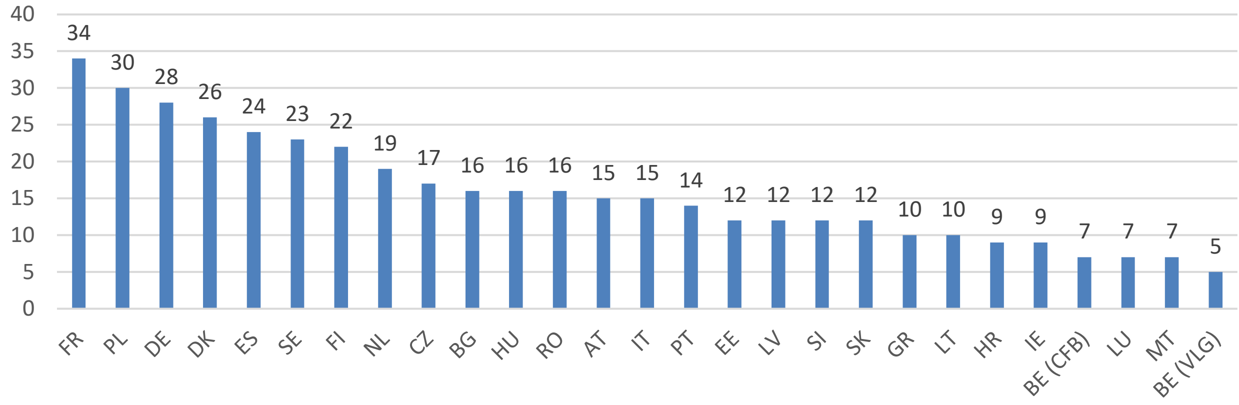


Figure 39: EU27 - Number of SVOD services available by Member State.

Source: European Audiovisual Observatory, 2021

However, as scale is important, only global pan-European players compete for subscribers in each national European market. Therefore, it is no surprise that global services dominate the EU27 + UK SVOD market in subscriber numbers and revenues (EAO, 2021).

SVOD services	Number in EU27 + UK
Netflix	28
Amazon Prime Video	28
YouTube Premium	28
Apple TV+	26
MUBI	19
HBO	16
Disney+	13
Eurosport Player	12
Hayu	8
Acorn TV	7
Sky	5

Table 19 - Top SVOD services by country presence in EU27 + UK, in number of countries, 2020.

Source: European Audiovisual Observatory, 2021

In 2020, Netflix and Amazon were by far the most popular SVOD services in the European Union, with market shares of around 39% and 29%, respectively. Apple TV+ was subscribed by 9% of SVOD users and thus, it ranked third (EAO, 2021). New entrants Disney and Apple, whose SVOD service is still free of charge for Apple device holders, quickly added subscribers and in the case of Disney, SVOD revenues, and are planning increased investments into content the coming years (EAO, 2021).

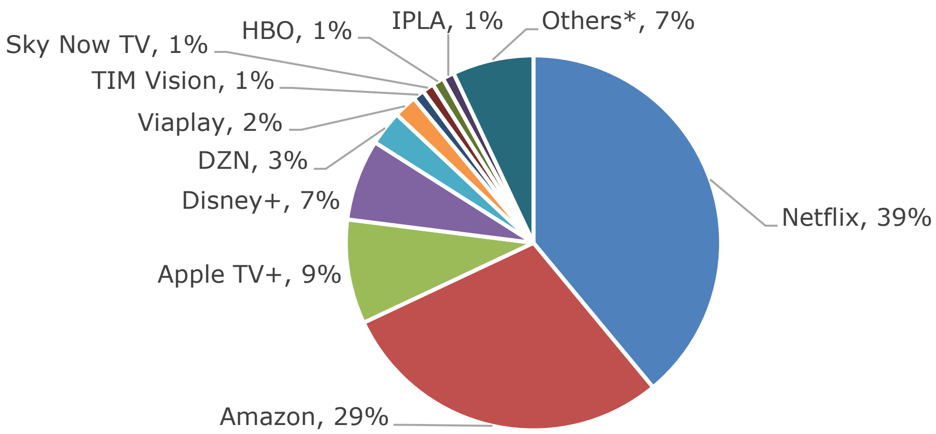


Figure 40 - Ranking of SVOD services by market share in the EU 2020.

Source: European Audiovisual Observatory, 2021

However, more developed European markets, such as the Nordics and the Netherlands have also strong national/local players, often launched by local pay TV groups or broadcasters. Table 20 shows, indeed, that the market concentration of the top 3 market players is actually lower than less mature markets. This may indicate that the SVOD is not a market with a "winner-takes-all" outcome and several players can coexist and compete but only a few will dominate (EAO, 2021).

Member State	1st Rank	2nd Rank	3rd Rank	Total OTT SVOD subscribers, in thousands	Market share Top 3
Austria	Amazon - 40%	Netflix - 39%	Disney+ - 8%	2378	87%
Belgium	Netflix - 52%	Amazon - 15%	Streamz - 14%	3152	81%
Bulgaria	Netflix - 39%	Apple TV+ -26%	Amazon - 24%	440	89%
Croatia	Netflix - 55%	Amazon - 37%	Voyo - 7%	209	99%
Cyprus	Netflix - 60%	Apple TV+ -25%	Amazon - 15%	82	100%
Czech Republic	Netflix - 52%	Apple TV+ - 24%	Amazon - 22%	876	98%
Denmark	Netflix - 24%	Viaplay - 23%	TV2 Play - 18%	3826	65%
Estonia	Netflix - 43%	Amazon - 20%	Apple TV+ -19%	122	82%
Finland	Netflix - 29%	Viaplay - 16%	Ruutu+ - 13%	2536	58%
France	Netflix - 54%	Amazon - 26%	Apple TV+ -12%	15453	92%
Germany	Amazon - 44%	Netflix - 32%	Disney+ - 6%	33333	82%
Greece	Netflix - 55%	Apple TV+ - 28%	Amazon - 17%	939	100%
Hungary	Netflix - 49%	Apple TV+ -28%	Amazon - 23%	690	100%
Ireland	Netflix - 54%	Amazon - 35%	Apple TV+ - 11%	978	100%
Italy	Netflix - 28%	Amazon - 18%	TIM Vision - 16%	13136	62%

Member State	1st Rank	2nd Rank	3rd Rank	Total OTT SVOD subscribers, in thousands	Market share Top 3
Latvia	Netflix - 35%	HBO - 27%	Amazon - 19%	162	81%
Lithuania	Netflix - 43%	Apple TV+ - 20%	Amazon - 19%	321	82%
Luxembourg	Netflix - 58%	Amazon - 29%	Apple TV+ -12%	144	99%
Malta	Netflix - 51%	Amazon - 29%	Apple TV+ - 20%	29	100%
Netherlands	Netflix - 44%	Amazon - 15%	Videoland - 15%	6250	74%
Poland	Netflix - 37%	IPLA - 29%	Amazon - 11%	4685	77%
Portugal	Netflix - 47%	Apple TV+ - 21%	Amazon - 13%	1473	81%
Romania	Netflix - 40%	Voyo - 38%	Amazon - 21%	1160	99%
Slovakia	Netflix - 42%	Amazon - 24%	Apple TV+ - 24%	451	90%
Slovenia	Netflix - 38%	Voyo - 23%	Amazon - 22%	243	83%
Spain	Netflix - 44%	Amazon - 25%	Apple TV+ - 10%	10824	79%
Sweden	Apple TV+ - 10%	Viaplay - 19%	HBO Nordic - 10%	5039	63%

Table 20 - Top 3 SVOD services by Member State presence in EU27, 2020.

Source: European Audiovisual Observatory, 2021

In terms of competition, a new emerging trend was studied by Ampere Analysis on the TV viewing habits of Internet households in Europe's big five markets (UK, France, Italy, Germany and Spain). The snapshot came at a time when the region experienced a series of lockdowns. The results show that on average, over 80% of pay-TV households across the UK, France, Spain, Italy and Germany also subscribe to at least one streaming service (*BroadbandTVNews, 28/04/2021*). France saw the highest increase with 72% of pay-TV households also taking SVOD in Q1 2021, compared to 66% in Q1 2020 (*BroadbandTVNews, 28/04/2021*).

In this regard, the YearBook of the *European Audiovisual Observatory* states that the competition on premium content, films and TV content, has increased. In fact, the scope of content available on SVOD services has expanded, basically covering all genres previously assembled in pay TV packages. Live sports remain the main differentiator between premium pay TV channels and SVOD services which, in turn, have been negatively impacted by chaotic sports seasons in 2020 (EAO, 2021).

The competition between SVOD services and pay TV services had led most pay TV players (IPTV, cable) distribute SVOD services on their platforms to offer their subscribers access to a large choice of content and SVOD services have entered distribution agreements in most EU Member States (EAO, 2021).

With an increased adoption of media streaming devices (Google's Chromecast, Amazon's Fire TV, Roku) and widespread penetration of Smart TVs and available streaming applications in EU27 households, a risk for pay TV players exists to lose their TV subscribers base and be relegated to only provide broadband access as these new entrants become increasingly gatekeepers (EAO, 2021).

For now, pay TV and SVOD players coexist and have entered mutual beneficial distribution agreements: for SVOD services this gives them higher penetration into consumers households and TV screens, for pay TV players their strategy is towards aggregation of services to offer their subscribers access to a large choice of content (EAO, 2021).

Pay TV distributors are, in the short term, protected by the bundling of Internet access and pay services. But the possibility of significant cord-cutting (consumers switching from legacy television distribution networks to Internet services) has increased, with pay TV services reorienting their distribution towards Internet and network operators refocusing on broadband Internet access as their core activity (EAO, 2021). In addition, Pay TV subscriptions grew at a low rate over the past five years, and it is expected that the SVOD services will surpass pay TV players in subscribers in 2021, becoming the main subscription-based entertainment source for a large share of EU27 citizens with room to grow ahead (EAO, 2021). The Figure overleaf shows that nine Member States are set to become countries with high SVOD penetration in the next two years, as they become mainstream in consumers' perception (EAO, 2021).

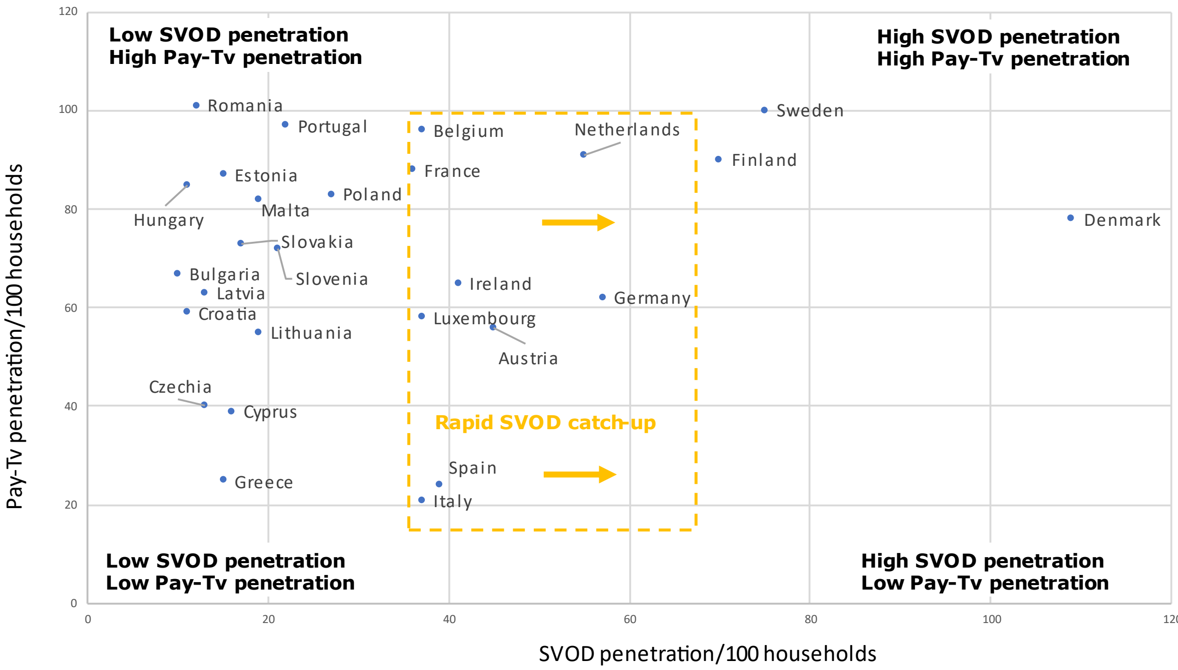


Figure 41 - Pay TV and SVOD penetration by Member State 2019.

Source: European Audiovisual Observatory, 2021

To note, in Member States in which SVOD has a high household penetration, the weight of SVOD revenues in the total revenues of audio-visual markets is more important, especially in the Nordics (EAO, 2021): however, in most markets, SVOD revenues are still a small part of audio-visual market revenues, especially in markets where pay TV prices are low and pay TV penetration widespread, broadband penetration below EU27 average and the number of available SVOD services smaller (EAO, 2021).

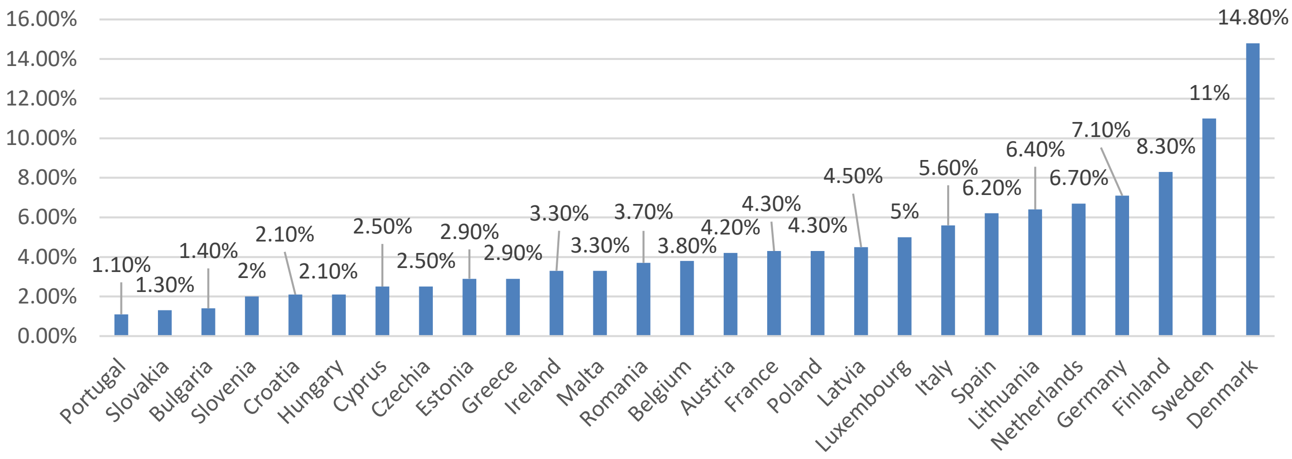


Figure 42 - Share of SVOD revenues of total audio-visual market revenues by Member State, 2019.

Source: European Audiovisual Observatory, 2020

3.2.2.2 TVOD

The digital segment of the home video market (i.e. TVOD - Transactional video on demand) more than doubled its share over the last five years. The jump was chiefly driven by retail, which has grown twice as fast, on average, year on year (CAGR +27%), as rental (CAGR +12%), over the last ten years. The TVOD market experienced an uplift in 2020 due to stay-at-home orders and digital releases of theatrical films (due to closed cinemas) which increased TVOD consumption, be it for retail or rental. Retail TVOD took the biggest portion of digital revenue and had caught up rental TVOD (EAO, 2021).

	2010	2020	CAGR
TVOD - Rental	293	947	12%
TVOD - Retail	84	930	27%

Table 21 - EU27 + UK –Transactional market digital In EUR million, 2010-2020.

Source: European Audiovisual Observatory, 2020

Over the last five years, on-demand services have been the growth engine of the audio-visual sector. But the segment is quite heteroclite. TVOD (i.e. the purchase or rental of an audio-visual work) is maturing - although annual growth is still running at a healthy 6%, the rate of growth is decreasing. SVOD is growing seven times faster and now accounts for over 80% of the on-demand market (EAO, 2021).

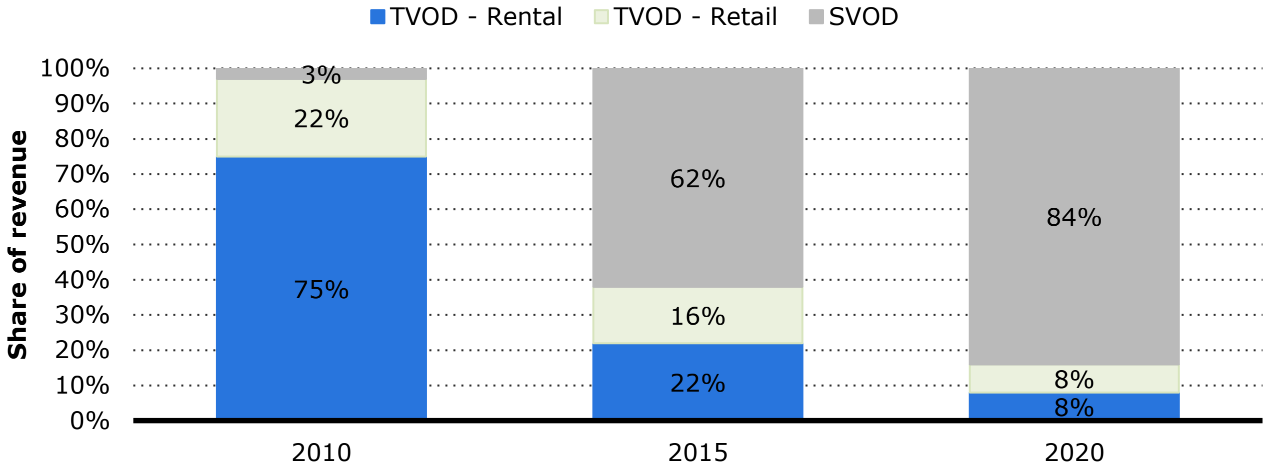


Figure 43 - TVOD and SVOD market shares in the EU 2010-2020.

Source: European Audiovisual Observatory, 2020

The Figure below shows that while in smaller Member States, TVOD revenues grew by over 20% in 2019, in some bigger Member States like France (-6%), TVOD revenues are levelling or decreasing. In addition, 'smaller' audiovisual markets tend to overperform in terms of growth (EAO, 2021).

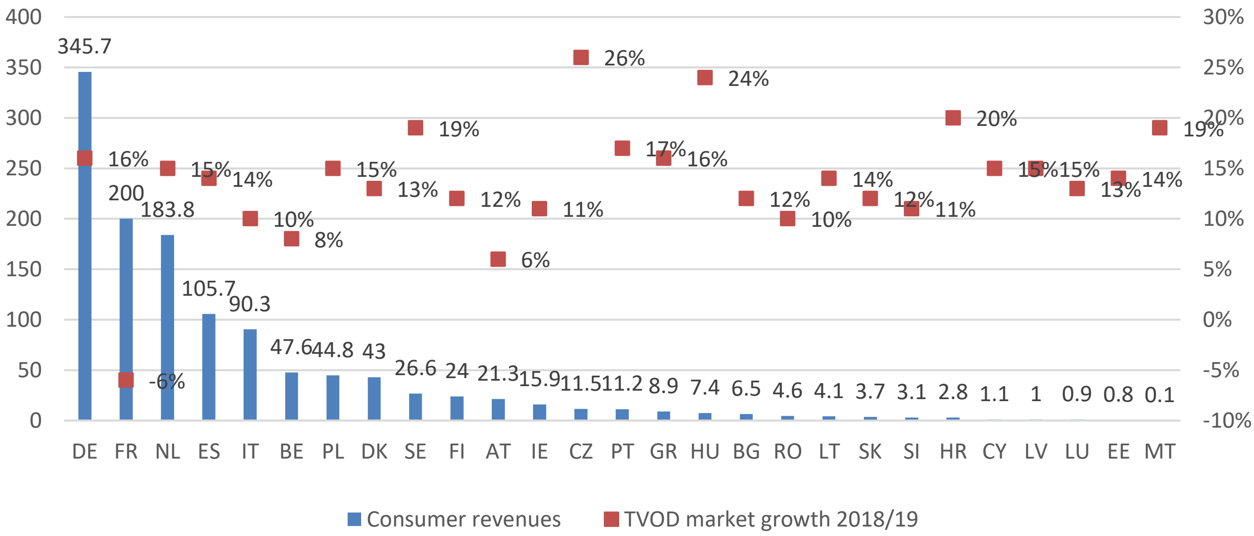


Figure 44 - EU27 –TVOD total retail and rental consumer revenues and growth by Member State and business model in 2019 In EUR million and % of change in total TVOD revenues 2018/19.

Source: European Audiovisual Observatory, 2020

The Figure below shows that there are considerable differences among Member States and their consumers' preference among TVOD Retail and TVOD Rental. It is possible to notice how the Baltics (i.e. Latvia, Lithuania and Estonia) prefer the use of TVOD Retail in 2019, as a larger number of consumers' revenue came from it. Whereas in 14 Member States (i.e. Bulgaria, Poland, Italy, Croatia, France, Denmark, Ireland, Slovenia, Slovakia, Hungary, Finland, Belgium, Netherlands and Cyprus), TVOD Rental dominates.

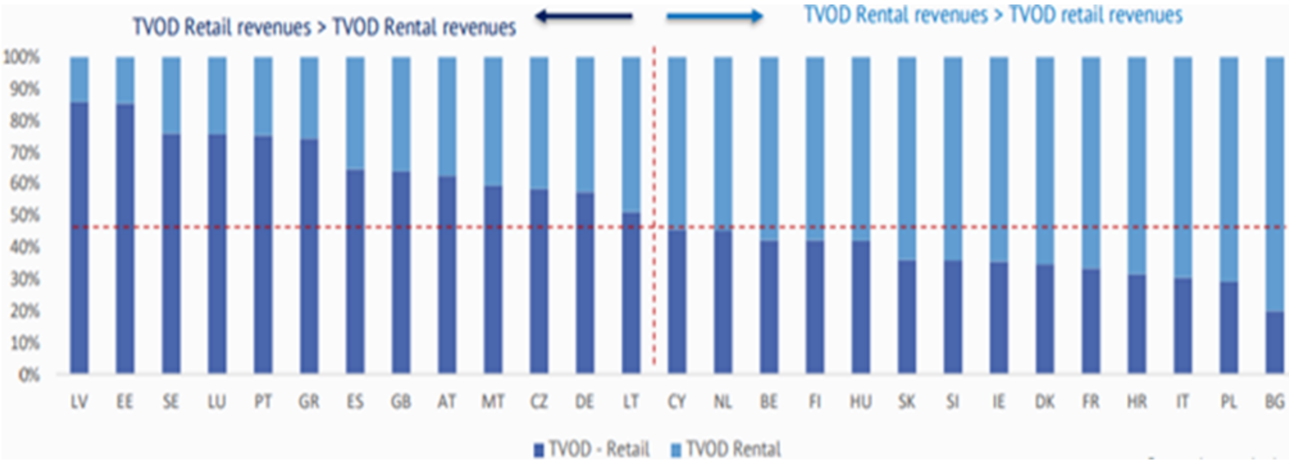


Figure 45 - EU27 + UK - Split of TVOD retail and rental revenues by country, In % of total TVOD revenues, 2019.

Source: European Audiovisual Observatory, 2021

In terms of distribution, the majority of TVOD services are established in another EU27 or (in the UK) other market than the one in which they offer their catalogue due to the establishment of pan-European/multi-country TVOD services. There are three major hubs for TVOD services, and these are: Ireland (82 services - Google, Apple, Microsoft), the UK (73 services – FilmDoo, MUBI, Sony's Playstation, NENT's Viaplay) and Spain (33 services – Rakuten). There are also national services, available mostly on their national market, are operated by broadcasters, telecom players and producers/distributors in most cases (EAO, 2021).

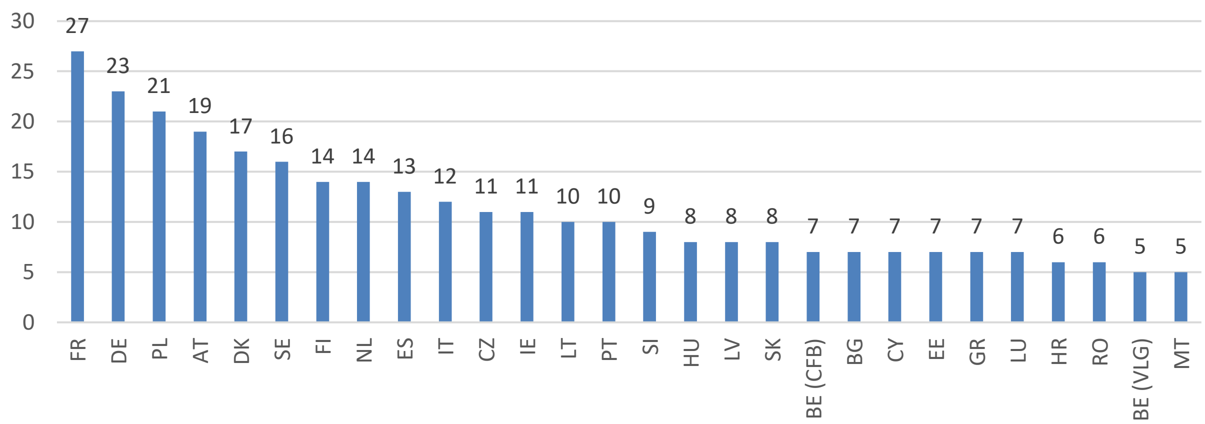


Figure 46 - EU27 - Number of TVOD services available by Member State in number of TVOD services, 2020.

Source: European Audiovisual Observatory, 2020

In the EU27 and UK, there are over 335 TVOD catalogues available to consumers, representing 140 TVOD services as several global services are operating in more than 1 country. EU27 + UK services, with some exceptions, operate their service on their national or regional market. This is notably the case of TVOD services of tech players which offer the rental or retail of films and TV shows in their App stores (Google, Apple, Microsoft, Playstation) or of specialised niche players, which concentrate on the curation of content (like FilmDoo does with international films) (EAO, 2021).

TVOD Service	Number of EU27 countries + UK
FilmDoo	28
Rakuten TV	28
Apple iTunes	26
Google Play	25
MUBI	19
YouTube Movies	18
Microsoft Movies & TV	12
Playstation Store	12
Chili	5
Pantaflix	4
Amazon TVOD	4
Viaplay TVOD	3
SF Anytime	3
Blockbuster	3
Wakanim	3
Liberty Global UPC/Virgin	3

Table 22 - TVOD Services available by country.

Source: European Audiovisual Observatory, 2021

However, over the years several TVOD services have closed as consumers transition to SVOD services and minimum guarantees paid to producers/studios by TVOD services represent a risk to smaller (and even bigger) TVOD services. Strategies on this market are either to go large (offer a large quantity of films) or go niche with curation (EAO, 2021).

Films, especially more recent ones, are the "*bread and butter*" of TVOD services. As Figure 47 shows, on average, TVOD services offer 5 times more films than SVOD services: with an average 5 216 film titles for TVOD services compared to an average 1 031 for SVOD services, as of data from May 2020. While there are on average more TV seasons on , TV content is the core business for SVOD services (EAO, 2021).

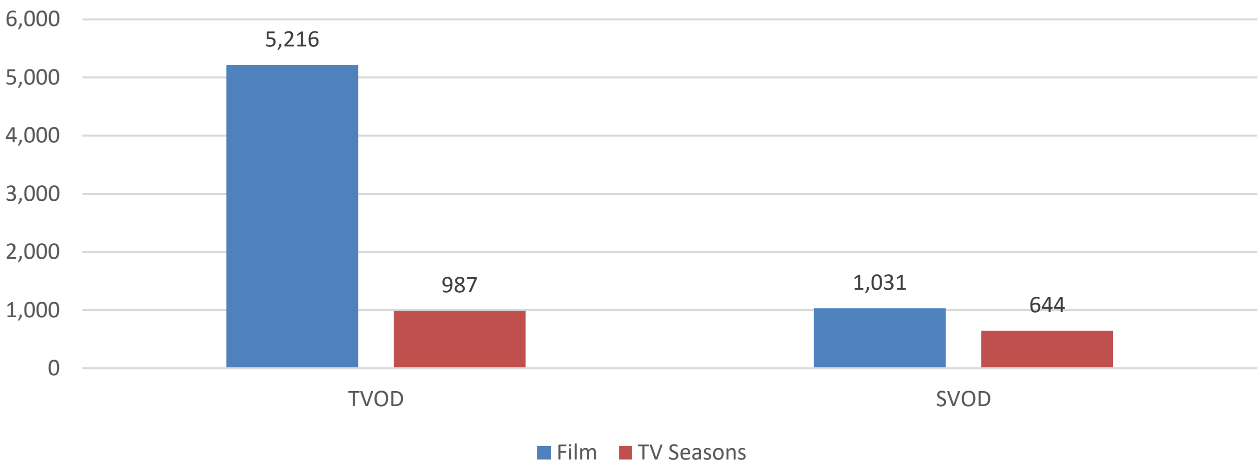


Figure 47 - Size of TVOD and SVOD catalogues (film and TV seasons), May 2020.

Source: European Audiovisual Observatory, 2020

TVOD services' main selling points are films, with recent and unique films being the main focus (Figure below). As TVOD services do not need to acquire licences for the exploitation of films as do SVOD services, and producers/studios search to further monetise their works, the larger offer on average than SVOD services comes to no surprise (EAO, 2021).

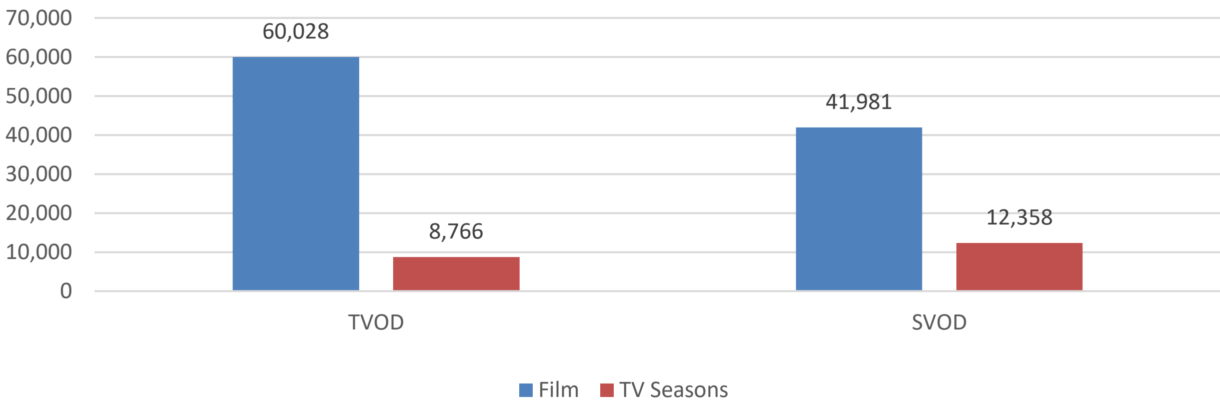


Figure 48 - Number of unique content titles by business model.

Source: European Audiovisual Observatory, 2020

According to the European Audiovisual Observatory (2021), the prominence of films and TV content highlights the very characteristics of TVOD services. On the one hand, TVOD's business model primarily relies on the sale or rental of a limited number of recent high potential films. On the other hand, these high potential films are supplemented by a "long tail" offering of older films and TV shows, which are hardly promoted. High-potential films are "pushed" towards consumers through intensive promotion, whereas other programmes are made available for consumers looking for specific titles (EAO, 2021).

With the increase of SVOD usage and consumers' growing habit of paying a flat fee to have access to content, the TVOD market will be driven mostly by films and helped by earlier windows than other distribution channels (EAO, 2021).

3.2.2.3 AVOD/BVOD

AVOD/BVOD services offer "free" access to consumers to content in exchange of their willingness to watch advertisements. AVOD/BVOD services are attractive to viewers in a crowded SVOD market and to traditional broadcasters to monetise their content online (EAO, 2021). Most European TV players have launched their own BVOD services to capture online viewing by audiences, which are seeing their core businesses in transition and try to adapt (EAO, 2020).

The table below shows that Germany (207), Austria (150) and France (144) are the Member States with most AVOD/BVOD and sharing platforms available. Smaller markets, Luxembourg, Cyprus and Malta are the ones with the least service available.

Member State	FOD	Sharing platforms	Catch-up TV	Total
AT	27	7	116	**150**
BE (CFB)	29	7	72	**108**
BE (DGB)	26	7	50	**83**
BE (VLG)	29	7	72	**108**
BG	24	7	30	**61**
CY	26	7	13	**46**
CZ	29	7	50	**86**
DE	32	7	168	**207**
DK	29	7	64	**100**
EE	26	7	22	**55**
ES	30	8	52	**90**
FI	30	7	36	**73**
FR	31	7	106	**144**
GR	25	7	37	**69**
HR	27	7	25	**59**
HU	28	7	49	**84**
IE	29	7	43	**79**
IT	28	7	28	**63**
LT	28	7	19	**54**
LU	25	7	11	**43**

Member State	FOD	Sharing platforms	Catch-up TV	Total
LV	26	7	20	**53**
MT	24	7	8	**39**
NL	32	7	45	**84**
PL	28	7	89	**124**
PT	27	7	42	**76**
RO	26	7	61	**94**
SE	32	7	65	**104**
SI	25	7	35	**67**
SK	25	7	39	**71**

Table 23 - Number of free on-demand audio-visual services (FOD), Sharing platforms and Catch-TV available in EU27 by type (2019).

Source: European Audiovisual Observatory, 2020

These on-demand service providers tend to provide to content created by TV broadcast media that is subsequently made available online (i.e. Catch-up TV) or user-generated content (Sharing Platform, e.g. YouTube). Premium content owners rarely use AVOD as it generates lower amounts of revenue than SVOD and TVOD (EAO, 2020).

Nevertheless, in the last years, AVOD/BVOD services have begun to find their audiences. The percentage of people who make use of internet to watch TV has more than doubled in the last ten years, reaching its peak in 2019 with 17% of the population in EU27 + UK making daily (or almost daily) use of these services.

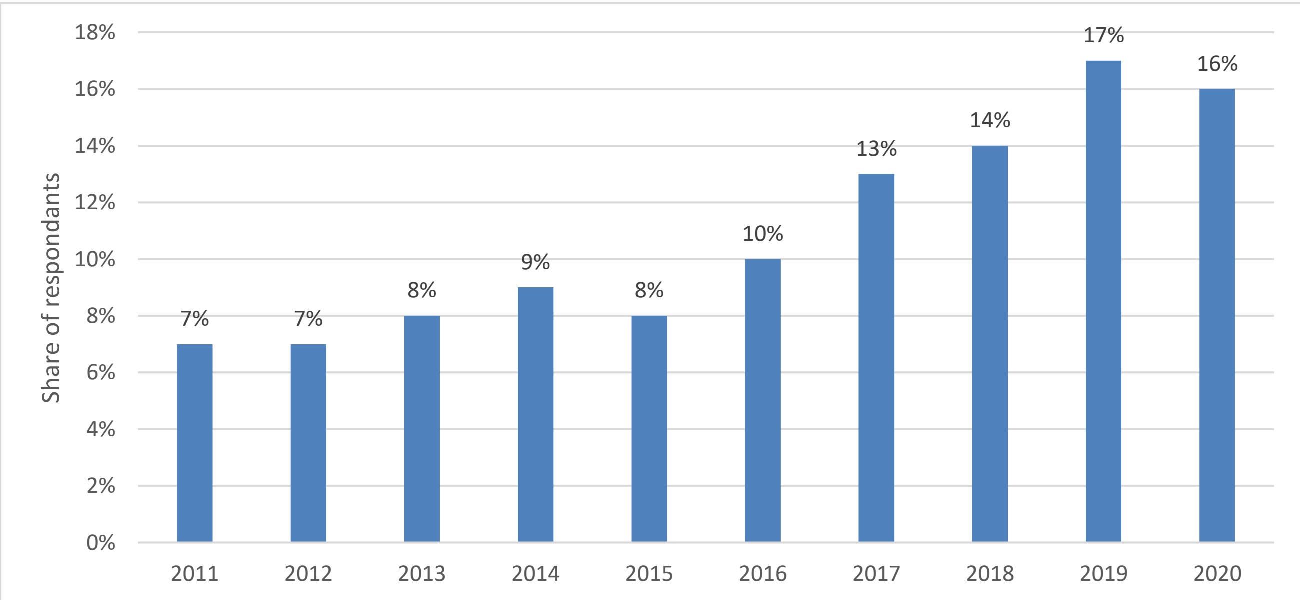


Figure 49 - Share of people who watched TV via the Internet every day or almost every day in Europe (EU27 + UK) from 2011 to 2020.

Source: Eurobarometer, 2021

The share of population watching TV online varies among Member States, in the Nordics (Sweden, Denmark and Finland) the practice is more diffused, as well as in Germany and Italy and smaller audiovisual markets like Malta, Cyprus, Ireland, Luxembourg and Croatia.

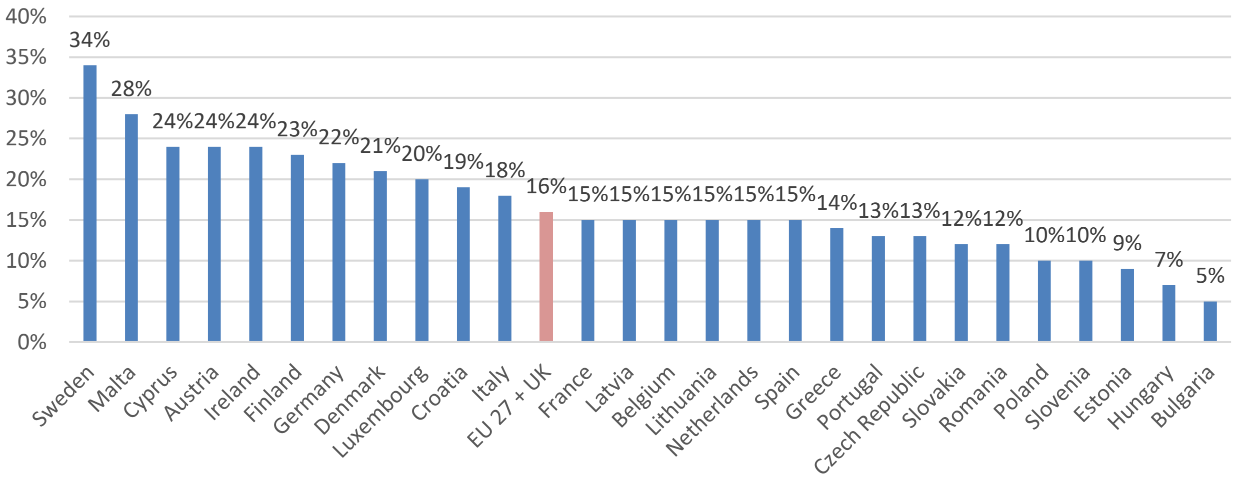


Figure 50 - Share of people who watched TV via the internet every day or almost every day in the European Union in 2021.

Source: Eurobarometer, 2021

The market is still nascent but holds a lot of promise in an era in which consumers spend more time online and the entertainment sector undergoes a transition, from a mass entertainment market as it is the case with broadcast television towards a more individualised, user-controlled entertainment market (EAO, 2020). AVOD/BVOD and others Free Video on Demand (FVOD) hold the promise to exploit user data for a better targeting and more individualised advertising, which is the cornerstone of online advertising (EAO, 2020).

Therefore, as the entertainment market transforms itself, so does the advertising market (EAO, 2020). These new services are competing for advertising budgets with traditional TV advertising players and could be the transition from a mass-advertising market towards a more individualised, targeted advertising market in the audio-visual sector (EAO, 2020).

AVOD/BVOD revenues, however, are a small part of online video advertising, dominated by international tech giants, video-sharing platforms and social media players (Google's YouTube, Facebook, Snapchat, TikTok, Amazon, etc.). The Figure below shows that the total revenues of selected networks in the European Union and in the UK amounted to EUR 700 million in 2020.

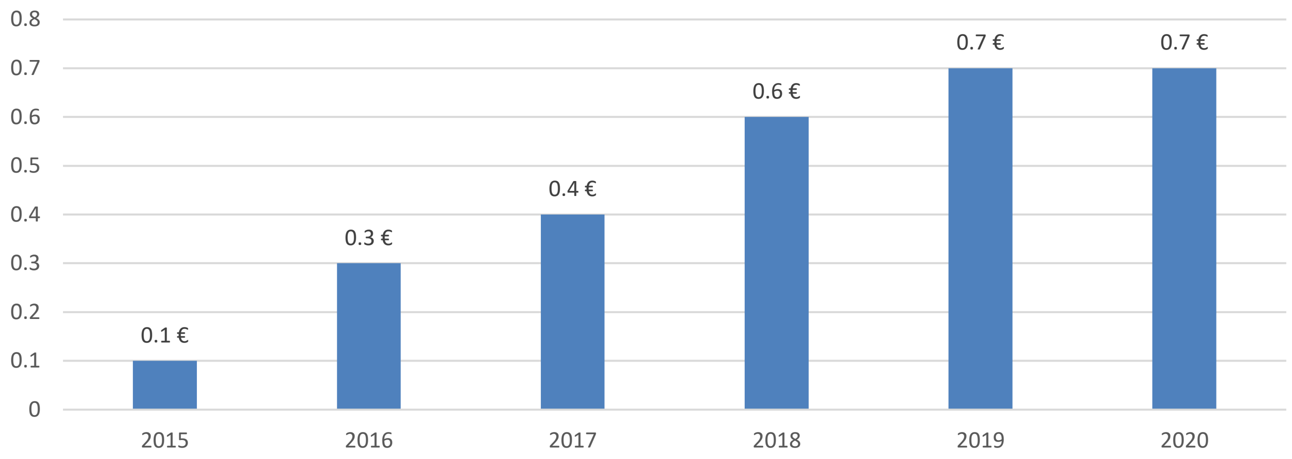


Figure 51 - BVOD revenues of selected networks in the European Union + UK from 2015 to 2020 (in billion euros).

Source: Statista, 2021

With the exception of some British TV channels, BVOD revenues are still a fragment of TV advertising ("analogue euros for digital cents") revenues in Europe for broadcasters but might set to play an important role in the near future. Room for growth and capture advertising spend might increase with higher online consumption by consumers.

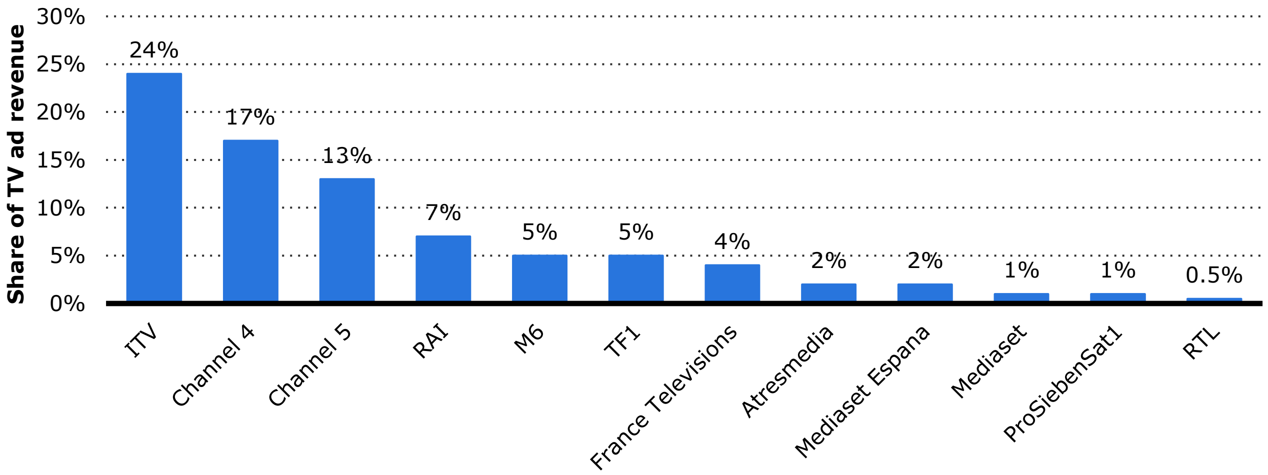


Figure 52 - Share of revenues BVOD of the total TV advertising revenue in the European Union + UK in 2020, by network.

Source: European Audiovisual Observatory, 2020

3.2.3 The COVID-19 impact on audio-visual consumption in the EU

Latest research by the European Audiovisual Observatory suggests the audiovisual sector lost over 6% of its revenues in 2020 compared to 2019[41], and close to 9% excluding on-demand services (EAO, 2020). However, many shares of the market resisted to this crisis. For instance, although its growth rate slowed down compared to the previous year, SVOD was immune. Pay TV was only marginally affected by the crisis and its resilience can be explained by bundled internet access and pay-tv packages. Among the linear distribution platforms only cable, due to digital, and IPTV were the ones where pay TV was able to expand revenue market share in 2020, up to 33% and 26%, respectively, both through uptake and ARPU. Another resilient share of the market is the public funding of broadcasters (remaining normally flat over 5 years). Another beneficiary of the lockdowns is the digital, transactional video on demand market, which combined with the physical market only decreased by 6%.

During 2020, consumers in Europe increased their linear and on-demand audiovisual content consumption.

On the linear TV consumption, Nielsen studies (Table 24) show that **home-bound consumers have led to a 60% increase in the amount of video content watched globally**. As each country was at a different stage of their COVID-19 response, TV engagement varied, but one thing was consistent: time spent per viewer watching news and entertainment is going up as the spread of COVID-19 worsens. This increase in daily television viewing time is also confirmed by data from the European Broadcasting Union (EBU): viewing time stood at 3h 43m in 2020, up 6 minutes on 5 years ago and 15 minutes versus 2019. For younger audiences viewing time stood at 1h 39m, which despite an increase of 7 minutes compared to 2019 is still below the highest historical figure recorded in 2015. Among youth, the EBU reports 11 markets in 2020 with an average daily viewing time of under one hour, compared to 1 market 5 years ago.[42]

[41] Greater Europe, which refers to the entire geographic space between Iceland and Norway in the North and Turkey in the South and the space from Portugal in the West to Russia in the east. In this analysis, the following countries were considered CH, IS, ME, MK, NO, RU and TR.

[42] In terms of weekly television reach, there is a similar pattern for younger people 62.5% of which were reached by television in 2020 (11.4 percentage points on 5 years ago). In 2020, 17 markets recorded an average weekly reach of European youth below 60% compared with 2 markets 5 years ago.

In addition, the EBU (2021) reports on the performance of the PSM television market, which compared to the general television market has had a positive performance in terms of retaining audiences (consistent across age groups): among youth PSM daily market share stood at 17.7% in 2020, up 2.6 percentage points on 5 years ago and up 0.7 percentage points versus 2019.

Member State	2/3/20 - 8/3/20	9/3/20 - 15/3/20	16/3/20 - 22/3/20	23/3/20 - 29/3/20
Bulgaria	291	307	334	357
Croatia	287	287	332	384
Cyprus	226	283	326	346
Czech Republic	229	252	280	273
Greece	320	354	409	439
Hungary	296	294	331	348
Ireland	148	168	187	177
Italy	297	345	357	370
Poland	266	288	312	313
Slovenia	253	375	301	331
Sweden	143	143	149	146

Table 24 - Average TV Engagement per person in minutes for selected Member States, in March 2020.

Source: Nielsen, 2020

Similarly, the Yearbook 2020/2021 of European Audiovisual Observatory shows that also on-demand media consumption has increased among the population in Europe. Specifically, Figure 53 indicates that the first lockdown has encouraged many more European households to experiment with SVOD and other platforms such as AVOD and BVOD, whereas consumption through TVOD remained constant.

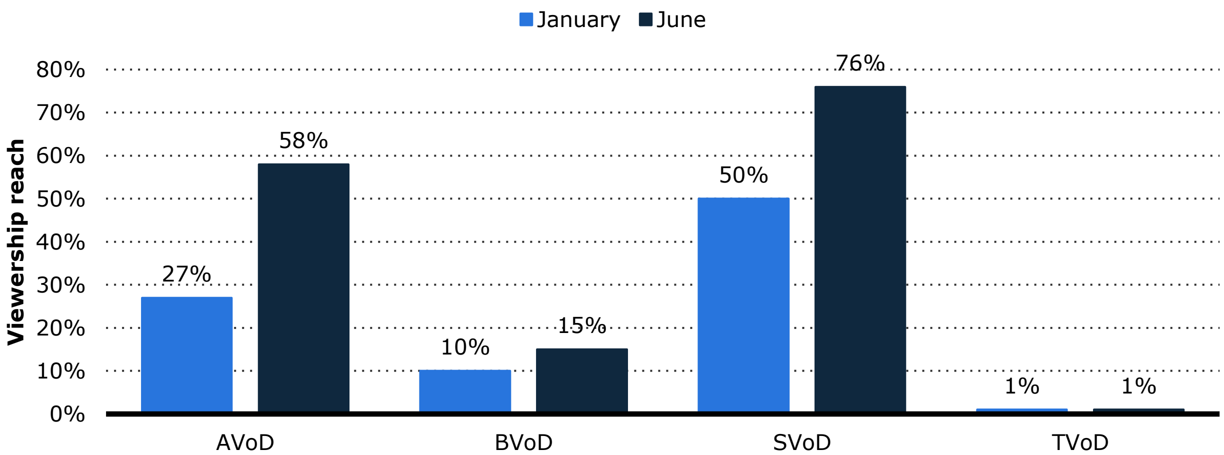


Figure 53 - Video-on-Demand (VoD) reach in Europe in January and June 2020, by VoD type.

Source: Samsung Ads, 2021

Public service broadcasting (PSB) groups benefited from the positive viewing trends in national audience markets. In 2020, the average audience market share of European[43] PSBs grew by 4% over

[43] Public service broadcasting (PSB) groups benefited from the positive viewing trends in national audience markets. In 2020, the average audience market share of European3 PSBs grew by 4% over the previous year. An increased need for news since the start of the pandemic is likely to be among the factors explaining this boost.

the previous year. An increased need for news since the start of the pandemic is likely to be among the factors explaining this boost.

Stay-at-home orders throughout the European continent provided a major boost to streaming services, as consumers increased, and shifted, their content consumption online throughout 2020 (EAO, 2020).

Nevertheless, in terms of subscriptions, the 2020 growth of SVOD (+46%) was similar to 2019 (+45%), which implies that COVID contributed to an ongoing trend, but not created a new one. In addition, this growth of SVOD subscriptions did not happen at the expense of pay TV services (which also registered an increase of 1.9% in terms of subscribers) (EAO, 2021).

As a consequence of this economic crisis, and related changes in consumer behaviour may well have intensified the ongoing shift of advertising budgets online (EAO, 2020). The years 2019 and 2020 will be looked back on as the time when direct-to-consumer services entered the mainstream in terms of consumption habits of audiences in Europe (and elsewhere). This consumer need for online entertainment options found fertile ground: media players undertook a strategic shift to position streaming as a core focus in order to be able to compete with streaming giants Netflix and Amazon (EAO, 2020).

Especially with the increased significance of AVOD and BVOD services in content consumption by European audiences, these streaming services could become a hedge for traditional commercial broadcasters considering the decline of linear advertising revenues (EAO, 2020).

The European Audiovisual Observatory comments that traditional TV advertising will still be used for brand building purposes and remains the only medium that can reach a mass audience at the same moment, notably related to major live events, but the future of advertising will be one in which each consumer is individually targeted (EAO, 2020). The COVID-19 has accelerated some trends in the industry, and this shift in consumer content and purchase habits may have profound repercussions for the audio-visual industry.

3.2.4 Consumption forecast to 2025 and to 2030

3.2.4.1 Methodological approach

In order to forecast a time series, exponential smoothing and ARIMA models are among the most widely approached (Athanasopoulos and Hyndman, 2018). The main difference between the two approaches relies on the fact that exponential smoothing models are based on a description of the trend and seasonality in the data while ARIMA models seek to describe the autocorrelations in the data. Additionally, ARIMA models generally require at least 50 but preferably 100 historical observations as a rule of thumb (Box and Tiao, 1975).

For the latter reason, we opt for exponential smoothing as a forecasting approach throughout the rest of the report. Practically, exponential smoothing means that forecast data are weighted averages of past observations, with the weights decaying exponentially as the observations are getting older (Athanasopoulos and Hyndman, 2018). This means that the highest weight is attached to the more recent observations. There are three different types of exponential smoothing: single, double, and triple. We opt for the latter as it is the most general one allowing to deal correctly for both trends and seasonality in the data.

3.2.4.2 Main findings

The methodology described above is used to forecast consumption trends for both linear TV and VOD based on the data reported in the tables presented in sections 3.2.1 and 3.2.2. For **linear TV**, the forecast predicts a decrease by 6% in 2025 and by 13% in 2030 compared to the value observed in 2019 and reported by Eurodata TV Worldwide, although differences in this trend are observed across Member States, especially between the Nordic countries where the decrease in more marked and certain countries in Central and Easter Europe where instead an increase is predicted. For VOD, the forecast instead predicts a significant growth in the near future with an increase in revenues for on-demand audio-visual services of 126% in 2025 and 254% in 2030 compared to values observed in 2020 reported by the European Audiovisual Observatory. Another relevant increase is forecast in the usage of internet to watch TV which is predicted to grow by 21% in 2025 and 26% in 2030 compared to the value observed in 2021 and reported by Eurodata TV Worldwide. A sharp growth is also foreseen for the TVOD and the SVOD markets. Indeed, the forecast predicts an increase in revenues for TVOD retail of 1511% in 2025 and of 2014% in 2030 and an increase of 335% in 2025 and 446% in 2030 for TVOD rental compared to the values observed and reported by the European Audiovisual Observatory.

Regarding SVOD, in most markets, SVOD revenues are still a small part of audio-visual market revenues ranging from 1,1% and 14,8%, especially in markets where pay TV prices are low and pay TV penetration widespread, broadband penetration below EU27 average and the number of available SVOD services smaller. Finally, for SVOD the forecast predicts full penetration in Europe by 2027.

3.2.4.3 Limitations

The data provided by the European Audiovisual Observatory are used in this report for multiple forecasting exercises. The dataset has the advantages of covering multiple audio-visual markets, collecting information on each Member State and providing multiple observations over time which are all essential features for a proper forecasting analysis. On the other hand, some limitations should be noted. Indeed, while the provider is the European Audiovisual Observatory, the data are actually collected by Ampere Analysis, a market data and analytics firm specializing in the media sector. This entails that the exact data collection procedures adopted are not clearly stated which prevents us from providing a more detailed description of potential caveats. In its report (EAO, 2016), it explains the market share of main television networks (distinguishing between digital terrestrial television (DTT); satellite; cable; IPTV over DSL or fibre) is difficult to assess as households often use several networks (e.g. for main and additional TV sets). Reliable figures, to an extent, usually only take into account the main TV set (“primary reception”), and may lead to an underestimation of the actual market share of certain networks, in particular DTT (EAO, 2016). For this reason, we also conducted in-depth interviews with relevant stakeholders to validate our own assessment and extrapolation (Annex D for overview). In addition, when possible, we also use different data sources and compare main trends.

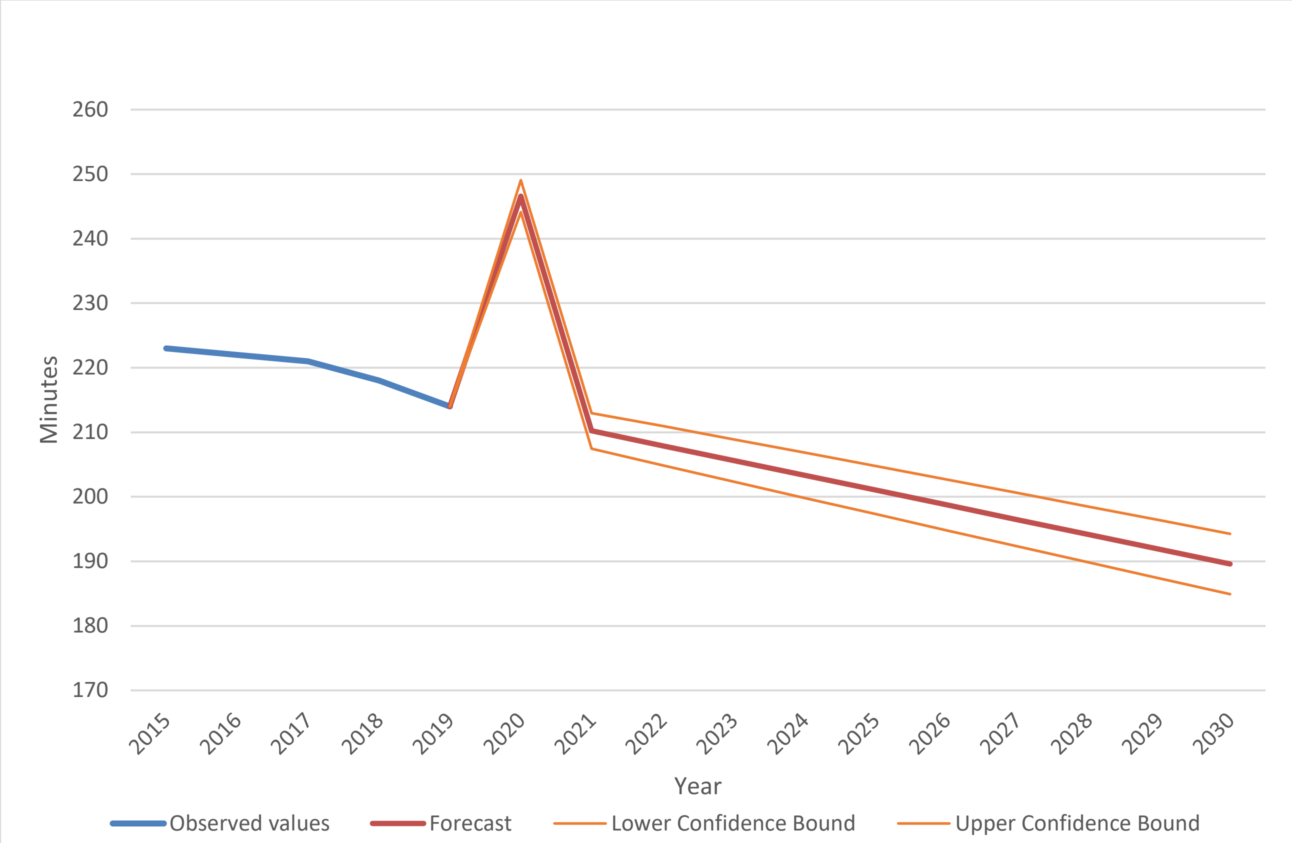


Figure 54 - Forecast average time watching television daily in EU27 and UK, 2015-2030.

Figure 54 shows the forecast average daily linear television viewing per person in the EU27[44] based on the data collected by Eurodata TV Worldwide, and reported in Figure 26 [45] As we can see, the trend is characterised by a spike in 2020 which corresponds to the widespread of the COVID-19 which results into an average increase of more than 13% in the average time spent watching linear TV daily in the EU27 and UK. This is comparable to the viewing time reported by the European Broadcasting Union for 2020, namely (3h 43m).[46] Nonetheless, the model predicts that the general downward trend observed before the pandemic will continue. The accuracy of this prediction clearly depends on how fast the COVID-19 crisis will abate. Nonetheless, it is reasonable to assume that the negative trend observed before 2020 will continue and will not be systematically changed as a result of an exceptional event such as the COVID-19 crisis. For 2025 and 2030, the average time spent watching

[44] This data includes figures of the UK (EU27+UK).

[45] The data to make the forecasting was also complemented with data from Nielsen (2020) who reported observations on average daily television viewing per person for 2020 for a selected number of Member States. This additional information is very relevant as it captures a preliminary effect of COVID-19 crisis. Since the data covers only a selected number of Member States, we first averaged the observations in table 12 to obtain a yearly value for each Member State. Then, in order to obtain the value for the entire EU in 2020 we calculate the average daily television viewing time per person weighting each value observed by the corresponding Member State population. With values for all the EU from 2015 until 2020, we finally did the forecasting with exponential smoothing in the same way as in all other forecasting in the report.

[46] In addition the same source distinguished between youth viewing time (1h 39m) which has been seen to continue decreasing compared to its historical peak in 201 (EBU)

linear TV daily in the EU27 and UK is estimated at 201 and 190 minutes respectively. These correspond to a 6% and a 13% decrease compared to the last value observed in 2019.

In the in-depth interviews with stakeholders (see Annex D for organisations consulted), it has been pointed out that the scaling of the graph is potentially misleading. However, the scale adopted is used to provide a clear identification of the trend and percentage decreases or increases are always reported below each graph and table in order to allow comparisons. Certain stakeholders have also indicated that they expect that once the spike related to the COVID-19 crisis will abate, the new level of linear television viewing is likely to be higher than the one observed pre-pandemic. Unfortunately, the data at our disposal do not allow us to further elaborate on this. Another observation from interviewees was that taking into account both linear and non-linear consumption would most likely result in stable if not growth in overall television viewing time.[47] DTT penetration has been indicated as an important factor explaining regional/country differences in addition to socio-economic and cultural factors (as well as variations between age groups).

Member State	2015	2016	2017	2018	2019	2020	Low 2025	2025	High 2025	Low 2030	2030	High 2030
AT	160	167	175	179	183	160	213	218	223	240	246	252
BE	183	183	180	171	170	182	140	146	152	120	126	133
BE(CFB)	194	199	195	183	179	194	134	151	167	106	126	147
BE(VLG)	174	172	171	164	163	174	137	142	147	118	124	131
BG	231	235	252	254	251	231	276	287	298	303	314	325
CY	204	204	209	209	210	204	221	223	225	228	230	233
CZ	206	208	211	210	206	206	200	208	215	198	208	217
DE	222	223	221	217	210	222	184	193	201	166	177	187
DK	175	160	150	142	137	175	69	80	90	21	34	47
EE	222	225	243	229	225	222	209	230	250	208	231	254
ES	234	229	225	233	222	234	212	224	236	209	222	235
FI	171	171	168	165	162	171	144	148	151	131	135	140
FR	224	223	222	216	210	224	182	189	196	162	171	180
GR	269	257	261	266	272	269	260	280	300	264	289	314
HR	265	265	260	260	268	265	260	268	275	262	269	277
HU	283	278	279	276	278	283	265	270	275	259	264	270
IE	194	186	175	167	157	194	100	101	101	55	55	56
IT	254	247	243	248	244	254	226	234	243	216	225	235
LT	214	225	236	224	215	214	185	216	247	174	213	251
LV	211	194	177	176	177	211	100	124	149	54	84	115
NL	189	183	178	173	156	189	104	112	121	63	73	83
PL	263	261	259	257	256	263	244	245	246	235	236	237

[47] For instance, in Germany a rise of average viewing time/overall TV content has been recorded with stronger development in the non-linear/on demand segment (resulting in an overall flat development of linear TV rather than a decrease i.e. viewing time went up around 10 minutes in 2020 and 2021).

PT	283	286	284	283	264	283	226	242	259	201	220	238
RO	329	347	346	337	329	329	293	324	355	277	316	355
SE	153	148	140	133	127	153	82	84	86	48	50	52
SI	205	215	215	218	227	205	236	243	250	258	265	273
SK	238	237	237	237	238	238	236	238	240	236	238	240

Table 25 - Forecast average time watching television daily in EU27, 2015-2030 disaggregated by Member State.

Source: European Audiovisual Observatory, 2021

The table above reports the forecast average daily television viewing per person by EU27 Member States based on the data collected by Eurodata TV Worldwide and reported in Table 14. Compared to the values observed in 2019, the sharpest decreases in daily television viewing are predicted for Denmark (-70% in 2025 and -300% in 2030), Ireland (-55% in 2025 and -185% in 2030) and Sweden (-51% in 2025 and -154% in 2030). On the other hand, for few countries the model actually predicts a slight increase in the average daily television viewing per person. Most notably Austria (+16% in 2025 and +26% in 2030), Bulgaria (+13% in 2025 and +20% in 2030) and Slovenia (+7% in 2025 and +14% in 2030).

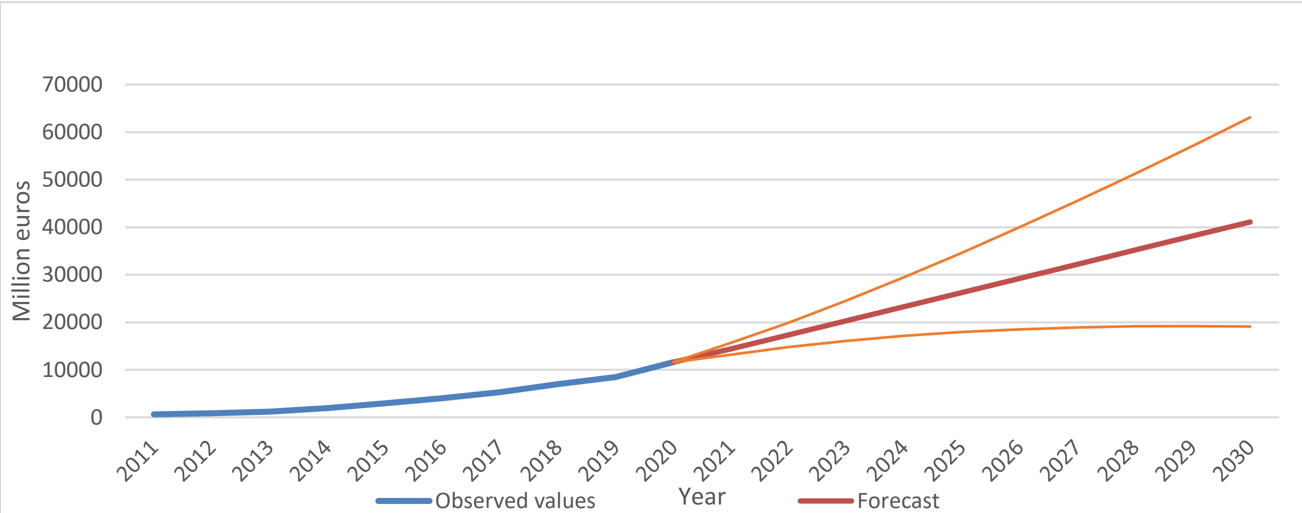


Figure 55 - Forecast consumer revenues for on-demand audio-visual services in the EU27 and UK, 2025-2030.

On the other hand, consumer revenues for on-demand audio-visual services in the EU27[48] are expected to further grow in the future as shown by the graph reported in Figure above. More specifically, the model forecasts an increase in revenues up to approximately EUR 26.2 billion in 2025 and EUR 41 billion in 2030. This represents an increase of respectively 126% and 254% compared to the EUR 11.6 billion revenues registered in 2020 by the European Audiovisual Observatory.

[48] This data includes figures of the UK (EU27+UK).

Some of the stakeholders that we have interviewed have pointed out that there are some signs of erosion in the growth of VOD consumer revenues. Some expect that subscriptions to VOD will peak and then decline also in light of increased competition from free-to-air offers.[49] In addition stakeholders point out that subscriptions to multichannel platforms (e.g. satellite, cable) have been declining and including this trend could lead to overall decreasing revenue volumes. Unfortunately, the data at our disposal do not allow us to further elaborate on this.

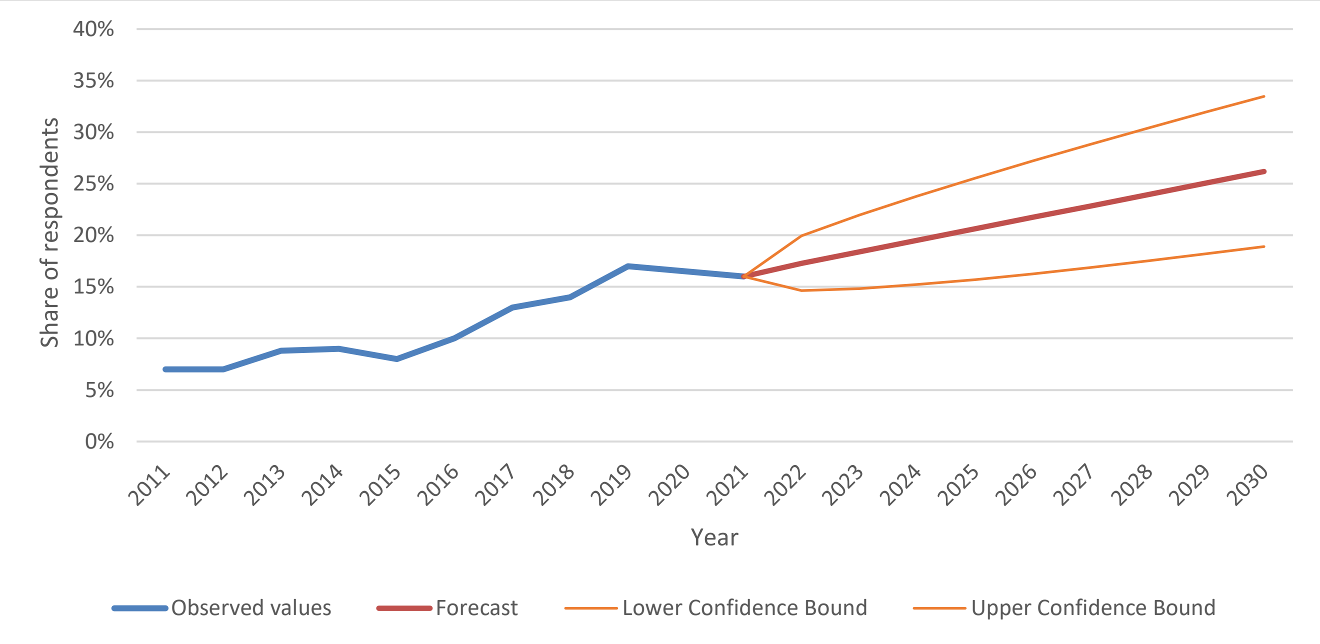


Figure 56 - Forecast share of people who watched TV via the internet every day or almost every day in EU27 + UK, 2025-2030.

The Figure above shows the forecast share of people who watch TV via the internet on a daily basis in the EU27 and UK based on the data collected by the Eurobarometer and reported in Figure 49 and Table 14. In line with the positive trend observed between 2011 and 2021, the model predicts a further increase in the shares of people who watch TV via the internet on a daily basis up to 21% in 2025 and 26% in 2030. Some stakeholders have raised concerns on the interpretation of the graph. To further clarify, the category 'people who watched TV via the internet every day or almost every day' doesn't consist in people who watch TV exclusively via the internet as other forms of media use are also contemplated. Nonetheless, the graph clearly indicates that more and more people in the EU are using the internet to watch TV content while other forms such the use of the television via a TV set, the radio and written press are characterised by a declining pattern according to the data released by the Eurobarometer. Although stakeholders partially agree that more people will watch content over IP networks in the future, they question the sustainability of this trend citing economic feasibility (related

[49] Nevertheless this development does not hold true for all EU Member States: for instance in Germany there is a double-digit Compound Annual Growth Rate recorded for specific subsets of the VOD market (i.e. SVOD; AVOD rather than TVOD).

both to the price of fixed broadband subscriptions and potential additional cost of content), carbon footprint[50] and digital divide (fibre access)[51]

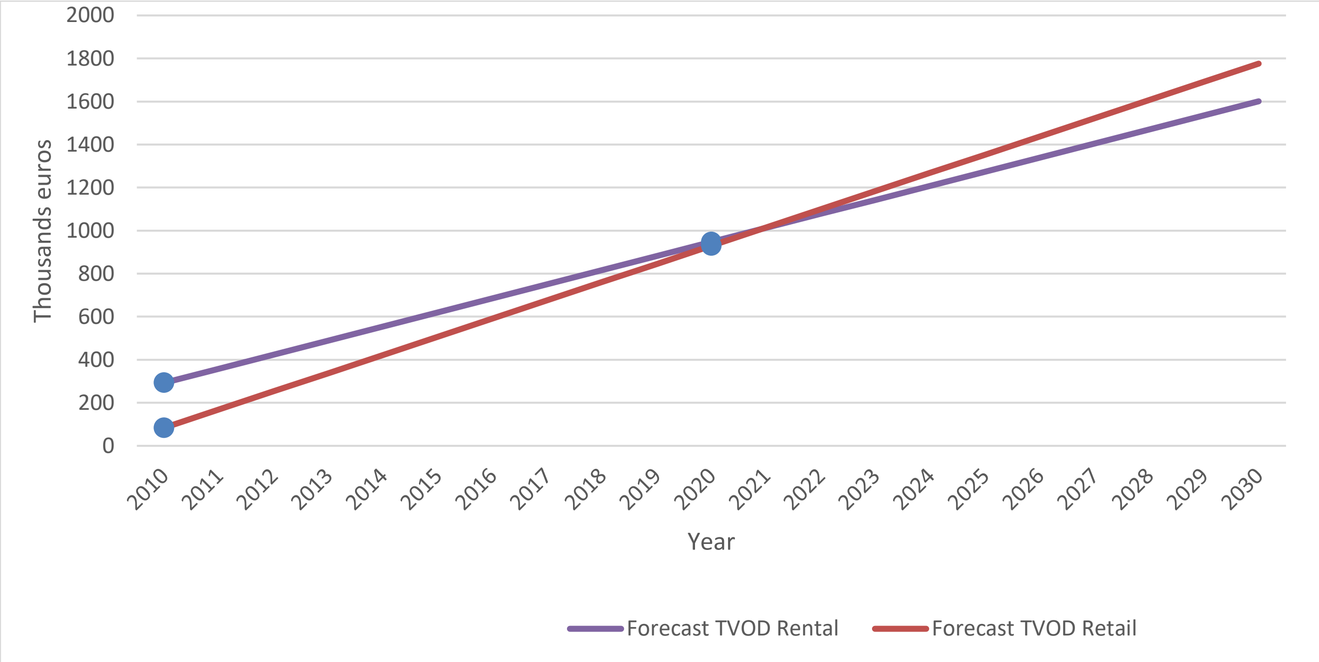


Figure 57 - Forecast consumer revenues in TVOD market in EU27 + UK, 2025-2030. Linear prediction over the two observed data points for 2010 and 2020 for TVOD Rental and TVOD Retail.

The Figure above shows the forecast consumer revenues for the digital segment of the home video market (TVOD) split between rental and retail based on the data collected by the European Audiovisual Observatory in 2010 and 2020 and reported in Table 21. Since there are only two data points observed, the graph in the Figure above is drawn as a linear prediction and not with an exponential smoothing as done for all the other forecasts. The forecasting should thus be interpreted with cautions. As we can see, consumer revenues for TVOD retail are expected to increase comparatively more than consumer revenues for TVOD rental and as of 2022 consumer revenues for TVOD retail will supersede those from TVOD rental. The model forecasts an increase of 335% for TVOD rental and 1511% for TVOD retail in 2025 and 446% for TVOD rental and 2014% for TVOD retail in 2030 compared to the values observed in 2020.

[50] Study by Carnstone (2021) shows DTT is 10 times more energy efficient compared to IP networks

[51] Nevertheless, there are notable for instance in Finland, the national public service media company foresees that internet publishing will become the main publishing platform by approximately 2025.

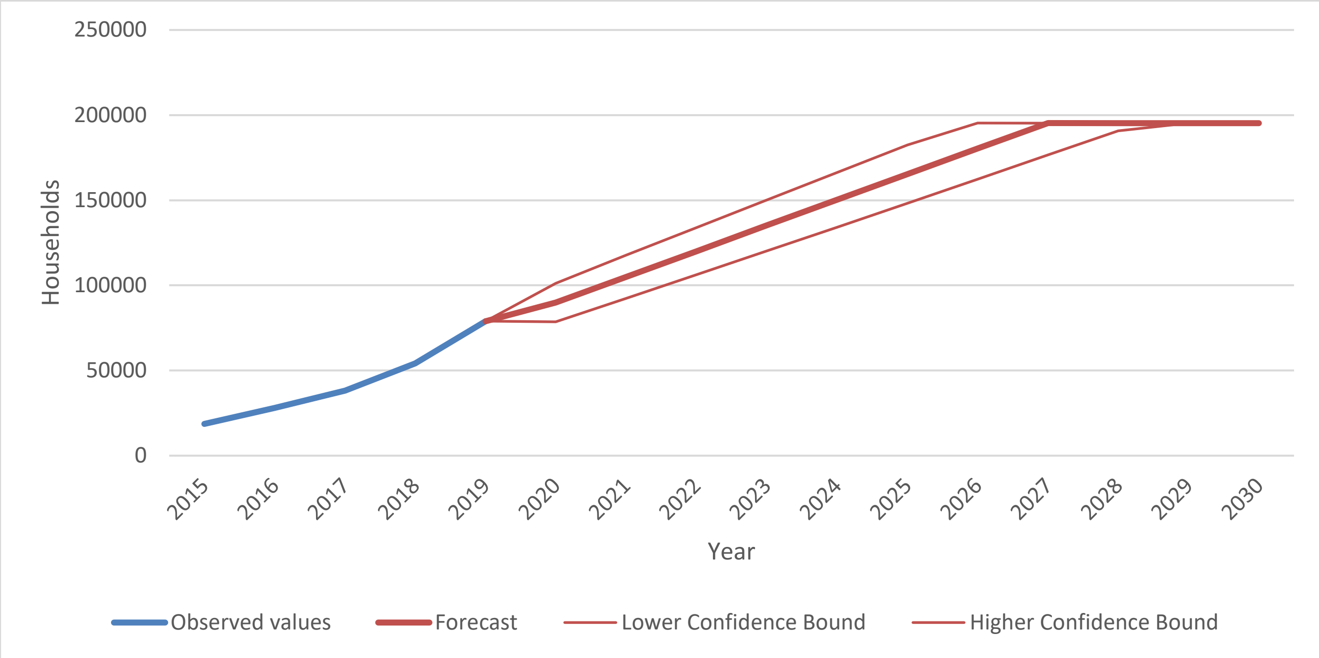


Figure 58 - Number of households subscribing to SVOD in EU27, 2025-2030.

The figure above shows the forecast number of households subscribing to SVOD in the EU27 based on the data collected by the European Audiovisual Observatory and reported in figure above. The model predicts that the number of households subscribed to SVOD will more than double by 2025 (+109%) and reach full penetration as of 2027. It is noteworthy to mention that the relative novelty of SVOD services and the low number of past observations may overestimate the steep growth predicted. Indeed, it is plausible to expect that a certain number of households in each Member State may actually not decide to get access to SVOD due to financial constraints or lack of interest. Additionally, some of the stakeholders interviewed agree that it is unrealistic to assume that there will be complete broadband access. However, for SVOD, data from a selected number of countries such as Spain and the US[52] seems to indicate that the growth will peak earlier and then become relatively flat.[53] Unfortunately, the data at our disposal do not allow us to further elaborate on this.

3.3 Linear broadcasting platforms analysis

The distribution of television and video content is becoming increasingly complex with viewing preferences, especially for young generations, moving towards a situation in which content is available on demand. In this regard, data clearly indicates a growing presence of nonlinear TV services and over-the-top (OTT) content offerings (Abreu et al., 2017). Despite these trends, most viewing is still nowadays linear, meaning that consumption of content occurs at the time of broadcast,

[52] The US subscribers of SVOD were cutting subscriptions to multichannel platforms: as a result SVOD users increased linear and local channel consumption via DTT. (Statista and RapidTVnews, 2021 via stakeholder interviews).

[53] Other trends include internet access and broadband penetration and consumer purchasing power/disposable income to acquire such services. For instance, stakeholders point out that in Italy: a 9.8% of customers have no IP connection and 29.8% of customers with mobile broadband only (insufficient for SVOD).

directly from the broadcast source (Sims et al., 2017). Such content is usually broadcasted on dedicated networks e.g., analogue and digital terrestrial television, cable, satellite, or broadband-based internet protocol television (often referred to as IPTV). What follows is a more in-depth analysis of the four main platforms through which content is consumed by viewers. In addition, an evaluation of current and future revenues for each market is provided based on the data provided by the European Audiovisual Observatory. The forecasting indicates that revenues for pay-DTT[54] are decreasing quite substantially, by 40% in 2025 and by 70% in 2030 compared to the values observed in 2018. On the other hand, revenues for cable, satellite and IPTV are expected to increase. For cable, the forecasting predicts an increase of 6% in 2025 and 11% in 2030 compared to the values observed in 2019; for satellite there is an increase of 10% in 2025 and 20% in 2030 compared to values observed in 2019; finally for IPTV there is an increase of 35% in 2025 and 63% in 2030 compared to the values observed in 2019.[55]

Note that the following sections presents forecasts for 2025 and 2030. The visualisations include 'real' data up to the year 2020 as collected by EBU (and as presented in section 3.2)

3.3.1 Terrestrial TV

Terrestrial TV services rely on a network of transmitter towers distributed around a given region. The highest towers provide wide area coverage and constitute the main network which is then complemented by a set of smaller towers needed to extend the coverage or fil the gaps (Broadcast Network, 2021). The number of main towers and complementary small towers varies by the country size and geography. The towers broadcast the TV signal through either VHF (very high frequency) or UHF (ultra-high frequency) transmission. Both VHF and UHF are part of the electromagnetic spectrum which are typically reserved for short-range communication. Signals do not generally travel far enough to affect communications in distant areas which makes them ideal for usage in TV and radio broadcasting. However, hills, mountains, or even large buildings can block terrestrial TV signals, meaning that a number of transmitter towers may be required to ensure that a given area has complete coverage (Adview, 2015).

Currently, UHF is preferred over VHF as there are a greater range of suitable frequencies for transmitting TV even though the properties of UHF transmission entails that the tolerances in reception equipment must be tighter to enable clear reception (Adview, 2015). With the expansion of

[54] DTT is Digital terrestrial television which is a technology for terrestrial television in which land-based (terrestrial) television stations broadcast television content by radio waves to televisions in consumers' residences in a digital format. The advantages of digital terrestrial television are similar to those obtained by digitising platforms such as cable TV, satellite, namely more efficient use of limited radio spectrum bandwidth, provision of more television channels than analogue, better quality images, and potentially lower operating costs for broadcasters (after the initial upgrade costs). DTT is also free but the Pay-DTT indicates having to subscribe to paid television services in order to continue receiving free-to-air channels.

[55] As already highlighted in section 3.2.4.3, one important limitation when it comes to concerns the platform distribution analysis reported by the EAO (2016). In its report, it explains the market share of main television networks (distinguishing between digital terrestrial television (DTT); satellite; cable; IPTV over DSL or fibre) is difficult to assess as households often use several networks (e.g. for main and additional TV sets). Reliable figures, to an extent, usually only take into account the main TV set ("primary reception") and may lead to an underestimation of the actual market share of certain networks, in particular DTT. For this reason, we also conducted in-depth interviews with relevant stakeholders to validate our own assessment and extrapolation (Annex D for overview).

technology, the range of usable frequencies has also substantially expanded with reception and broadcast equipment also becoming increasingly cheaper.

The relatively short-range nature of terrestrial transmissions means that several transmitter sites are required. For example, in a market such as the UK, this would be over 1,000 transmission towers to reach 99 % population coverage while in a market as large as China, in excess of 30,000 transmitter sites would be required for substantial population coverage using similar frequencies and technologies as North America and Europe (Adview, 2015).

Over the last twenty years, digital terrestrial (DTT) services have replaced many of the analogue terrestrial TV services across the world with the consequence that the spectrum can be reallocated to revenue generating services such as mobile broadband. DTT allows to distribute a set of programs (typically between 20 and 50), which are digitally coded and grouped in multiplexes (typically 4 to 8) then transmitted over the air from the TV towers (high power high tower infrastructure) operated by Broadcast network operators throughout the territory (Broadcast Network 2021).

Digitization of the terrestrial platform has several benefits (GSMA, 2014):

- It allows more efficient use of limited radio spectrum bandwidth.
- It allows the provision of more television channels.
- It allows for regulatory and government bodies to reclaim spectrum and repurpose it.

Member State	2014	2015	2016	2017	2018	Low 2025	2025	High 2025	Low 2030	2030	High 2030
AT	2	3	4	5	5	12	12	12	16	16	17
BE	0	0	0	0	0	0	0	0	0	0	0
BG	0	0	0	0	0	0	0	0	0	0	0
CY	0	0	0	0	0	0	0	0	0	0	0
CZ	0	0	0	0	0	0	0	0	0	0	0
DE	0	0	0	0	0	0	0	0	0	0	0
DK	129	135	128	121	111	58	76	93	28	49	71
EE	9	9	8	10	13	16	20	24	21	25	30
ES	36	18	0	0	0	0	0	0	0	0	0
FI	49	46	42	39	38	15	17	19	1	3	5
FR	456	406	370	348	321	61	93	124	0	0	0
GR	0	0	0	0	0	0	0	0	0	0	0
HR	4	5	6	6	7	12	13	14	16	17	18
HU	7	6	6	6	6	3	4	4	1	2	3
IE	0	0	0	0	0	0	0	0	0	0	0
IT	538	558	617	588	535	432	555	678	401	552	703
LT	4	4	3	3	2	0	0	0	0	0	0

Member State	2014	2015	2016	2017	2018	Low 2025	2025	High 2025	Low 2030	2030	High 2030
LU	0	0	0	0	0	0	0	0	0	0	0
LV	7	6	5	4	4	0	0	0	0	0	0
MT	10	9	8	7	5	0	0	0	0	0	0
NL	60	53	44	37	31	0	0	0	0	0	0
PL	0	0	0	0	0	0	0	0	0	0	0
PT	0	0	0	0	0	0	0	0	0	0	0
RO	0	0	0	0	0	0	0	0	0	0	0
SE	216	201	190	170	152	34	41	47	0	0	0
SI	0	0	0	0	0	0	0	0	0	0	0
SK	0	1	1	1	1	1	2	2	2	2	2
EU27	1527	1459	1431	1344	1230	677	738	799	305	373	441

Table 26 - Forecast revenues for pay-DTT in millions of euros, 2015-2030 disaggregated by Member State.

Source: European Audiovisual Observatory, 2020

The Table above reports the forecast revenues for pay-DTT by EU27 Member States based on the data collected by the European Audiovisual Observatory from 2014 until 2018. As can be seen from this table, most revenues for pay-DTT in EU27 are concentrated in a handful of Member States. In 2018, the last observation collected by the European Audiovisual Observatory, more than 80% of all EU27 revenues were concentrated in only three countries, namely Italy (43%), France (26%) and Sweden (12%). With respect to the forecasting, the model predicts that already by 2025 most of the revenues for pay-DTT will be concentrated in Italy (66%) with the share of revenues from France (11%) and Sweden (5%) considerably reduced. Finally, as of 2030 the concentration of revenues will be even more pronounced with more than 80% of the EU27 revenues for pay-DTT coming only from Italy.

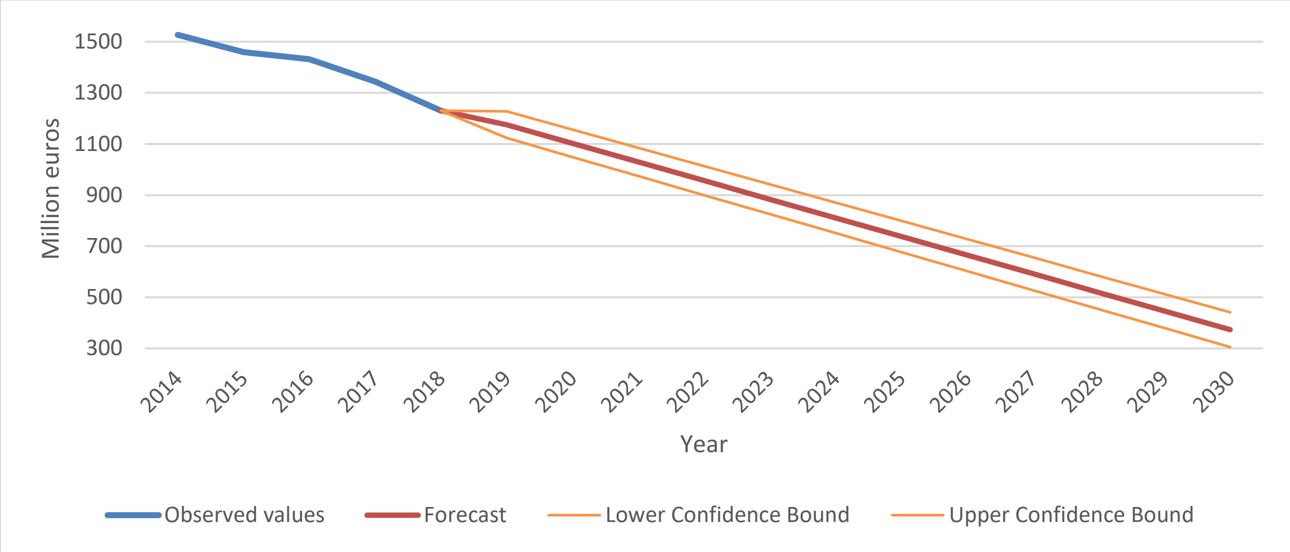


Figure 59 - Forecast revenues for pay-DTT in EU27, 2025-2030.

The previous figure shows the forecast revenues for Pay-DTT for the entire EU27. As we can see, the model predicts that the negative trend observed between 2014 and 2018 continues with revenues for pay-DTT reaching the value of 738 million euros in 2025 (-40% compared to 2018) and 373 million euros in 2030 (-70% compared to 2018).

3.3.2 Cable TV

Cable TV services were basically the first non-terrestrial TV transmission medium which originated in United States in the late 1940s and were designed to improve the reception of commercial network broadcasts in remote areas (Britannica, 2021). The functioning of cable TV is relatively simple. It consists of a system of wires and amplifiers used to gather television and radio signals from a variety of sources and deliver them to the homes in a given geographic area.

While cable rely on much the same methods of transmission as terrestrial TV services, using frequencies in the UHF range, the signal is on the other hand disseminated along a copper or fiber cable (Adview, 2015). Given that cabling shields the TV signal from interference from external signals and also avoid that the transmission is carried from leaking and affecting terrestrial communication, cable TV has become more than a simple retransmission mechanism. The spectrum that is reserved for other uses in the terrestrial domain could be re-used via cable, allowing multiple additional TV channels and radio stations to be carried (Adview, 2015). The larger number of channels available made cable TV ideal for use in broadcasting pay TV, where users would pay extra in order to receive more channels.

There has been a great evolution of cable services. From its inception, cable services have moved to digital encoding of their signals, accompanied by roll-out of two-way data services. These enables subscribers to communicate with programming facilities or information centers within the system. For example, home viewers can use the cable connection to participate in public-opinion polls or call up various kinds of written and graphic materials. The latter feature is offered by systems called videotex, which were first introduced in Great Britain and West Germany (Britannica, 2021). Two-way cable-television systems increasingly allow subscribers with home computers to link up with computer networks, giving the subscribers access to data banks and permitting them to interact with other online users. Cable operators have also experimented with video compression, digital transmission, and high-definition television (HDTV).

The main important disadvantages of cable generally arise from the fact that households must be physically connected to the network in order to receive the signal. Cabling large numbers of households is extremely expensive and necessitates vast quantities of up-front capital expenditure. Costs of cabling on a per household basis vary depending on population density and geographical or planning issues, but a typical cost in developed markets such as the US or Western Europe would be EUR 500- EUR1,000 per home connected or greater, and in the region of €200 for developing markets, such as China (Adview, 2015).

Furthermore, cable TV is usually economically profitable only in highly populated areas. Indeed, returns on investments are unlikely in more sparsely populated area due to the cost of cabling geographically dispersed houses (Broadbadnow, 2021).

Member State	2015	2016	2017	2018	2019	Low 2025	2025	High 2025	Low 2030	2030	High 2030
AT	315	312	315	303	328	315	333	351	324	343	361
BE	823	816	817	820	821	810	820	830	808	820	832
BG	104	95	93	92	92	66	76	87	52	64	77
CY	10	10	11	11	12	16	17	17	19	20	21
CZ	99	98	102	106	107	123	127	131	135	139	144
DE	3139	3155	3240	3243	3238	3357	3406	3454	3491	3539	3588
DK	566	562	545	510	476	299	337	375	169	216	264
EE	26	26	26	24	26	19	21	23	16	18	20
ES	235	305	366	366	371	482	574	666	616	731	846
FI	482	498	518	524	536	604	617	629	667	682	698
FR	236	271	297	326	365	545	551	557	703	708	714
GR	0	0	0	0	0	0	0	0	0	0	0
HR	26	27	28	30	32	39	40	42	46	47	49
HU	206	209	211	222	232	261	272	283	293	307	321
IE	106	94	73	64	62	0	0	0	0	0	0
IT	0	0	0	0	0	0	0	0	0	0	0
LT	26	25	25	25	24	20	21	21	17	18	18
LU	35	34	33	32	31	26	27	28	22	23	24
LV	17	18	18	18	17	17	18	19	17	18	19
MT	14	13	15	16	18	23	25	27	29	31	34
NL	1058	1031	1000	1007	1015	895	948	1001	833	900	966
PL	697	689	681	685	697	670	694	718	666	696	725
PT	258	272	285	293	304	365	371	376	420	426	433

Member State	2015	2016	2017	2018	2019	Low 2025	2025	High 2025	Low 2030	2030	High 2030
RO	296	311	328	345	364	461	465	469	545	550	555
SE	270	275	286	264	285	247	271	294	236	262	288
SI	70	69	67	68	67	59	62	64	55	58	61
SK	49	45	46	47	49	44	50	57	44	52	61
EU27	9164	9258	9424	9444	9571	10039	10148	10257	10444	10588	10732

Table 27 - Forecast revenues for cable audio-visual services in millions of euros, 2015-2030 disaggregated by Member State.

Source: European Audiovisual Observatory, 2020

(1) Data for IT is not available.

(2) Predictions for IE are not available.

The Table above shows the forecast revenues for cable audio-visual services by EU27 Member States based on the data collected by the European Audiovisual Observatory from 2015 until 2019. As in the case of Pay-DTT, most revenues for cable audio-visual services in EU27 are concentrated in a handful of Member States. In 2019, the last observation collected by the European Audiovisual Observatory, Germany was the country with by far the highest revenues accounting for more than 34% of all EU27 revenues followed by the Netherlands (11%) and Belgium (9%). The predictions of the model indicate a similar situation in the EU27 for subsequent years, with revenues for cable audio-visual services mostly concentrated in Germany (34% in 2025 and 33% in 2030) followed again by the Netherlands (9% in 2025 and 8% in 2030) and Belgium (8% for both 2025 and 2030).

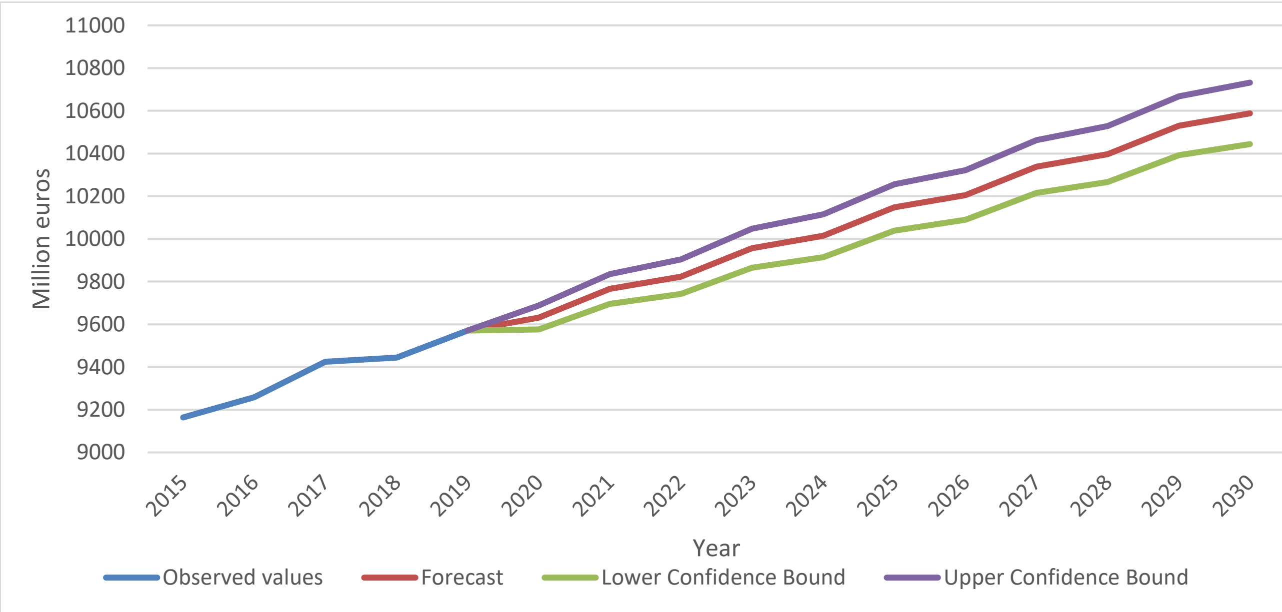


Figure 60 - Forecast revenues for cable in EU27, 2025-2030.

The Figure above shows the forecast revenues for cable audio-visual services for the entire EU27. As we can see, the model predicts that the positive trend observed between 2015 and 2019 continues, with revenues for cable audio-visual services reaching the value of 10 billion euros in 2025 (+6% compared to 2019) and 10.5 billion euros in 2030 (+11% compared to 2019).

3.3.3 Satellite TV

TV content was broadcast for the first time via satellite in the 1960s but it was not until the 1980s and 1990s that the platform really began to take off as a means for domestic television reception (Klein, 2012).

The services provided by satellite TV transmit signals in the C-band or Ku-band frequencies of the electromagnetic spectrum. These frequencies do not fall in the same areas of spectrum which is used for radio distribution and for terrestrial television as these are using a higher frequency (Mignone et al., 2011). Indeed C-band and Ku-band frequencies are usually not effective for TV transmission from terrestrial transmitter towers or masts, given that the signals are prone to interference from geographical features and buildings which in turn cause them to attenuate rapidly. On the other hand, when the signal is delivered in the frequency ranges using satellites, there are typically no such obstacles which in turn allows C-band and Ku-band frequencies to be an effective method of signal dissemination (Mignone et al., 2011).

Even though there are no physical obstacles, the satellite is at 42 thousand kilometers distance from the earth which means that the signal is usually relatively weak when it reaches the reception point. This means that specialized equipment, namely a parabolic satellite dish, is needed in order to collect the signal from the satellite and then reflects into a central reception antenna (Adview, 2015). This process allows the signal to be amplified and eliminate at the same time any interference or noise. Compared to cable and terrestrial TV, the broadcasting of analogue and digital satellite always requires a specialized satellite set-top box to decode the signal. The reason is that satellite broadcasts are encoded at different frequencies to broadcasts occurring via terrestrial or cable TV (Adview, 2015).

Among the advantages of satellite there is the higher frequencies which satellite broadcasts rely on in terms of data transfer which allow satellite to carry more channels than equivalent cable or terrestrial TV services (Broadbadnow, 2021). In addition, compared to cable and terrestrial TV, start-up costs are lower and, at the same time, an entire market or region can be covered disregarding how densely populated making satellite TV a more economical proposition in more sparsely populated areas (Adview, 2015).

Satellite TV has some disadvantages compared to other broadcasting platforms. The disadvantage of satellite TV services compared to cable TV or IPTV is that there is no one-to-one connection which in turn means that it is rather difficult to enable true interactive services via satellite TV. Any signal that is sent out is picked up by all the users of the satellite service. As a consequence, satellite services have been turning to alternative methods of connection to enable interactive services such as a secondary connection to the set-top box, often in the form of a broadband connection (Adview, 2015). The delivery of content in a one-to-one basis to users, as well as interactive services can then be achieved. Another potential disadvantage arises from the fact that bad weather conditions such as solar flares, sun outages, strong winds or heavy rainstorms or snowstorms may create troubles in the reception of the signal (Offerband, 2021).

Member State	2015	2016	2017	2018	2019	2020	Low 2025	2025	High 2025	Low 2030	2030	High 2030
AT	149	160	171	182	193	197	259	259	260	314	315	316
BE	34	36	37	38	39	39	45	46	47	51	52	53
BG	57	61	62	67	72	75	88	91	94	105	108	111
CY	0	0	0	0	0	0	0	0	0	0	0	0
CZ	73	78	81	84	100	112	123	130	138	151	160	168
DE	1196	1.361	1.582	1.679	1.740	1.737	2384	2547	2710	3001	3206	3410
DK	121	105	99	87	72	58	15	20	26	0	0	0
EE	7	7	7	6	6	5	4	4	4	2	2	2
ES	407	224	155	157	155	148	0	0	0	0	0	0
FI	37	31	30	33	35	31	20	28	36	14	23	32
FR	1984	1,773	1,664	1,600	1,519	1,413	706	874	1041	136	346	555
GR	224	226	221	218	211	199	168	179	190	141	155	169
HR	19	21	22	23	24	25	29	30	31	34	35	37
HU	81	78	75	71	67	63	47	49	52	29	33	36
IE	396	416	439	446	445	434	503	529	554	560	593	625
IT	2284	2,372	2,579	2,712	2,760	2,696	3495	3563	3630	4134	4202	4269
LT	12	11	10	9	8	7	0	1	2	0	0	0
LU	0	0	0	0	0	0	0	0	0	0	0	0
LV	7	6	6	6	5	5	3	3	3	0	0	1
MT	0	0	0	0	0	0	0	0	0	0	0	0
NL	141	140	136	134	135	134	121	123	125	112	114	116
PL	1285	1,245	1,244	1,194	1,139	1,126	1164	1190	1216	1118	1146	1175
PT	127	128	121	113	105	102	61	71	81	29	42	55
RO	167	167	169	187	191	184	228	238	249	264	275	287
SE	304	288	279	267	256	208	212	218	225	168	174	181
SI	5	3	5	6	6	6	13	14	14	17	18	18
SK	74	80	92	100	107	113	161	165	168	205	208	212
EU27	9192	9,016	9,287	9,419	9,389	9,117	10191	10491	10791	11046	11380	11715

Table 28 - Forecast revenues for pay satellite in millions of euros, 2015-2030 disaggregated by Member State.

Source: European Audiovisual Observatory, 2021

The Table above reports the forecast revenues for pay satellite by EU27 Member States based on the data collected by the European Audiovisual Observatory from 2015 until 2020. Most revenues for pay satellite in EU27 are concentrated in four Member States. In 2020, the last observation collected by the European Audiovisual Observatory, more than 76,5% of all EU27 revenues were concentrated in Italy (29,5%), Germany (19%), France (15,5%) and Poland (12,3%). With respect to the forecasting, the model depicts as rather similar situation for 2025 and 2030 with some changes. Indeed, while in Italy and Germany the share of revenues for pay satellite are expected to grow (34% in 2025 and

37% for Italy, 24% in 2025 and 28% in 2030 for Germany), in Poland and France the share of revenues is expected to decline (11% in 2025 and 10% in 2030 for Poland, 8% in 2025 and 3% in 2030 for France).

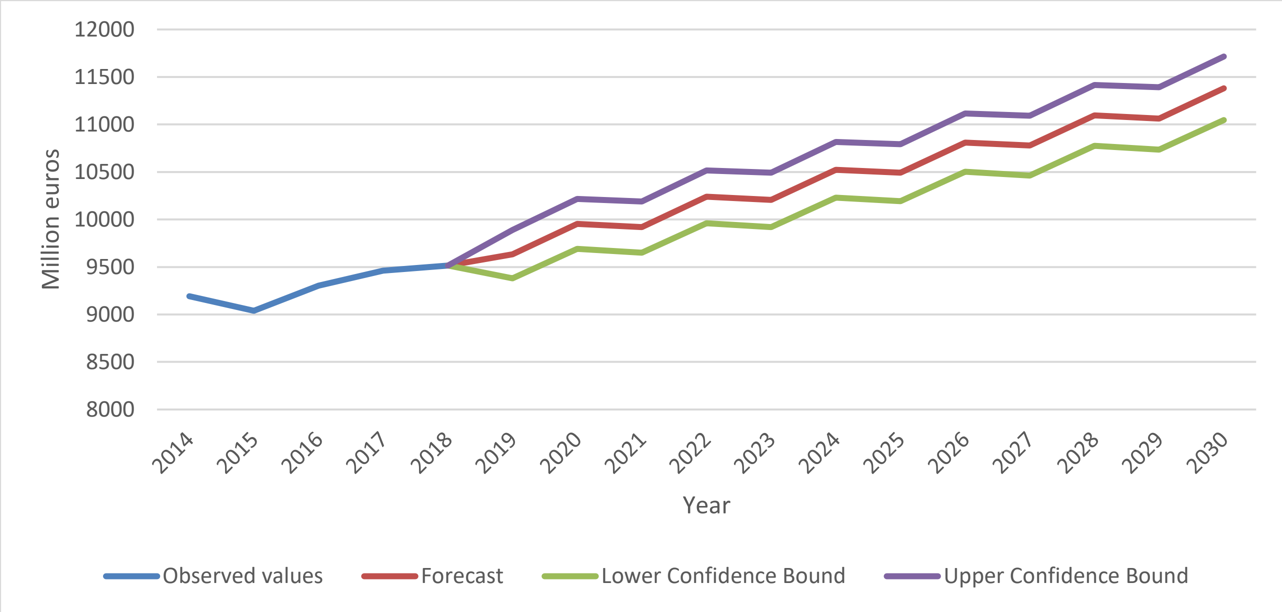


Figure 61 - Forecast revenues for pay satellite in EU27, 2025-2030.

The previous figure shows the forecast revenues for pay satellite for the entire EU27. As we can see, the model predicts that the positive trend observed between 2014 and 2018 continues, with revenues for pay satellite reaching the value of 10.5 billion euros in 2025 (+10% compared to 2018) and 11.3 billion euros in 2030 (+20% compared to 2019).

3.3.4 IPTV

IPTV is service that provides television programming and other video content using the Transmission Control Protocol/Internet Protocol (TCP/IP) suite, in contrast to broadcast TV, cable TV or satellite signals. In the same way as all data are delivered via Internet Protocol, IPTV uses a process called as packet switching in order to encode video into small chunks of data and send them piecemeal to designated IP addresses (Broadbadnow, 2021).

With IPTV, when the user switches channel, the signal is pass on the network, the unwanted channel signal switched off and the desired channel then sent to the user. This actually means that IPTV services are less constrained in the number of channels that can be offered in comparison to cable since the limiting factor, which is usually the bandwidth of the cable at the point of reception is no longer a major issue (Adview, 2015).

While similar in the functioning, IPTV services should be considered distinct from online or web-TV services. Indeed, IPTV services are delivered via a closed network which is usually owned by the IPTV service operator which make the information conveyed inaccessible to those that are outside the network. On this regard, IPTV services can be seen as analogous to digital cable TV operations since it is only the households that are connected to the network can access the TV service. This is not the case online TV services which are usually accessible through any internet-connected network (Broadbadnow, 2021). Based on interviews with stakeholders, IPTV is often used in additional to satellite and/or DTT (multiplatform households).

One main advantage of IPTV is the two-way nature of the connection. As a consequence, all IPTV set-top boxes can communicate with the network which allows the inclusion of interactive functionality especially straightforward, with on-demand services available by default for most IPTV systems (Adview, 2015).

One of the main issues currently faced by IPTV services arises from the fact that the infrastructure that is used is not designed to carry TV signals. Traditional copper telephone lines cannot accommodate a great deal of data, meaning that in older networks, the bandwidths at the user end may limit what can be received. Generally, standard ADSL lines are the minimum requirement for IPTV and will normally allow the delivery of a single standard definition TV channel if compressed using MPEG-4 to roughly 2Mbit/s (Offerband, 2021).

Member State	2015	2016	2017	2018	2019	2020	Low 2025	2025	High 2025	Low 2030	2030	High 2030
AT	26	28	30	32	34	35	47	47	47	57	57	58
BE	327	360	384	397	418	423	529	548	567	631	656	680
BG	15	18	22	26	31	36	54	56	58	75	77	80
CY	19	19	20	21	22	23	26	26	27	30	30	31
CZ	21	24	28	38	53	74	85	98	112	122	138	155
DE	716	759	888	969	1059	1.259	1619	1657	1695	2052	2092	2131
DK	190	197	211	224	233	199	302	308	314	358	365	372
EE	15	16	18	20	22	21	31	32	33	39	40	41
ES	612	853	953	1055	1085	1.030	1582	1791	2000	2087	2349	2610
FI	124	131	141	153	160	205	217	222	228	265	271	277
FR	2663	2668	2745	2829	2878	2.918	3178	3238	3298	3468	3535	3603
GR	13	10	10	11	15	38	12	19	25	15	23	31
HR	56	56	60	62	66	67	79	81	83	92	95	97
HU	68	76	85	90	96	109	133	137	142	166	172	178
IE	8	10	14	15	15	15	25	28	31	34	38	42
IT	10	0	1	5	12	21	00	16	34	0	21	44
LT	16	19	22	25	28	30	45	45	45	59	59	60
LU	14	17	18	20	21	22	30	32	34	38	40	43
LV	18	20	22	24	25	25	35	36	37	43	44	46
MT	4	6	8	11	13	15	26	28	29	38	40	42
NL	318	359	392	415	435	442	585	610	634	721	752	783
PL	64	78	91	81	93	105	107	124	141	133	152	170
PT	296	323	351	388	426	494	606	620	634	766	784	802
RO	4	5	6	8	9	10	16	17	17	22	23	23

Member State	2015	2016	2017	2018	2019	2020	Low 2025	2025	High 2025	Low 2030	2030	High 2030
SE	159	176	196	218	238	280	353	357	362	452	457	463
SI	64	70	79	85	89	89	125	128	130	156	159	162
SK	33	35	38	40	44	49	59	60	61	73	74	75
EU27	6254	6740	7245	7685	8089	8.034	10756	10866	10976	13022	13160	13297

Table 29 - Forecast revenues for IPTV in millions of euros, 2015-2030 disaggregated by Member State.

The Table above reports the forecast revenues for IPTV by EU27 Member States based on the data collected by the European Audiovisual Observatory from 2015 until 2020. Most revenues for IPTV in EU27 are concentrated in three Member States. In 2020, the last observation collected by the European Audiovisual Observatory, more than 64,8% of all EU27 revenues were concentrated in France (36,3%), Spain (12,8%) and Germany (15,6%). With respect to the forecasting, the model depicts a very similar situation for subsequent years, with revenues for IPTV concentrated in France (30% in 2025 and 27% in 2030) followed again by Spain (16% in 2025 and 18% in 2030) and Germany (15% in 2025 and 16% in 2030).

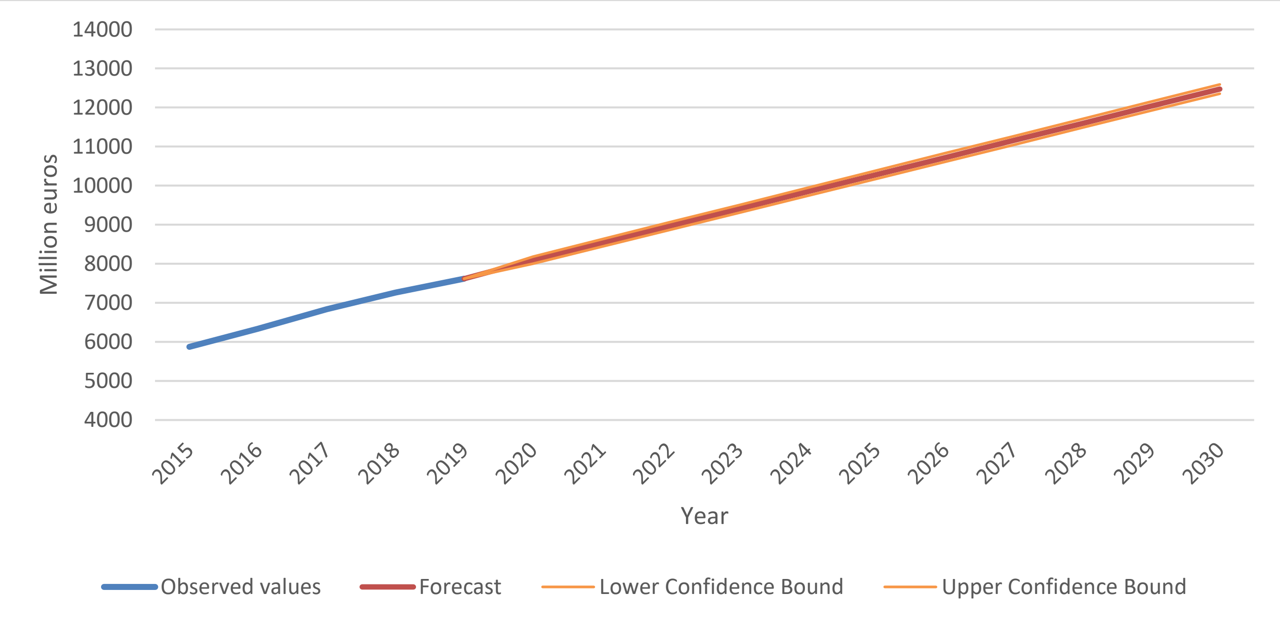


Figure 62 - Forecast revenues for IPTV in EU27, 2025-2030

The Figure above shows the forecast revenues for IPTV for the entire EU27. As we can see, the model predicts that the positive trend observed between 2015 and 2019 continues, with revenues for IPTV reaching the value of 10.2 billion euros in 2025 (+35% compared to 2019) and 12.5 billion euros in 2030 (+63% compared to 2019).

3.3.5 Broadcasting platforms market analysis

In this section, an overview on the status of the market for broadcasting platforms is provided. As already anticipated in the audiovisual consumption analysis, similar to consumption patterns, distribution mechanisms are heterogenous across European TV markets.

Member State	Cable	Satellite	Digital terrestrial	IPTV	Digital TV household (Digital TVHH	Total TV households [56] (Total TVHH)	Digital TVHH / Total TVHH
AT	1248	1962	380	314	3904	3912	99,8%
BE	2677	418	398	1666	5160	5284	97,7%
BG	567	1037	1009	560	3173	3173	100,0%
CY	48	n.a.	204	94	346	347	99,8%
CZ	628	1581	1898	536	4643	4808	96,6%
DE	16852	17183	4644	3480	42159	42159	100,0%
DK	1188	183	777	490	2639	2762	95,5%
EE	119	94	271	208	692	692	100,0%
ES	2041	1065	12781	4124	20011	20028	99,9%
FI	1812	16	258	666	2752	2802	98,2%
FR	2618	4513	4850	19645	31627	31627	100,0%
GR	0	868	3149	394	4412	4412	100,0%
HR	181	190	656	448	1475	1475	100,0%
HU	1293	954	477	926	3650	4279	85,3%
IE	310	761	474	81	1626	1626	100,0%
IT	0	12685	11882	302	24869	24869	100,0%
LT	217	155	560	305	1237	1333	92,8%
LU	71	85	51	76	285	285	100,0%
LV	114	48	534	235	931	1004	92,7%
MT	105	n.a.	56	61	223	223	100,0%
NL	3507	624	909	2429	7469	7974	93,7%
PL	3136	6310	1995	925	12365	13640	90,7%
PT	1312	760	576	2463	5111	5111	100,0%
RO	3204	2349	48	143	5744	8607	66,7%
SE	2248	121	2064	1470	5904	6496	90,9%

[56] Refers to the number of homes using TV.

Member State	Cable	Satellite	Digital terrestrial	IPTV	Digital TV household (Digital TVHH	Total TV households [56] (Total TVHH)	Digital TVHH / Total TVHH
SI	247	129	134	366	875	879	99,5%
SK	287	1055	202	306	1849	1893	97,7%
EU27	**46,030**	**55,146**	**51,238**	**42,715**	**195,129**	**201,697**	**96,7%**

Table 30 - Number of households (in thousands) by platform and by Member State in 2020.

Source: European Audiovisual Observatory, 2021

Table 30 reports the number of digital TV households by platform and by EU27 Member States based on the data collected by the European Audiovisual Observatory in 2021. As we can see from the market penetration of each platform varies strongly depending on the Member State considered. Overall, the Digital TV household represent 96,7% of the total TV households in the EU27.

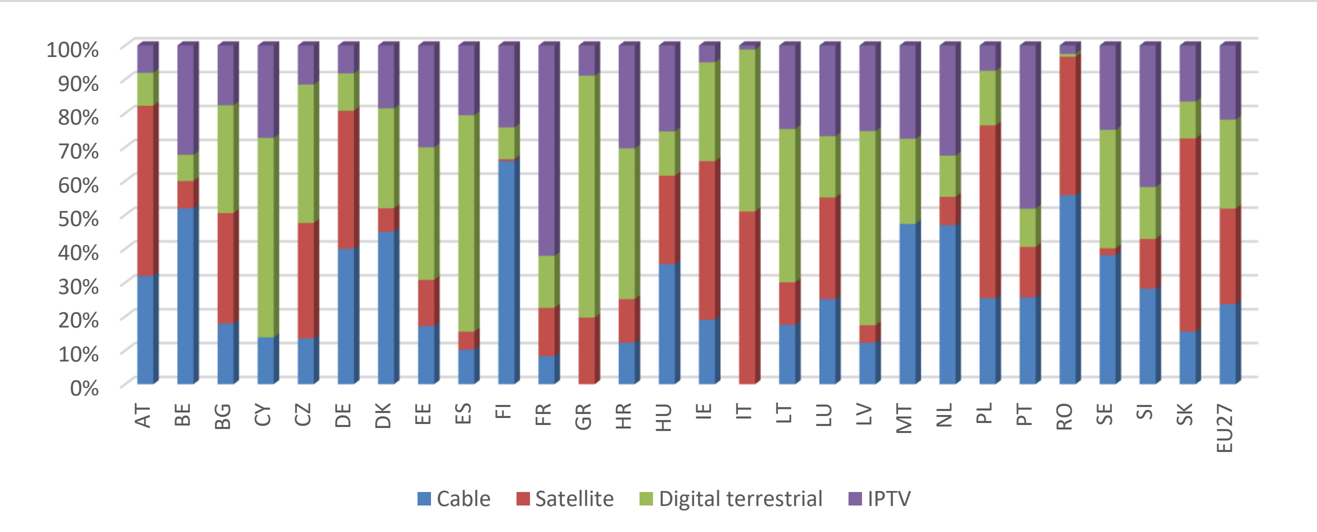


Figure 63: Share of households by platform, 2020.

Source: European Audiovisual Observatory, 2021

In order to have a better visualization of the data, Figure 63 shows the share of households by platform by Member State (European Audiovisual Observatory, 2020)[57]. If look at the data for the entire EU27, we can see that the shares are rather equally split across platforms. Indeed, there are 26% of households with access to digital terrestrial, 27% to satellite, 23% to cable and 22% to IPTV. However, for several Member States the shares are not equally split and as a predominant platform emerges.

A clear predominance of digital terrestrial is observed for Greece (71%), Spain (64%), Italy (48%), Cyprus (59%), Latvia (57%), Croatia (45%), Czech Republic (41%) and Lithuania (45%). Cable is instead the predominant platform for Finland (66%), Romania (56%), Belgium (52%), Malta (47%),

[57] All the data we gathered from the European Audiovisual Observatory are provided by Ampere Analysis, a data and analytics firm specialising in the media sector.

the Netherlands (47%) and Denmark (45%). Satellite is the predominant platform in Slovakia (57%), Poland (51%), Austria (50%) and Ireland (47%). Finally, IPTV is the predominant platform in France (62%), Portugal (48%), and Slovenia (42%).

For certain Member States, two platforms dominate. Most notably, in Germany both cable and satellite are the preferred platform with almost an equal split between the two (40% cable and 41% satellite). Also, in Sweden the split between cable households (38%) and digital terrestrial households (35%) is quite uniform. For all the other Member States, a clear predominance of one or more platforms cannot be easily determined.

It worth noting that for the reasons outlined in section 3.2.4, the exact methodology used by EAO to collect the data is not fully clear and thus conclusions should be drawn with caution. Indeed, as noted by relevant stakeholders, the data refers only to primary TV platforms while secondary TV platforms or platforms in holidays' houses may not be taken into account. Similarly, the way different categories are identified may not be fully accurate as according to some interviewed stakeholders, the number of households with DTT seems to be underestimated.

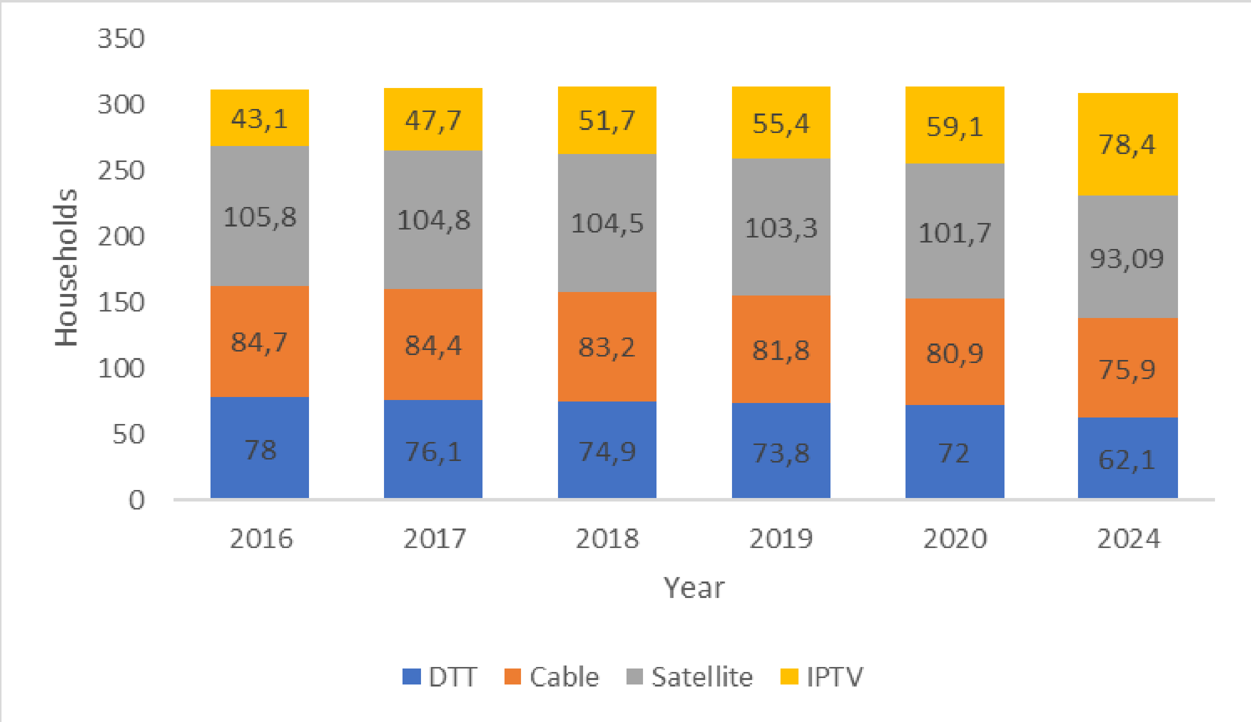


Figure 64 - Changes concerning access to TV services in Europe (households in millions).

Source: IDATE, 2021

The Figure above shows the number of households in millions with access to the different TV platforms. The data comes from IDATE and include all European countries plus Russia and Turkey. As we can see, the number of households with access to DTT, cable and satellite is decreasing while the only platform that records an increase in number of households with access to it is IPTV. These results are in line with the market forecasting in section 3.3.6. In order to double check the accuracy of our forecasting, we have also used the data provide by IDATE and forecast the number of households with access to the different platforms. Graphs are reported in section 3.3.6. to ease the comparison with the forecast obtained with the data from the European Audiovisual Observatory.

Due to limitations of the EAO dataset highlighted by interviewees, based on inputs from the regulator survey circulated by the study team (which focuses in most cases on the share of households with access to one of the distribution platforms rather than primary reception), the table below provides an alternative outlook on the current broadcasting landscape. In some cases, national regulators no longer report data distinguishing between the traditional TV platforms (e.g., due to market convergence/bundled offers) or publish information on selected platforms only. The overview below compiles data made available by national regulators (where available, complementing inputs from the 26 surveyed MS with regulator reports) to contextualise the information and forecast based on EAO. In addition, the next subsection compares an additional dataset compiled by industry stakeholders (EBU/BNE/DVB), focusing on DTT reception.

Member State	TV households	Digital terrestrial reception	Satellite reception	Cable reception	IPTV
AT	3,851,000[58]	6%	52%	45%[59]	19.6%
BE	4,000,000[60]	Market characterised by convergence: 64% of all residential customer relationships are based on a bundle (data not reported per platform).[61]			
BG	2,027,890[62]	No data reported	45%[63]	26%[64]	29%[65]
CY	347,000[66]	67%[67]	Small percentage	13%	20%
CZ	4,957,000[68]	53.2%[69]	20%[70]	13%[71]	22%[72]
DE	38,520,000[73]	6.3%	44.1%	43.6%	2.9%[74]

[58] Latest figure reported by RTR (2019); EAO data 3,998,000 TV households.

[59] IPTV households are classified under cable reception; overall figure refers to “analogue cable reception” based on RTR 2019 report

[60] 2020 estimation from BIPT (2020)

[61] 95% share of the total television access BIPT (2020)

[62] Source: CRC, 2021

[63]A total of 913,947subscribers/users reported by CRC including bundled services. Source: CRC, 2021

[64] A total of 523,170 subscribers/users reported by CRC including bundled services. Source: CRC, 2021

[65] A total of 590,773 subscribers/users reported by CRC including bundled services. Source: CRC, 2021

[66] EAO data (2019)

[67]Based on NRA survey, 67% of households have access to DTT, while the majority of households have access to DTT

[68] EAO data (2019)

[69] Source: Nielsen Atmosphere research, 2021 via regulator survey

[70]Source: Nielsen, 2021

[71] Source: Nielsen, 2021

[72] Source: Nielsen, 2021

[73] Source: Digitisation in Germany, 2020

[74] 2.9% (OTT) 10.6% (managed) Source: Digitisation in Germany, 2020

Member State	TV households	Digital terrestrial reception	Satellite reception	Cable reception	IPTV
DK	2,530,000[75]	<1%	No data reported		
EE	775,000[76]	14%[77]	No data reported		Largest market share[78]
ES	8,344,197[79]	no subscriptions/data reported	2%[80]	7%[81]	25%[82]
FI	2,770,000 [83]	19%[84]	2%	54%	22%
FR	26,386,000[85]	46.30%	17.1%	3.9%[86]	61.40%[87]
GR	1,071,000[88]	No data reported	81,5%	No data reported	18,5%
HR	1,475,000[89]	~41% of households[90]	10%	12%	30%
HU	3,632,000[91]	12%	16%	47%	29%
IE	1,606,000[92]	36%	55%[93]	22%[94]	6%

[75] Source: Danmarks Statistik via Kantar (2020)

[76] EAO data (2019)

[77] Based on NRA survey 14% households depend on paid DTT: 9,6 % paid+FTA and 5,4% on FTA only.

[78] Based on NRA survey: data/figures not available

[79] Figure referring to total number of TV subscriptions. Source: CNMC TV households data via EAO (2019): 19,637,000

[80] Computation based on EAO TV households data and CNMC satellite subscriptions (437,011).

[81] Computation based on EAO TV households data and CNMC cable subscriptions (1,335,956).

[82] Computation based on EAO TV households data and CNMC IPTV subscriptions (4,901,902).

[83] Source: NRA survey

[84] Source: NRA Survey

[85]Estimated based on NRA survey

[86] Terrestrial TV over free cable distribution Source: NRA survey

[87] reception by: xDSL, pay cable and fibre Source: NRA survey

[88] EETT data (2019)

[89] EAO (2019)

[90] (data calculated using following formula: RH households with digital terrestrial reception only = (1.520.026 (number of households in the Republic of Croatia according to the last census of population from 2011) – 2.6% households without TV) – (number of Cable receptions + number of IPTV + number of Satellite receptions + digital terrestrial reception_pay TV)).

[91] NMHH 2021

[92] EAO data (2019)

[93] Source: Nielsen 2021. The regulator reports 18% of households with to other satellite services and households using “combi” television sets / boxes to receive UK FTA Sat and Irish DTT Source: NRA survey

[94] Source: Nielsen 2021. The regulator reports circa 60% of households receive television primarily via paid satellite or paid cable systems Source: NRA survey

Member State	TV households	Digital terrestrial reception	Satellite reception	Cable reception	IPTV
IT	25,973,000[95]	91%[96]	19%[97]	-	42[98]
LT	1,304,000[99]	Not reported[100][101]	7.7%	45.1%	46.2%
LU	280,900[102]	Not reported[103]			
LV	1,127,000[104]	14%	5%	28%	42%
MT	201,000[105]	1.81%	Not reported	61.3%	36.89%
NL	7,866,000[106]	Not reported	Not reported	50.6%[107]	Not available
PL	13,610,000[108]	35.3% of households[109]	51.5%	36.1%	12.2%
PT	4,500,000[110]	No data reported	10%	30%	56%[111]
RO	2,721,000[112]	No data reported	20.9%	77.4%	1.5%
SE	867,000[113]	5.1%[114]	8.5%	45.4%	30.4%
SI	858,000[115]	0.9%	2%[116]	36.9%	57.5%
SK	1,820,000[117]	13%	47%	35%[118]	

[95] Estimation based on FUB 2021
[96] 23,700,000 households combining FTA and pay-DTT Source: FUB, 2021
[97] 4,400,000 households Source: FUB, 2021
[98] 11,000,000 OTT TV households Source: FUB, 2021
[99] Source: EAO (2019)
[100] RRT 2021
[101] 7,2% MDTV subscriptions reported by RRT (2021)
[102] EAO data (2019)
[103] 73,000 cable subscriptions and 75,900 IPTV subscriptions based on ILR (2021)
[104] EAO data (2019)
[105] EAO data (2019)
[106] EAO data (2019)
[107] Estimation based on cable retail subscriptions reported by ACM 2021
[108] EAO (2019)
[109] Households dependent on DTT FTA (no information on pay-DTT) Source: NRA Survey
[110] Estimation based on ANACOM 2021
[111] FTTH and 5% ADSL
[112] EAO (2019)
[113] EAO (2019)
[114] Statistik pts 2021 (pay DTT subscriptions)
[115] EAO (2019)
[116] AKOS (2021)
[117] teleoff 2021
[118] NRA survey data for Cable and IPTV

Table 31 - Broadcasting landscape (regulator survey and reports).

3.3.5.1 DTT access (pay TV and FTA)

In order to cross-check the information specifically on DTT access and ensure this accounts for the FTA reception, in the table below a comparison is drawn between data from EAO, a dataset compiled by EBU/DVB/BNE[119] and regulator data presented above (Table 31). In addition, Table 31 provides an overview of estimated households entirely dependent on DTT for FTA based on surveyed regulators across 15 EU MS surveyed to date.

Member State	Digital terrestrial share (EAO)	DTT penetration (EBU/DVB/BNE data)	Regulator data
Austria	10%	8%	6%
Belgium	8%	5%	Data for the Flemish community: < 5% (others not available)
Bulgaria	32%	12%	No information available
Croatia	45%	70%	41%
Cyprus	59%	68%	67%
Czech Republic	41%	55%	53%
Denmark	29%	15%	1%
Estonia	39%	23%	14%
Finland	9%	48%	46%
France	15%	50%	46%
Germany	11%	11%	6%
Greece	71%	85%	74%
Hungary	13%	15%	12%
Ireland	29%	38%	36%
Italy	48%	94%	91%
Latvia	57%	37%	14%
Lithuania	45%	38%	No data available
Luxembourg	18%	10%	No information available
Malta	25%	7%	2%
Netherlands	12%	3%	<3% estimated
Poland	16%	44%	35%
Portugal	11%	25%	5%
Romania	1%	2%	0%
Slovakia	11%	27%	13%

[119] Representing % of TVHH using DTT, whether as the sole means of reception or alongside other platforms.

Member State	Digital terrestrial share (EAO)	DTT penetration (EBU/DVB/BNE data)	Regulator data
Slovenia	15%	10%	0.9%
Spain	63%	92%	Less than 1%
Sweden	30%	29%	5%[120]

Table 32 - Comparison of DTT shares based on alternative datasets (EU27).

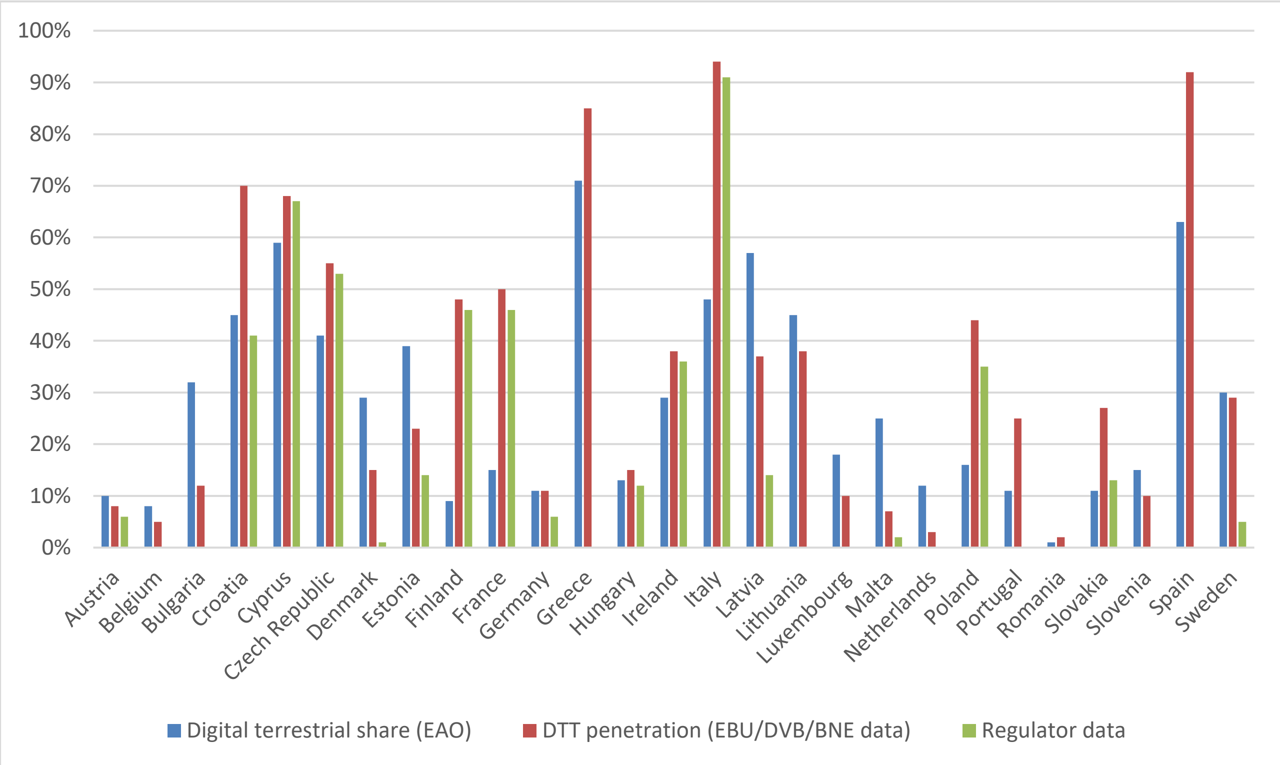


Figure 65 - Comparison of DTT shares based on alternative datasets

3.3.6 Market forecast to 2025 and to 2030

In the following section, we forecast the evolution of the TV market distinguishing between pay-DTT, cable, satellite and IPTV.

According to the forecasting based on the data provided by the EAO, the only platform that is expected to increase in terms market demand it is IPTV with a forecast growth of number of households with access to it in 2025 of 29% and 53% in 2030 as compared to the values observed in 2019.[121] For

[120] Pay DTT subscriptions

[121] This is in line with predictions from Analysys Mason (2021), who foresee in traditional pay-TV business the number of customers using an OTT offer to increase significantly over the next two years, as will the number of IPTV lines. GSMA intelligence (2020) also highlights the impact of OTT on traditional pay TV penetration, highlighting countries such as Denmark, Germany, Sweden, Netherlands and Poland where significant cord-cutting is expected to take place by 2025.On the other hand pay TV markets are expected to hold up or grow in a number of markets such as Finland, Spain, Portugal, Romania and Bulgaria.

cable and satellite, the forecasting indicates a slight decrease of demand. For both platforms, the number of households with access to the respective platforms is expected to decrease by 2% in 2025 and by 3% in 2030 compared to the values observed in 2019. Finally, for pay-DTT the forecasting indicates that the number of subscribers is expected to decrease by 35% in 2025 and by 60% in 2030 compared to the values observed in 2019. It's worth nothing that for pay-DTT the forecasting is using data on the number of subscribers and not households which makes the direct comparison more difficult. For this reason, we have also collected data from IDATE and replicate the forecasting for all four platforms. The forecasting with IDATE data provides a similar picture, with an expanding market for IPTV, slightly decreasing for cable and satellite and significantly more decreasing market for DTT.

Some of the in-depth interviews conducted with relevant industry and public broadcaster organisation (see Annex 3) have also highlighted some potential limitations in our analysis which suggests having a precautionary approach in drawing conclusions from the forecasting. For DTT, it is important to note that the data provided by EAO only concerns pay-DTT.[122] Some stakeholders have underlined that free to air DTT is still highly relevant for EU consumers and its market even growing in certain overseas countries such as the US.[123]

Member State	2014	2015	2016	2017	2018	Low 2025	2025	High 2025	Low 2030	2030	High 2030
AT	22	33	42	51	57	157	174	191	226	245	264
BE	0	0	0	0	0	0	0	0	0	0	0
BG	0	0	0	0	0	0	0	0	0	0	0
CY	0	0	0	0	0	0	0	0	0	0	0
CZ	0	0	0	0	0	0	0	0	0	0	0
DE	0	0	0	0	0	0	0	0	0	0	0
DK	307	286	269	244	222	68	73	78	0	0	0
EE	56	56	55	79	84	124	143	162	163	184	206
ES	231	0	0	0	0	0	0	0	0	0	0
FI	195	180	165	157	148	56	66	76	0	9	21
FR	774	749	705	651	608	276	306	335	0	0	0
GR	0	0	0	0	0	0	0	0	0	0	0
HR	48	52	60	67	73	119	122	125	155	159	162
HU	117	104	101	97	92	45	53	62	16	25	35
IE	0	0	0	0	0	0	0	0	0	0	0

[122] According to EBU, pay-DTT has always been only a small part of DTT – available in only 18 EU countries. The weight of FTA channels in terms of public service can be measured by looking at channel audience. According to the same source, there are 1948 national FTA and local programmes in EU27 (provided via DTT) compared to 650 Pay DTT programmes.

[123]For instance this study from Deloitte (2019) in the US

Member State	2014	2015	2016	2017	2018	Low 2025	2025	High 2025	Low 2030	2030	High 2030
IT	1710	2010	2010	1975	1820	1494	1544	1593	869	913	953
LT	57	51	38	32	14	0	0	0	0	0	0
LU	0	0	0	0	0	0	0	0	0	0	0
LV	121	89	75	64	55	0	0	0	0	0	0
MT	57	51	46	34	22	0	0	0	0	0	0
NL	441	350	295	245	203	0	0	0	0	0	0
PL	0	0	0	0	0	0	0	0	0	0	0
PT	0	0	0	0	0	0	0	0	0	0	0
RO	0	0	0	0	0	0	0	0	0	0	0
SE	560	541	487	433	379	7	50	93	0	0	0
SI	0	0	0	0	0	0	0	0	0	0	0
SK	9	11	12	13	14	20	22	23	25	27	29
EU27	4707	4564	4361	4142	3791	2466	2553	2640	1455	1562	1670

Table 33 - Forecast number of subscribers (in thousands) for pay-DTT, 2015-2030 disaggregated by Member State.

The table above reports the forecast number of subscribers for pay-DTT by EU27 Member States based on the data collected by the European Audiovisual Observatory from 2014 until 2018. As we can see from the table, in several Member States there are no pay-DTT services (e.g. Czech Republic, Portugal, Cyprus, Ireland).[124] In 2019, the last observation collected by the European Audiovisual Observatory, almost half of the subscribers for pay-DTT in the EU27 are concentrated in Italy (48%), followed by France (16%) and Sweden (10%). With respect to the forecasting, the model indicates quite some changes in subsequent years. As we can see, in several Member States the number of subscribers for pay-DTT decline up to zero, even in Member States where the penetration of pay-DTT was relatively high such as France and Sweden. Italy remains the Member States with the highest share (60% in 2025 and 58% in 2030) despite a decrease in the number of subscribers. The reason for this is that compared to many other Member States, the decrease in subscribers occurs at a slower pace.

[124] Nevertheless, in Germany where no data is reported by the EAO, based on stakeholder interviews the pay DTT market is present and growing (no figures provided).

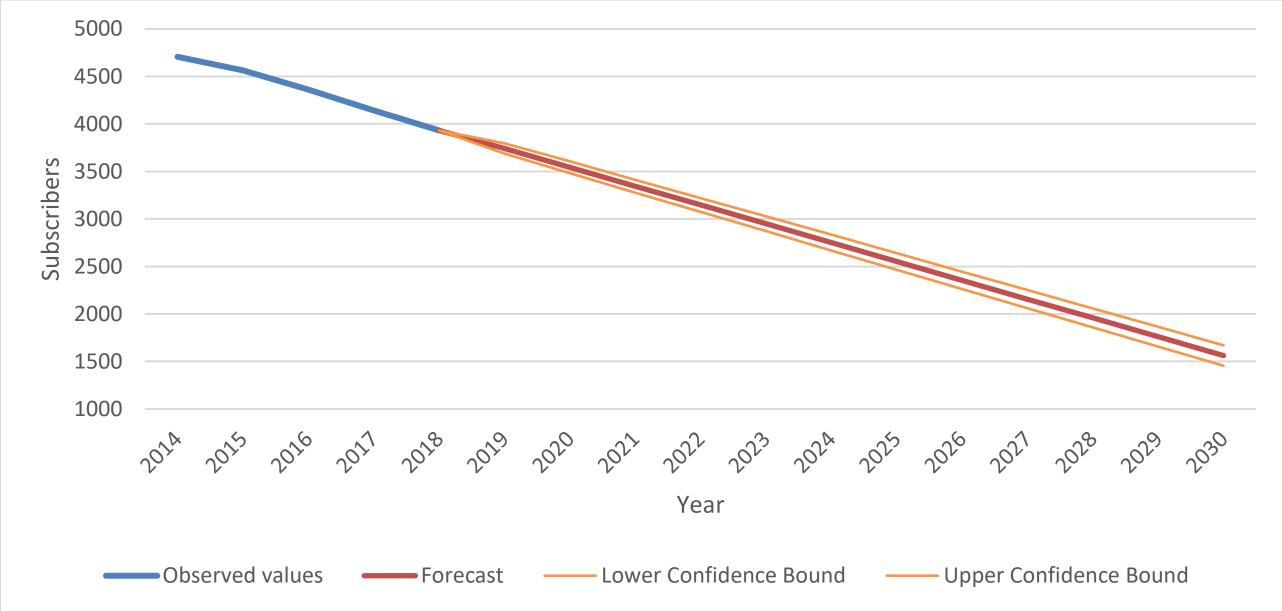


Figure 66 - Forecast number of subscribers (in thousands) for pay-DTT in EU27, 2025-2030

The figure above shows the forecast number of subscribers for pay-DTT for the entire EU. As we can see, the model predicts a sharp decrease for the period 2020-2030 in line with the negative trend observed between 2015 and 2019. The model predicts that the number of subscribers for pay-DTT will be down to 2.5 million in 2025 (-35% compared to 2019) and 1.5 million in 2030 (-60% compared to 2019).

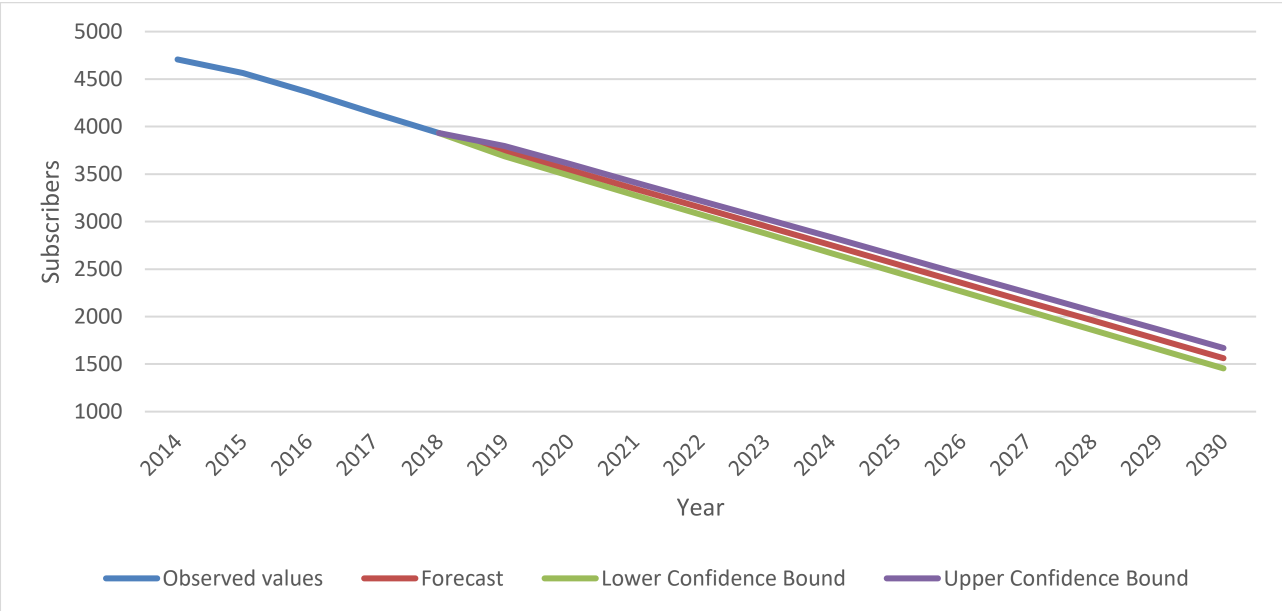


Figure 67 - Forecast number of households (in thousands) with DTT in Europe, Russia and Turkey, 2025-2030

Source: iDate, 2021

The figure above shows the forecast number of households (in thousands) with access to DTT for Europe plus Russia and Turkey. While a direct comparison cannot not be made directly due to the presence in the sample of two highly populated extra EU country and due to the focus on access to DTT and not specifically to pay-DTT, the negative trend is in line with the one observed in the previous figure.

Member State	2016	2017	2018	2019	2020	Low 2025	2025	High 2025	Low 2030	2030	High 2030
AT	1.200	1.222	1.234	1.244	1.256	1237	1280	1323	1262	1310	1358
BE	2.974	2.906	2.876	2.843	2.801	2537	2557	2577	2326	2347	2367
BG	607	584	559	564	567	436	459	482	346	375	403
CY	40	40	43	46	49	79	82	85	96	100	103
CZ	845	841	837	817	794	747	771	795	686	713	740
DE	18.238	17.474	17.343	17.135	16.852	14353	14636	14919	12733	13023	13313
DK	1.436	1.380	1.288	1.233	1.212	668	792	916	262	418	573
EE	211	210	121	119	119	185	187	190	171	174	177
ES	1.676	1.763	1.722	1.848	2.059	2132	2437	2742	2534	2917	3299
FI	1.601	1.654	1.699	1.763	1.812	2081	2112	2143	2359	2394	2400
FR	1.791	1.905	2.085	2.306	2.618	3285	3333	3382	4155	4204	4252
GR	0	0	0	0	0	0	0	0	0	0	0
HR	161	169	178	177	181	219	226	234	253	261	269
HU	1.906	1.905	1.967	1.946	1.922	2061	2103	2145	2179	2226	2273
IE	305	293	271	280	310	85	152	218	0	55	138
IT	0	0	0	0	0	0	0	0	0	0	0
LT	377	376	350	332	313	233	245	258	145	159	173
LU	91	89	84	78	71	55	56	58	36	37	38
LV	224	217	210	204	187	168	182	196	147	163	179
MT	77	86	96	101	105	132	141	151	163	174	185
NL	4.223	4.147	4.117	4.060	4.012	3313	3526	3740	2832	3099	3366
PL	4.600	4.480	4.440	4.395	4.411	3951	4015	4080	3693	3759	3826
PT	1.348	1.356	1.344	1.323	1.312	1668	1693	1718	1807	1838	1869
RO	4.740	5.000	5.270	5.430	6.061	6847	6938	7028	7743	7743	7743
SE	2.619	2.607	2.429	2.425	2.394	2603	2742	2881	2376	2531	2687
SI	263	254	253	245	251	209	218	226	182	192	201
SK	312	320	323	327	331	332	343	354	343	356	368
EU27	**51867**	**51278**	**51139**	**51241**	**51997**	**50452**	**50850**	**51248**	**50019**	**50427**	**50835**

Table 34 - Forecast number of households (in thousands) with cable, 2016-2030 disaggregated by Member State.

Source: European Audiovisual Observatory, 2021

The previous table reports the forecast number of households with cable by EU27 Member States based on the data collected by the European Audiovisual Observatory from 2016 until 2020. Compared to pay-DTT, digital satellite and IPTV, there is less concentration of households in few Member States. Still, Germany has by the highest share (32,4%) in 2020, the last observation collected by the European Audiovisual Observatory. Romania follows with 11,6% which indicates a rather high penetration of cable given the relatively low population of the country compared to other Member States. Another interesting fact is that there is no content distribution taking place in Italy via cable[125] (the third Member State in the EU27 by population). With respect to the forecasting, the model depicts rather stable situation for subsequent years, with most of household with cable still concentrated in Germany (27,8% in 2025 and 25,8% in 2030) followed again by Romania (13,6% in 2025 and 15,4% in 2030) and Poland (7,9% in 2025 and 7,5% in 2030). Stakeholders highlight a relevant trend regarding cable TV as a stand-alone service, namely that it is being replaced by bundled telecom offers.

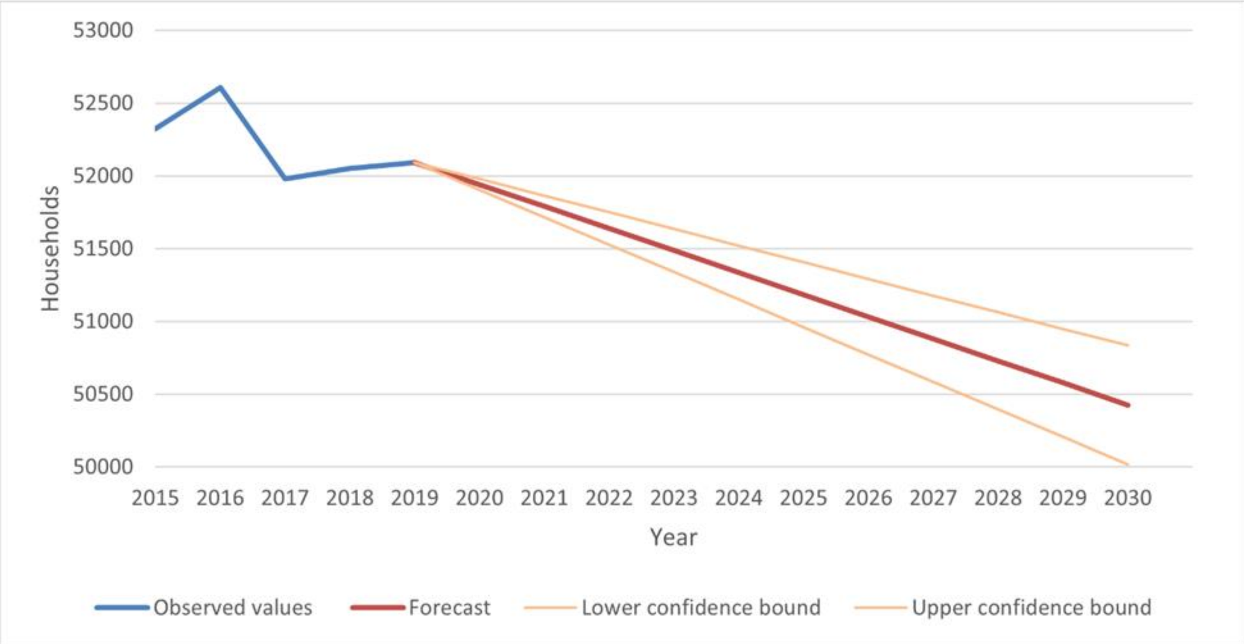


Figure 68 - Forecast number of households (in thousands) with cable in EU27, 2025-2030.

Source: iDate, 2021

The previous figure shows the forecast number of households with cable for the entire EU. As we can see, the model predicts that the overall negative trend observed between 2015 and 2019 continues, with the number of households with digital satellite down to 50.8 million in 2025 (-2% compared to 2019) and 50.4 million in 2030 (-3% compared to 2019).

[125] Based on stakeholder interviews

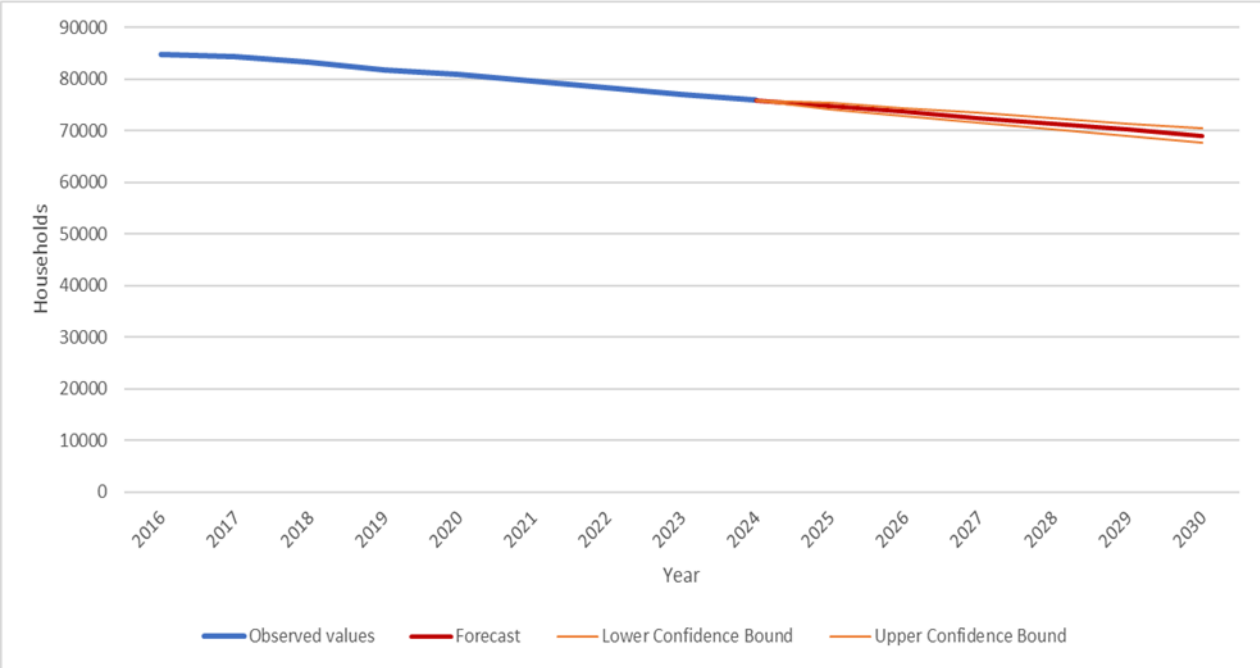


Figure 69 - Forecast number of households (in thousands) with cable in Europe, Russia and Turkey, 2025-2030

Source: iDate, 2021

The Figure above shows the forecast number of households (in thousands) with access to cable for Europe plus Russia and Turkey. While a direct comparison cannot not be made directly due to the presence in the sample of two highly populated extra EU country, the negative trend is in line with the one observed in the figure above.

Member State	2015	2016	2017	2018	2019	2020	Low 2025	2025	High 2025	Low 2030	2030	High 2030
AT	1917	1995	2049	2049	2004	1962	2162	2257	2352	2294	2413	2532
BE	444	448	441	432	425	418	375	390	405	342	361	379
BG	909	941	902	1015	1023	1037	1139	1243	1346	1333	1462	1592
CZ	1596	1509	1495	1495	1600	1581	1381	1565	1749	1344	1574	1805
DE	17591	17123	17502	17333	17199	17183	16917	17313	17709	16496	16902	17308
DK	290	290	285	285	285	183	274	276	279	267	269	272
EE	124	117	111	104	99	94	59	61	62	27	29	31
ES	2100	1800	1542	1321	1132	1065	0	0	0	0	0	0
FI	116	52	52	78	79	16	138	142	145	150	154	157
FR	5620	5410	5290	5123	4856	4513	3712	3780	3847	2792	2860	2927
GR	960	981	987	977	952	868	832	886	940	772	840	908
HR	160	178	178	186	192	190	213	222	232	249	260	270
HU	969	969	965	962	958	954	970	970	970	970	970	971

Member State	2015	2016	2017	2018	2019	2020	Low 2025	2025	High 2025	Low 2030	2030	High 2030
IE	730	769	803	795	782	761	793	863	933	832	920	1007
IT	8570	9370	9620	10003	11067	12685	12487	12892	13298	14533	14987	15441
LT	153	155	155	155	155	155	155	157	160	156	159	162
LU	70	73	76	79	82	85	99	100	101	114	115	116
LV	90	78	73	64	56	48	8	11	14	0	0	0
NL	714	695	665	657	644	624	520	534	547	430	445	460
PL	6500	6430	6430	6470	6366	6310	6269	6377	6486	6192	6305	6417
PT	1071	940	872	817	779	760	238	338	438	0	0	0
RO	2629	2645	2642	2647	2572	2349	2517	2633	2748	2474	2619	2764
SE	664	658	645	629	597	121	476	502	528	385	418	451
SI	134	132	133	130	129	129	121	123	124	113	115	117
SK	1081	1047	1054	1054	1053	1055	993	1025	1056	967	1002	1037
EU27	**55202**	**54804**	**54967**	**54858**	**55083**	**55146**	**53219**	**53530**	**53840**	**52383**	**52693**	**53004**

Table 35 - Forecast number of households (in thousands) with digital satellite, 2015-2030 disaggregated by Member State.

Source: European Audiovisual Observatory, 2021

The previous table reports the forecast number of households with digital satellite by EU27 Member States based on the data collected by the European Audiovisual Observatory from 2015 until 2020. Most households in EU27 with digital satellite are concentrated in three Member States. In 2020, the last observation collected by the European Audiovisual Observatory, more than 66% of all households in the EU27 with digital satellite were concentrated in Germany (31,1%), Italy (23%)[126] and Poland (11,4%). With respect to the forecasting, the model depicts rather stable situation for subsequent years, with most of household with digital satellite still concentrated in Germany (32% in both 2025 and in 2030) followed again by Italy (24% in 2025 and 28% in 2030) and Poland (12% in both 2025 and in 2030).

[126] Stakeholders interviewed confirm that 5 million households in Italy are expected to continue using satellite in the next 5 years.

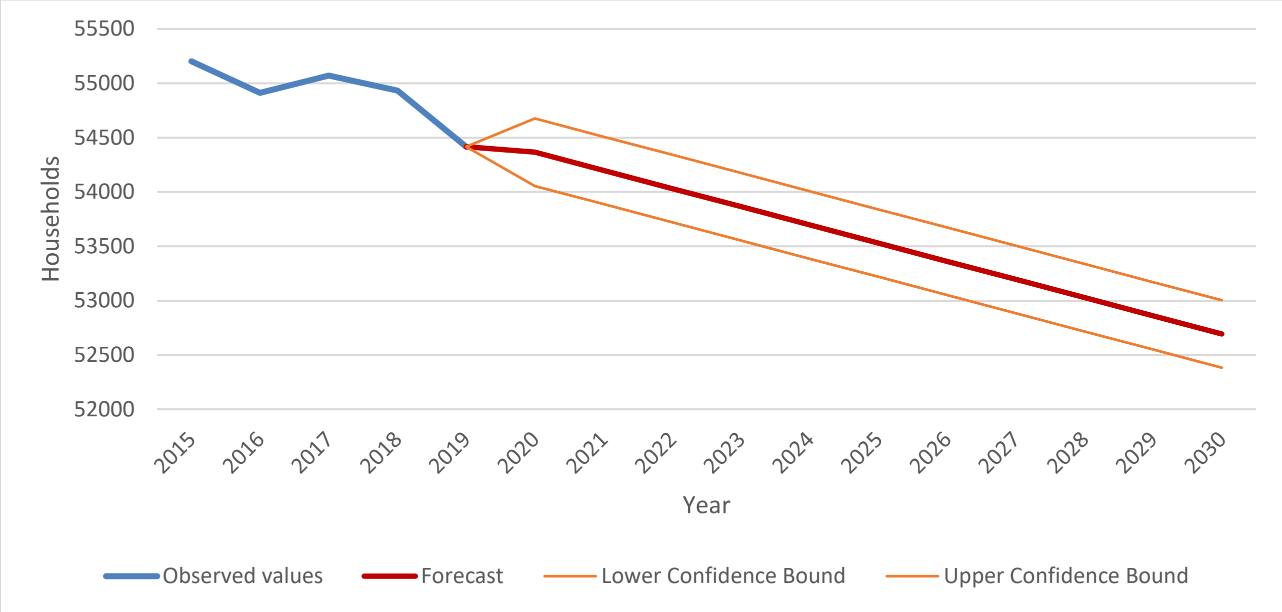


Figure 70 - Forecast number of households (in thousands) with digital satellite in EU27, 2025-2030.

The previous figure shows the forecast number of households with digital satellite for the entire EU. As we can see, the model predicts that the negative trend observed between 2015 and 2019 continues, with the number of households with digital satellite down to 53.5 million in 2025 (-2% compared to 2019) and 52.7 million in 2030 (-3% compared to 2019).

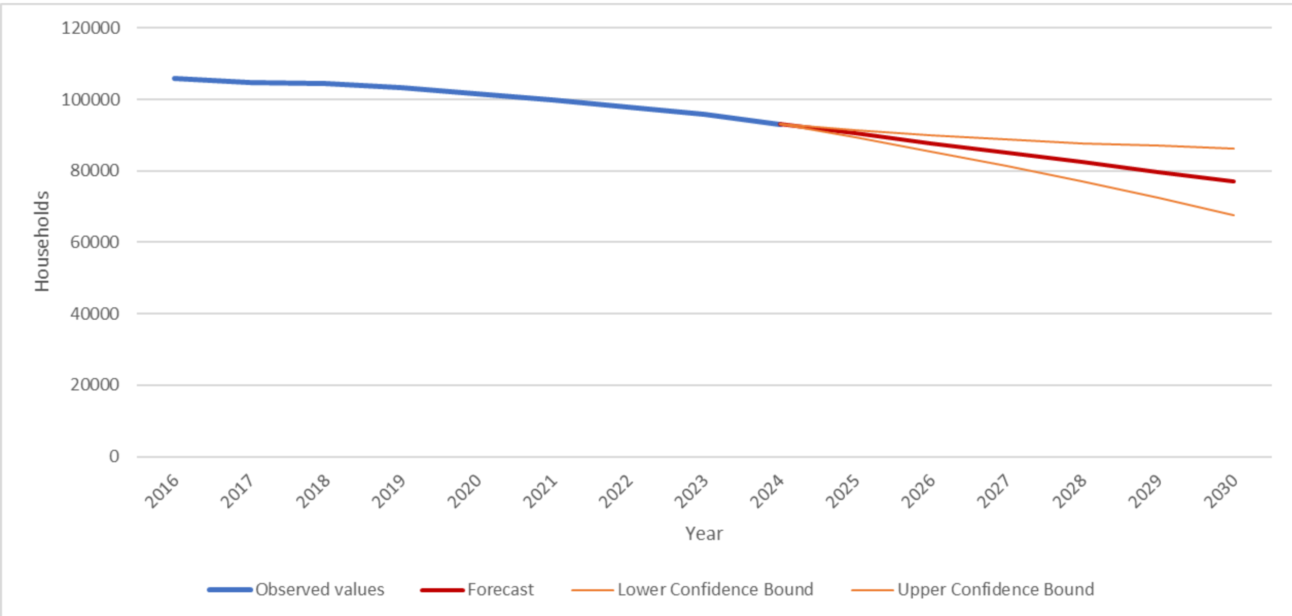


Figure 71 - Forecast number of households (in thousands) with satellite in Europe, Russia and Turkey, 2025-2030

Source: iDate, 2021

The graph above shows the forecast number of households (in thousands) with access to satellite for Europe plus Russia and Turkey. While a direct comparison cannot not be made directly due to the presence in the sample of two highly populated extra EU country, the negative trend is in line with the one observed in the figure above.

Member State	2016	2017	2018	2019	2020	Low 2025	2025	High 2025	Low 2030	2030	High 2030
AT	284	297	313	324	314	407	409	410	478	480	481
BE	1489	1560	1611	1630	1666	1907	1969	2030	2161	2239	2316
BG	308	370	440	502	560	876	894	911	1195	1217	1239
CY	83	86	89	91	94	107	107	108	120	120	121
CZ	221	255	327	429	536	664	758	852	930	1049	1167
DE	1913	2356	2638	3067	3480	3997	4091	4184	5069	5186	5304
DK	456	469	484	484	490	735	747	759	888	900	913
EE	177	200	212	212	208	288	302	316	346	361	375
ES	3551	3928	4253	4229	4124	5677	6336	6994	7139	7964	8790
FI	403	439	458	487	666	588	606	624	698	718	738
FR	17963	18596	18767	19025	19645	20998	21479	21960	22837	23440	24042
GR	79	84	132	255	394	289	379	468	428	540	653
HR	398	414	424	437	448	511	513	516	572	575	578
HU	637	711	715	815	926	1038	1094	1149	1275	1338	1400
IE	63	74	80	75	81	100	123	147	130	159	189
IT	n.a.	31	95	208	302	212	411	609	360	608	857
LT	206	229	259	283	305	446	453	461	582	590	599
LU	59	66	70	73	76	101	104	107	125	129	133
LV	210	223	232	239	235	296	300	304	342	346	350
MT	26	36	48	55	61	111	116	120	160	165	169
NL	2198	2330	2399	2421	2429	2861	3042	3222	3304	3530	3756
PL	475	575	696	803	925	1521	1591	1661	2117	2205	2293
PT	1734	1887	2089	2280	2.463	2918	2971	3023	3638	3704	3770
RO	95	117	135	144	143	241	250	259	326	336	345
SE	1105	1213	1343	1376	1.470	1871	1938	2005	2340	2423	2507
SI	308	334	349	359	366	454	483	512	544	581	617
SK	237	241	252	282	306	355	366	378	430	442	453
EU27	**34679**	**37119**	**38909**	**40586**	**42715**	**50780**	**51794**	**52808**	**60137**	**61407**	**62678**

Table 36 - Forecast number of IPTV households (in thousands), 2016-2030 disaggregated by Member State.

Source: European Audiovisual Observatory, 2021

The table above shows the forecast number of households with IPTV by EU27 Member States based on the data collected by the European Audiovisual Observatory from 2016 until 2020. From the table, it is possible to see how one single Member State dominates this market. Indeed, if as of 2020, the last observation collected by the European Audiovisual Observatory, almost half of the households in the EU27 with IPTV were in France (46%). Spain (9,6%) and Germany (8,1%) which follows France in the order, are much less represented especially if we account for the population of these two Member States. With respect to the forecasting, the model depicts rather stable situation for subsequent years, although the share of households with IPTV in France is expected to decline. Nonetheless, the model predicts that most of household with IPTV will still be concentrated in France in the near future (41,4% in 2025 and 38,2% in 2030).

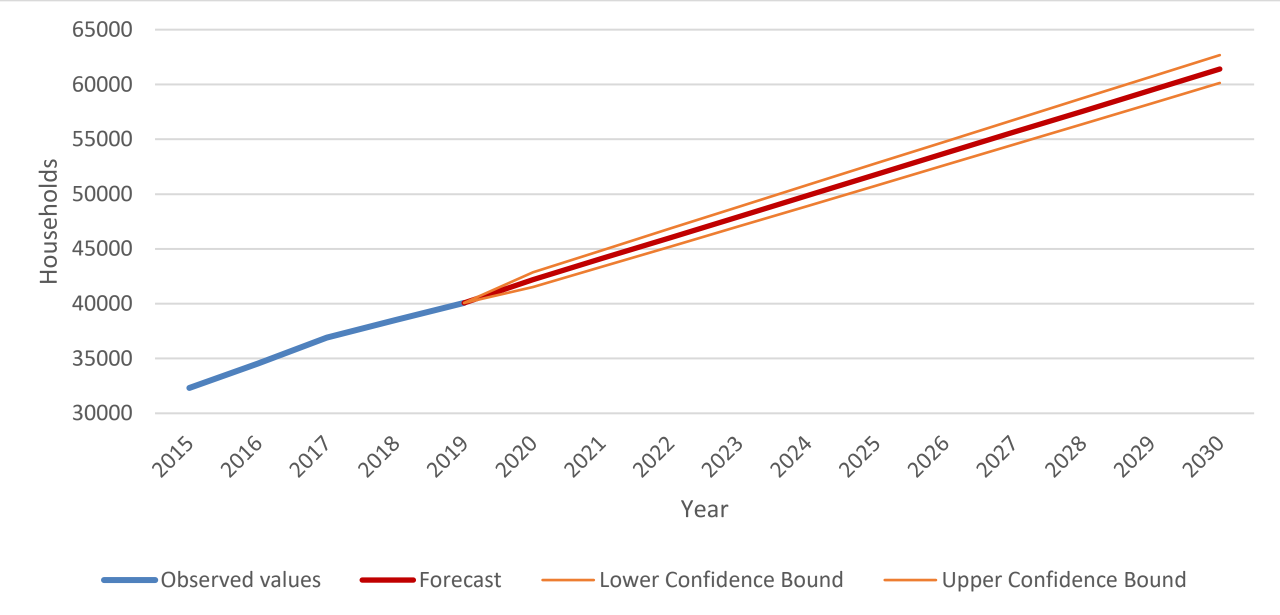


Figure 72 - Forecast number of IPTV households (in thousands) in EU27, 2025-2030.

The figure above shows the forecast number of households with IPTV for the entire EU. As we can see, the model predicts that the positive trend observed between 2016 and 2020 continues, with the number of households with IPTV up to 51.8 million in 2025 (+29% compared to 2019) and 61.4 million in 2030 (+53% compared to 2019). Stakeholders highlight the main driver of growth being the availability of fast broadband and bundling of IPTV with telecom services (telephone, Internet access, mobile subscription).[127]

[127] Specific trends can be highlighted in MS e.g. in Italy IPTV subscriptions have been declining whereas OTT subscriptions have been rising: as a result it is expected that IPTV will be replaced by OTT.

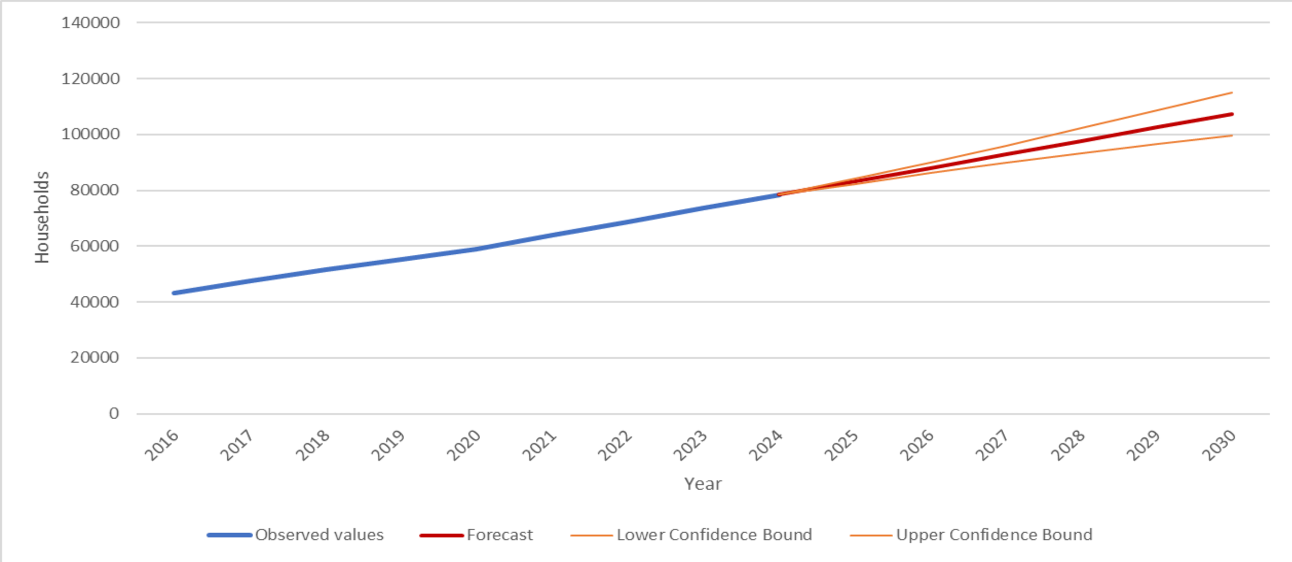


Figure 73 - Forecast number of IPTV households (in thousands) in Europe, Russia and Turkey, 2025-2030

Source: iDate, 2021

The figure above shows the forecast number of households (in thousands) with access to IPTV for Europe plus Russia and Turkey. While a direct comparison cannot not be made directly due to the presence in the sample of two highly populated extra EU country, the positive trend is in line with the one observed in the figure above.

4 PSM mission requirements

4.1 Introduction

UNESCO defines public broadcasting as broadcasting that is "*made, financed and controlled by the public, for the public. It is neither commercial nor state owned, free from political interference and pressure from commercial forces*." While this quote refers to "*broadcasters*", public service media extends this definition and refers to public broadcasters in the contemporary digital media era, where they provide services across multiple platforms in addition to TV and radio (Public Media Alliance, n.d). So, public service media counts as any media – whether it is TV and radio or digital media – that is owned or funded by the public and is therefore accountable to them (Public Media Alliance, n.d).

The main purpose of public media is to provide a variety of quality content that is universally accessible to a diverse audience on a national level and this includes providing reliable information to the public so that they can participate in society in a meaningful way, for example: reliable COVID-19 information or rigorous and impartial election coverage. Impartial domestic and international news coverage is also central to PSM in order to inform public understanding of a complex and globalised world (Public Media Alliance, n.d).

A widely accepted understanding of public media (in its purest) is that they usually have the core remit to "*Inform, Educate and Entertain*", a set of principles that originated along with the BBC in 1922.

The Council of Europe also recognises the important role of public service media in upholding the fundamental right to freedom of expression and information, in accordance with Article 10 of the European Convention on Human Rights, enabling people to seek and receive information, and promoting the values of democracy, diversity and social cohesion.

As stated in "Empowering Society: A declaration on the core values of public service media", EBU[128] Members, as public service media, share the same core values of:

- *Universality*: reaching and offering audiovisual content to all segments of society, with no-one excluded, promoting inclusion and social cohesion;
- *Independence*: being completely impartial and independent from political, commercial and other influences and ideologies and as well as being autonomous in all aspects within the PSM's remit, such as programming, editorial decision-making, staffing;
- *Excellence*: acting with high standards of integrity and professionalism and quality;
- *Diversity*: striving to be diverse and pluralistic in the genres programmed and the views expressed, as audiences consist of a diverse range of interest groups: generations, cultures, religions, majorities as well as minorities;
- *Accountability*: being transparent and subject to constant public scrutiny;

[128] European Broadcasting Union: the organisation representing 115 PSM member organisations in 56 countries, and 31 associate members from a further 20 countries.

- *Innovation*: being driving force of innovation and creativity, with the aim of promoting new formats, new technologies and new ways of connectivity with audiences.

Public service broadcasting has been a major source of social interpretation for news and events in much of Europe, especially in Western Europe (Trappel, 2008). Dialogue, debate and deliberation are three core ingredients of the European mediated public sphere and pointed to the role of PSM here, both in its capacity to mediate in the interests of representative and participatory democracy (Trappel, 2008).

The obligations of public service media are consequently built upon fulfilling these roles, this leads to the following remit for PSM (Council of Europe, 2006):

- PSM must be used on a regular basis and have a high reach;
- PSM must provide a range of content and services that are both different from what the market can provide and at the same time able to attract large audiences;
- Providing content and specific services to small groups with specific needs and to citizens as individual consumers are also a part of the PSM remit.

This should not be limited to linear TV but also including all range of "new media" services under the operations of the PSM (Council of Europe, 2006). PSM must maintain a high-quality level and, typically, "*universal service*" to further social, political and cultural cohesion and to justify its public finance.

In addition, by EBU (2014), in order to fulfil the basic principles which determine the business model of PSM, the following general requirements are considered relevant for the distribution their linear broadcasting service:

- *Possibility for free-to-air or equivalent*, no additional costs for the viewers and listeners
- *Deliver the services of public service broadcasters to the public without blocking or filtering the service offer*, i.e. no gate keeping.
- *Content and service integrity* - no modification of content or service by third parties, e.g. TV content must be displayed on screen unaltered and without unauthorized overlays.
- *Quality of service* requirements to be defined by the broadcaster, such as:
    - QoS when the network is up and running
    - ◦ availability of network: robustness, up-time, reliability
- *Quality of Service* for each user shall be independent of the size of the audience.
- *Geographical extent of the service area* (e.g. national, regional, local) is to be defined by the broadcaster
- Viable on the market and capable of supporting *a minimum service offer* (e.g. a minimum number of programmes) defined by the broadcaster and *ease of use* - straightforward accessibility of broadcast offer.
- *Low barrier* for access to broadcasters' content and services for people with disabilities.

- Ability to reach audience in *emergency situations*

The EBU's Technical Report also highlights the need to fulfil specific requirements for use case, such as:

- *Data rate:* to ensure high quality user experience the average bit rates per programme are specified:
- *For live television content* the following data rates are assumed for HDTV signals encoded by means of MPEG-4 / H.2641 average 8 Mbit/s, minimum 5 Mbit/s:
- *for stationary and portable TV* set: average 5 Mbit/s,
- *for TV set in a vehicle, desktop and portable computer, smartphone, and tablet*: minimum 2.5 Mbit/s.
- *Live content* requires real-time encoding while for *on-demand content* more sophisticated non-real-time encoding algorithms can be employed giving rise to lower required bit rate for the same perceived picture quality.
- *Bit error rate:* rate has to be controlled and within predefined limits. Typically, this is referred to as quasi error free. This means that after decoding the incoming signal, a maximum bit error rate shall not be exceeded. *For television* a bit error rate of 10-11 is considered the required value. In the case of *streaming audiovisual content* over the Internet the bit error rate may not be the proper parameter to describe the quality of the delivered signal.
- *Targeted peak size of the concurrent audience*: in order to decide if a particular distribution option can enable a use case it is important to understand that the number of concurrent users is not static but varies from one moment to another. Therefore, it is a requirement for the available distribution options to cope with this variation and support the expected maximum number of concurrent users, i.e. a peak demand. In other words, peak demand corresponds to the maximum number of concurrent users for a given use case at a given point in time. For example, peak demand for the use case "linear TV/large TV screen/permanent" could be the total number of people watching linear TV in their living rooms on a large flat screen at 20:00 which is usually the peak hour for TV.

According to EBU, any distribution option needs to allow implementing these principles in one way or the other in order to be suitable for PSM. These general requirements implicitly address not only technical issues but also regulatory, market and business-related aspects relevant for public service broadcasters (EBU, 2014).

In this context, the study team conducted a survey with regulators in EU27, asking them to rank the importance of FTA for PSM. While for a small number of countries (e.g. Denmark and the Netherlands with high broadband penetration) the FTA model has a limited weight, for the majority of respondents i.e. 20 countries (including MS with a limited terrestrial TV market share) FTA is still important or very important, as presented in the graph below.

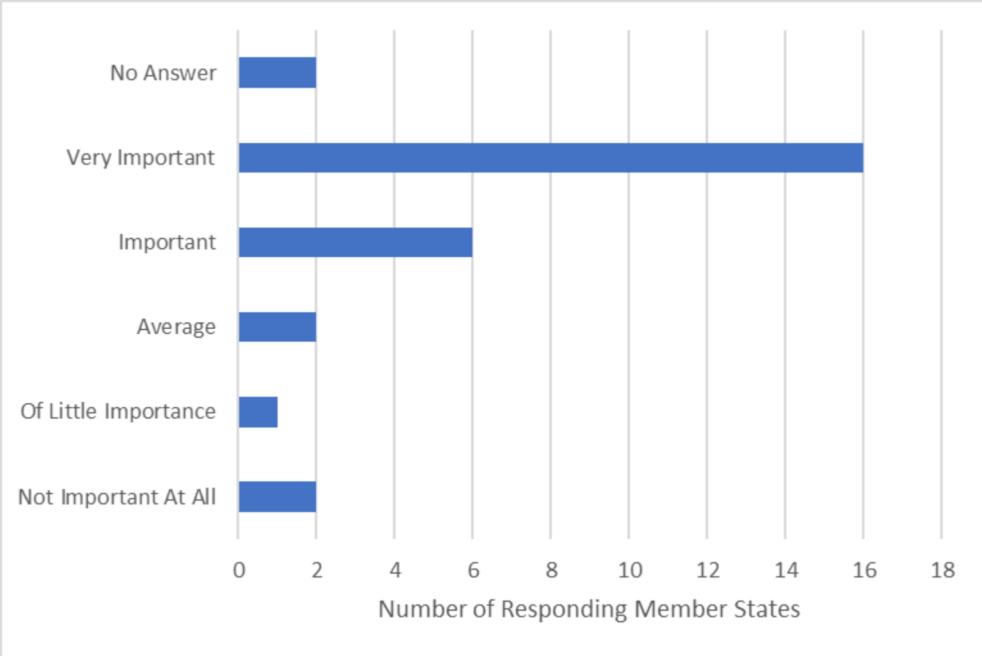


Figure 74 - NRA survey (27 MS - Belgium per language community)[129].

4.2 Analysis of other platforms for public broadcasting services

DTT was first deployed in Europe in the late 1990s to replace analogue broadcast networks as part of the digital switchover process (Plum, 2021). Terrestrial broadcast TV networks have traditionally played a key role in the delivery of public service broadcasting (Plum, 2021). This continues to be the case with DTT and the increased capacity of DTT networks has facilitated the introduction of more free-to-air public and commercial TV services, and in some cases pay-DTT (Plum, 2021).

The DTT platform is designed primarily for the provision of linear TV services[130], but in all countries multiple options are available to consumers (i.e. Cable, Satellite and IPTV). For instance, Cable and satellite TV platforms, while originally developed for delivering subscription-based linear TV channels, have innovated rapidly in recent years through integration with broadband and IP-delivery systems which are able to support VOD and other online content (Plum, 2021). IPTV, by its nature, relies on broadband to deliver content (Plum, 2021).

The low cost of DTT technology for consumers means that it remains a common method of accessing content (Plum, 2021). Many markets still rely heavily on DTT for television broadcasts, particularly in markets where this has historically had a high market share (Plum, 2021). The coverage alternative options tend to vary depending on country-specific circumstances and there is huge variation across the EU in terms of digital TV reception (see Table 31).

[129] No response provided by the Danish regulator: less than 1% of population is identified as "dependent" on DTT for FTA.

[130] Although it is possible for DTT to be combined with on-demand services and interactive features through connected TVs and set-top boxes

As a matter of fact, PSM organisations seek to be available on all relevant networks and platforms. This is the only way to reach the entire audience since no single distribution network or platform has universal reach (EBU, 2019). Following Art. 114 of Directive 2018/1972/EC establishing the European Electronic Communications Code (Replacing the Art. 31 of Directive 2002/22/EC (Universal Service Obligation), a *must-carry obligation* is in place in most Member States for certain television and/or radio channels to be carried over certain networks in the interest of legitimate public policy considerations. However, such obligations should only be imposed where they are necessary to meet general interest objectives clearly defined by Member States in accordance with Union law and should be proportionate and transparent. Traditionally these rules were applicable only to cable networks, but some Member States extended "*must-carry*" or similar rules to other networks.[131]

[131] Based on a survey conducted with the Member States, in addition to the implemented "must-carry" obligation (Art. 114 of the Code), some Member States have national FTA (and coverage) requirements for Public Services Media which in most cases is not limited to the DTT platform.

Member State /EBU Member	FTA provided via DTT (Yes/No)	Alternatives for PSM
Austria/ ORF	No: FTV via access cards	Satellite: FTV via access cards Cable: encrypted subscription services, IPTV: encrypted subscription services, Open Internet: Linear channels and on demand programmes available via ORFtvThek with certain content requiring subscription
Belgium/ RTBF (Wallonia) & VRT (Flanders)	(Flanders) No[132]: (Wallonia) Yes[133]	Satellite: subscription required Cable: subscription required, IPTV: subscription required, Open Internet: live and (most) on-demand content available after registration
Croatia/ HRT	Yes	Satellite: No FTA. PSM programmes are encrypted (access card is required) and available FTV Cable: No FTA IPTV: No FTA Open Internet: All linear channels and on-demand programmes are available via an app. Registration and login are required but there are no additional charges for the content. The viewers pay for the internet access
Denmark/ DR	Yes	Satellite: No FTA. No must carry rules. Encrypted services include PSM, but they are only available with subscription. Cable: Limited must carry rules, operator entitled to charge, no regulation of price for viewers IPTV: No FTA, no must carry rules, operator entitled to charge Open Internet: All channels “FTA”, both live and on demand services. Geo-blocking used for all live services but for only 5-10% of on demand (on demand catalogue is mostly DR own content, or content from EBU partners).

[132] According to the Belgian regulator FTA is not available via DTT in Flanders. PSM is available via the internet without subscription, but under condition of identification. But PSM is still available on DTT but in the subscription offer, offered by a service provider.

[133] According to the regulator, despite the low access to DTT, free access to PSM on DTT platform is still important in the French speaking Community. In addition, RTBF is a member of TV5MONDE and therefore provides contents through this FTA channel

Member State /EBU Member	FTA provided via DTT (Yes/No)	Alternatives for PSM
Finland/ Yle	Yes	Satellite: No FTA service available, but exceptionally outside DTT areas access cards are made available with subsidy. Regional PSM channel variants not available Cable: Must Carry. FTA but CTV operators allowed to charge a technical service fee ~€5/month for the CTV connection. Traditionally retransmission of DTT, but recently also original transmission by PSM, based on agreement between PSB and CTV operator IPTV: No FTA. Traditionally retransmission of DTT, but recently also original transmission by PSM, based on agreement between PSM and CTV operator Open Internet: All main channels of PSM as FTA. Regional PSM channel variants not yet available, but in the pipeline.
France/ FTV	Yes	Satellite: PSM services are encrypted for rights reasons, but with either free or one off-payment for viewing card (FTV).[134] "Must carry'' of PSM channels and "must deliver'' for commercial DTT channels in all commercial satellite offers (no extra charges for DTT channels). Not all sub-local services are available Cable: "Must carry", minimum subscription €28/pm for triple play (no extra charge for DTT channels). IPTV: "Must carry", minimum subscription €30/pm for triple play (no extra charge for DTT channels). Not all sublocal services available Open Internet: OTT under the trend francetv.fr.
Germany/ ARD BR DW HR MDR NDR RBB SR SWR WDR ZDF	Yes	Satellite: FTA Cable: Subscription required (for single family at least 17 € per month, depending on local CATV operator, less for a flat in an apartment block) IPTV: Subscription required (normally bundled with Internet and phone connection, from about 39 € per month) Open Internet: All channels "FTA", both live and on demand. Some Live-Stream with Geo-blocking depending on Content-Licensing. Occasional regional or national event live streams
Ireland/ RTE	Yes	Satellite: FTA (on Ka Band spot beam) and FTV on Ku Band as part of a subscription package

[134] 2 Free to view offers available: FRANSAT, TNTSAT

Member State /EBU Member	FTA provided via DTT (Yes/No)	Alternatives for PSM
		Cable: Must carry - Subscription required IPTV: Must carry – Subscription required Open Internet: FTA services available in Ireland. Geo-blocking for some content – subscription service available for some content.
Italy/ Rai	Yes	Satellite: FTA. Encrypted for rights reasons, but with one-off payment for viewing card (FTV) Cable: Almost no cable coverage nor penetration IPTV: <1% use Open Internet: All channels FTA, both live and on demand services. Geo-blocking for content rights
Netherlands/ NPO	Yes	Satellite: PSM is available within payTV packages. Cable: Subscription is required. The generalist PSMs are "must carry" and available in all pay packages. IPTV: Subscription is required. The generalist PSMs are "must carry" and available in all pay packages Open Internet: All PSM channels (general and thematic) are available FTA in SD
Poland/ TVP	Yes	Satellite: FTA - only news channel (TVP info HD and Polonia) and Belsat TV (on Astra 4A) Other PSM channels included in pay TV packages on third parties' platforms and encrypted. Cable: Third parties' networks: some programmes FTA under must-carry obligation / some encrypted. IPTV: No FTA. Minimum subscription required. Selected programmes only Open Internet: VOD services and several online channels available through TVP website and mobile app, also in Youtube and Facebook channels. Geo-blocking used for some live services
Portugal/ RTP	Yes	Satellite: Two channels FTA: RTP International and RTP Africa. Sometimes, due to technical difficulties and when one transmitter is costly for few viewers, the owner of DTT network may supply satellite receivers, as a special service Cable: No FTA IPTV: No FTA Open Internet: PSM channels are available through RTP Play (catch-up). Geoblocking for content rights outside Portugal.
Slovakia/ RTVS	Yes	Satellite: PSM services are encrypted for content rights reasons. FTV possible with access cards

Member State /EBU Member	FTA provided via DTT (Yes/No)	Alternatives for PSM
		Cable: FTA IPTV: PSM included in a TV package bundled with Internet connection and STB lease Open Internet: Streamed FTA. Geoblocking in other countries, depending on content rights.
Slovenia / RTVSLO	Yes	Satellite: PSM encrypted, two main PSM programmes included in pay TV packages. Cable: No FTA (PSM included in pay TV packages) IPTV: No FTA (PSM included in pay TV packages) Open Internet: Streamed FTA. Geoblocking in other countries, depending
Spain/ RTVE	Yes	Satellite: PSM encrypted, two main PSM programmes included in pay TV packages Cable: No FTA, two main PSM programmes included in pay TV packages IPTV: No FTA, PSM encrypted, two main PSM programmes included in the pay TV packages Open Internet: All the programmes are FTA in the Spanish territory. Geo-blocking in other countries, depending on content rights
Sweden/ SVT	Yes	Satellite: PSM encrypted and limited to the Swedish audience with one-off payment for viewing card (FTV) Cable: Must carry but charged. Freeview in analogue cable. IPTV: Must carry but charged Open Internet: Streaming of PSM channels on open Internet. Geo-blocking outside Sweden.

Table 37 - Availability of European PSM Services on TV distribution platforms.

Source: adapted from EBU, 2019

However, for public service broadcasters the decline in the traditional TV audience and the fragmentation of audiences across multiple services, platforms and modes of content consumption affects their ability to sustain high levels of reach, impact and value to audiences which is core to meeting the objectives of public service media, such as universality of access and appeal, delivering public value and promoting citizenship (Plum, 2021).

"*Universal access is crucial if the benefits of PSB are to be maintained*" (Ofcom, 2021) and Free-to-air (FTA) distribution is one of the principals means of fulfilling the universal service obligation and in many countries it is a legal obligation for PSM organisations (EBU, 2019).

In many countries, DTT is the only distribution platform offering FTA television services (EBU, 2019).[135] Table 37 shows the current availability of PSM distribution platforms in 16 European countries. It is possible to notice that in all countries, public-service broadcasters' content is available on DTT, but not on any or all alternative platforms, for technical, regulatory and commercial reasons. In many countries, there is a legal or licensing requirement for DTT to be available to a large proportion of the population. Not all alternative platforms can offer this. In particular, cable networks and IPTV are often still not available in many rural areas (due to high deployment costs). Other platforms cannot easily replace DTT and that in most countries, but DTT is essential for PSM services because it is the only free-to-air platform. Unless these reasons are addressed the alternative platforms cannot replace DTT for provision of PSM services in these countries (EBU, 2019).

In addition, all alternatives to FTA are either only available to subscribers as part of a paid package, via "*Free to View*" access cards or via an internet or mobile subscription (EBU, 2019). Subscriptions clearly represent a hurdle to those who cannot afford, or do not wish to pay for, a commercial package (whether just TV, an internet connection or a combination package including both or triple play (incl. mobile subscription)). The use of access cards represents an extra burden and costs on either broadcasters or platform providers, i.e. to manage databases of eligible households, handle the cards, and provide user support (EBU, 2019). In this regard, in the "Availability of European PSM services on TV distribution platforms*"* paper, EBU stated that platform operators whose core proposition is to provide pay-TV packages are reluctant to provide Free-to-View cards and the corresponding user equipment (EBU, 2019).

The DTT platform may be less flexible compared to other technologies in terms of adapting to future developments and evolving consumer needs. It is widely recognised that IP-based distribution of media will become the norm in the digital media landscape and this is reflected in the pace of technical innovation and industry investment. A number of recent reports suggest the life expectancy of broadcasting as a free-to-air television platform may be no more than 15 years. The public service broadcasters (PSBs) in both the UK and Finland, BBC and Yle and the UK regulator Ofcom – have each reached this conclusion in discussions about the future of news (BBC, 2015a), media distribution (YLE, 2014) and digital terrestrial television (DTT) (Ofcom, 2014a). Although broadcasting will be necessary some years yet, all three suggest that after 2030 DTT could be switched off and – under certain conditions – completely replaced with internet protocol (IP) -based solutions for public service

[135] There are significant variations between different countries with regards to existing legal or regulatory basis for the free-to-air model. In some countries free-to-air distribution of public service broadcast (PSB) services is a constitutional requirement, in others it is defined e.g. in the Broadcasting Act, or in the PSM remit, or possibly in the licence conditions. The current European legislation does not explicitly require FTA distribution (EBU, 2019).

media (PSM) delivery. According to Yle, the substance of FTA has changed in the sense that PSM content is available through open internet for the cost of broadband subscriptions expected to be paid by the audience similar to electricity bills (Yle, 2021).

Across the EU, the TV market landscape varies significantly: in some large markets such as Italy and Spain, DTT penetration and usage remain high and the DTT platform migration to alternative platforms would require large investments, either borne by individual households or governments (EBU,2019). The latter may be difficult due to platform neutrality considerations (EBU, 2019). In addition, even in markets where the demand for linear TV is declining, certain audience segments, such as the older viewers and low-income households, may still be dependent on DTT (c.f. Table 38 for the current outlook). In fact, all broadcast TV channels are subject to accessibility requirements to ensure that disabled people – particularly those with sight and hearing impairments – are able to watch PSM programmes, no similar requirements for on-demand services (including the PSM's own services and SVoDs) (Ofcom, 2021).

Most PSMs are providing a free service on the internet for accessing their content. The use of OTT internet to access PSM services is slowly growing via fixed or mobile broadband networks. However, coverage of both fixed and mobile IP networks is not normally universal and can have QoS issues (EBU, 2019). These services are often seen as an additional service to the primary linear service in each country, where the viewer can also catch up through VoD-content. For the open internet to be an alternative platform it must provide the same QoS as DTT – especially at peak viewing events such as the football World Cup and the Olympics (EBU, 2019). It must also provide the same level of redundancy and resilience as DTT infrastructure (EBU, 2019).

DTT will continue to be vital that vulnerable groups, as well as those who don't have access to the internet. This means there will still be demand for DTT capacity in some markets at the end of this decade and beyond, though the level of demand is likely to be much reduced in many countries (EBU, 2019).

DTT is also convenient for the provision of local TV services as the network coverage can be adjusted to the regulatory and commercial requirements. In many countries local TV services are only available on DTT and it may not be viable to provide them on other platforms, in particular where alternative platforms are not available or where the costs would be prohibitive on cable or satellite platforms (EBU, 2019).

According to a report commissioned by EBU, free-to-air channels reach over 800 million Europeans (Yle, 2021). Interviews (with representatives of the broadcasting industry) also stress the importance (and efficiency) of broadcasting to distribute live content to large audiences. The table below presents an overview of households dependent on DTT for FTA and future outlook according to regulators in 27 Member States:

Member State	Estimated share of households dependent on DTT for FTA	Future Outlook
AT	6% of Households	No current plans to change use of band (at least until 2030). DTT platform expected to adapt in order to enable homogeneous distribution of media content (DTT, cable TV, satellite TV, IPTV and devices TV/PC/smartphones etc.)

Member State	Estimated share of households dependent on DTT for FTA	Future Outlook
BE (NL, FR, DE)	Figure for French and German speaking communities not available. No FTA available on DTT in Flemish community (< 5% relying on pay-DTT)	No foreseeable developments. Regulator expects to maintain band usage for broadcasting in the next 10 years.
BG	No figures available.	There are no plans to change the current use of the band and the regulator does not monitor DTT market data.
CY	67% of households relying on DTT only	No plan to change band usage in the next 10 years. FTA TV broadcasting is very important and is expected to continue to have a significant role.
CZ	Exact numbers not available: number of households dependent on DTT- is lower compared to DTT reception (53%).	Ongoing discussion: all DTT licences are valid till 31. 12. 2030 only and regulator highlights annual growth of mobile data throughput.
DE	Less than 10%	No official viewpoint
DK	<1%	No specific plans to change use of band. Agency will work to ensure that the band 470-694 MHz may be used for mobile broadband when the band is no longer relevant for DTT (including opportunity to use non-broadcast services in the band if they are compatible with existing DTT/reduction in DTT/PMSE spectrum) .
EE	4.2% of households have access to FTA DTT only.[136]	No plans on changes in frequency use. DTT FTA remains important messaging channel and public service (PSM). Development of fibre-optic networks will increase number of households, where IPTV and TV over PC is used, TV on mobile networks will gain more popularity.
EL	According to the National Telecommunication and Post Commission (2021), in 2021 the subscriptions for pay-TV (satellite or ip-tv) were 1,110,281. In this sum the mobile -TV subscriptions are not included.	There is no viewpoint on the future of the sub-700 MHz spectrum. This is expected to be established after the WRC' 27 results.
ES	Free DTT reception is the only way of TV viewing for approx.. 64% of Spanish households	In Spain DTT is expected to continue even after 2030.
FI	8% (FTA, 20% DTT)	Considering co-primary mobile allocation. There is a change towards broadband usage from the FTA TV broadcasting, however the FTA TV service will be available as long as

[136] 14.0% households depend on paid DTT: 9,6 % paid+FTA and 5,4% on FTA only.

Member State	Estimated share of households dependent on DTT for FTA	Future Outlook
		needed. Only the number of programmes may reduce, mainly paid TV channels, which are already mainly watched via broadband connections. More and more TV content is watched via broadband systems (e.g. cable TV, satellite TV, IPTV, TV over PC, laptop, tablet, smartphone) than DTT. Already audience below 45 year are using more broadband than DTT.
FR	21.2% of households	No plan to change the use of this band within the next 10 years. Multiple factors may impact the future broadcasting landscape in the middle or long term. The evolution of the different TV reception modes shows no disruption, but rather a smooth transition from one mode to another, with a large degree of complementarity between various reception modes (e.g. for households owning multiple TV-sets). DTT would remain a major tool to meet the goals of pluralism and diversity of opinions.
HR	~41% of households[137]	The terrestrial TV market share in Croatia is still quite high and FTA DVB-T2 multiplexes will remain important at least until the end of 2030.
HU	10%[138]	There is a declining trend in viewership of DTT platform with no planned change in the usage of the band in the next 10 years. Future outlook is that the proportion of cable TV and DTT will be relatively unchanged, IPTV and online TV are expected to grow, while satellite TV will decrease
IE	12%-13%[139]	The share of viewers entirely dependent on FTA TV broadcasting reception is relatively static overtime. In 2022, ComReg will commence a study to consider the current and future spectrum requirements of broadcasting services in the national frequency range.
IT	No information is available[140]	DTT platform is expected to remain the privileged platform for accessing FTA content in the coming years.
LT	DTT is used by around 35-37% households in Lithuania. No data on the proportion of those households having access to other way of reception. Only free-to-air DTT is available in Lithuania.	No official prediction.

[137] data calculated using following formula: RH households with digital terrestrial reception only = (1.520.026 (number of households in the Republic of Croatia according to the last census of population from 2011) – 2.6% households without TV) – (number of Cable receptions + number of IPTV + number of Satellite receptions + digital terrestrial reception_pay TV)).

[138] households with no access to satellite TV, cable TV or IPTV

[139] The Broadcasting Authority also reports 18% of households have access to other Satellite (non Sky)

[140] 91.3% of Italian households access TV through the FTA (Free To Air) DTT services

Member State	Estimated share of households dependent on DTT for FTA	Future Outlook
LV	No information available[141]	All free-to-air (PSM) programmes are available online. No plans to change band usage within the next 10 years.
LU	There is no dependency on FTA TV in Luxembourg.	DTT is granted until 2030, so until then no changes are expected.
MT	Information not available but expected figure is very low.[142]	The future of commercial DTT services is uncertain since the current DTT licence will expire on end June 2022 and no interest has so far been expressed to continue the offering of commercial DTT by the same or other network players. Cable TV and IPTV will remain the dominant platforms for the delivery of television distribution services, while the continued provision of FTA DTT is subject to ongoing (national) study.
NL	1-2% estimated	It is expected that the market share of DTT will decrease. The main distribution will be cable TV and IPTV, as is now the case. If DTT were to be (partly) replaced by 5G broadcast, then the focus of this service will probably shift from fixed TV to tablet and smartphone reception. Future use of the band will be influenced by WRC23 discussion.
PL	35.3% households	Despite the decreasing number of DTT viewers audience (including households entirely dependent on DTT) is expected to be significant enough beyond 2030.
PT	5%	The future of the DTT will depend on (1) the renewal of the existing right of use of frequencies (RUF) or (2) a Governmental decision on the matter in case the renewal does not occur
RO	0%	No change foreseen
SE	8% households (FTA, 20% DTT)	The trends in media consumption described above indicate that the current media landscape will continue to change towards decreased consumption of content delivered by DTT and increased consumption of content delivered by other means, such as broadband where internet-based play services as well traditional broadcasters' own play services are of specific interest. It worth to mention that 73% of population in Sweden already today have access to smart-tv.
SI	3% households (FTA, 0.9% DTT)	The DTT share is already very low 0.9%, however, we expect it to stay at this level or decrease a bit as show trends. On the other hand, cable TV and IPTV shares are high and are growing and we do not expect any significant change regarding the trends
SK	No information is available but an estimated percentage	The use of FTA TV broadcasting will gradually decrease as other distribution technologies advance and various streaming platforms become more available and used. Already today FTA

[141] 14% of pay-DTT subscriptions (92 681) reported by SPRK in 2020

[142] Broadcasting Authority audience survey which states that 0.8% of viewers use FTA TV as one of the reception services for watching TV.

Member State	Estimated share of households dependent on DTT for FTA	Future Outlook
	would be quite low.	broadcasting holds onto an older demographic. Nevertheless in terms of broadcasting platform shares the following outlook is expected: DTT will remain stable above 10-13 % (FTA + PayTV), declining satellite above 25 % (PayTV) under pressure of IPTV above 20 %.

Table 38 - Dependency on DTT for FTA and future outlook (regulator survey).

Source: NRA survey

5 Spectrum needs and technology trends in PMSE

The ECC (CEPT ECC, 2021) finds the needs of programme making and special events (PMSE) users are growing, both in terms of the amount of PMSE equipment needed at a typical given location or event, and the number of events/locations at which PMSE is required. Whilst the need for PMSE spectrum is temporary or restricted to certain locations, the increase in the amount of PMSE equipment in use at a given location or event serves to increase the peak demand. This, coupled with the reduction of available spectrum within the UHF band brought about by clearance of broadcast services from the 700MHz band, has affected PMSE users. Whilst other bands are available for use by PMSE (for example the 174-216 MHz and 1785-1800 MHz bands, and amongst some non-safety aeronautical services such as in the lower L-band or around 1300MHz), the UHF band is harmonised at a European level, helping to foster an ecosystem of standardised equipment.

This section investigates the developments in PMSE technology, to what extent these developments have been adopted by users, and the current and foreseen demand for PMSE within Member States.

5.1 Technological Developments

5.1.1 Power Amplifier Linearity

Historically, power amplifiers utilised within PMSE equipment have been operated so as to minimise battery consumption, with the drawback that amplification has been very non-linear. The result of this however has been the generation of intermodulation products, whereby the mixing of two or more signals passing through a non-linear amplifier can generate interfering signals at a number of different frequencies (Cambridge Consultants, 2014). When a number of pieces of equipment are operated in close proximity, this has the effect of reducing the amount of spectrum available, as equipment cannot be used on a frequency subject to these intermodulation products. Where a single radio microphone might be expected to occupy a 200kHz bandwidth, the use of 20 radio microphones or IEMs with non-linear amplifiers in close proximity can result in effective bandwidth requirements of as much as 1MHz per device (Cambridge Consultants, 2014).

Developments in the design of very linear power amplifiers have helped tremendously in this field by improving the intermodulation performance of PMSE equipment (RADIO SPECTRUM POLICY GROUP, 2017). Manufacturers are now able to offer analogue PMSE equipment achieving 20-30 audio channels per 8MHz block, i.e. an effective bandwidth of ~270-400kHz, using higher linearity power amplifiers and quadrature signal cancellation circuits. The drawback of this improved performance however is higher levels of energy (battery) consumption, and more complex calibration of equipment (Cambridge Consultants, 2014).

5.1.2 Digital PMSE

Digital technologies have historically been less well suited to PMSE due to the increased latency they achieve, but developments in digital technologies have narrowed the gap in achievable latency between the two systems (now 2-3ms (Sennheiser, 2021) as opposed to the ~0ms latency achieved via analogue systems (ETSI, 2021)). Note that this level of latency may still be too high for certain applications, for instance IEM (in ear monitors) (RADIO SPECTRUM POLICY GROUP, 2017), and as such digital PMSE potentially cannot be deployed in all instances.

Studies find that digital transmission over PMSE is not inherently more spectrally efficient than analogue, as is often the case with other services. This is primarily found to be due to the high levels of overhead contained within the digital transmission, including for example channel signalling and synchronisation symbols (Stratix, 2017). However, one particular benefit of a transition to digital PMSE equipment is that digital equipment includes the linear power amplifiers necessary to combat intermodulation products. As such, with intermodulation issues reduced, higher levels of spectral efficiency can be obtained by default, closer to the 20-30 audio channels per 8MHz block observed for high end analogue equipment (Cambridge Consultants, 2014).

Some manufacturers offer equipment capable of functioning at higher densities than this, achieved typically through a combination of higher levels of filtering on the output transmission or by using narrower transmit bandwidths or more robust modulation schemes. These both come with trade-offs, either in the form of increased equipment cost and complexity, or reduced capacity and audio quality (Stratix, 2017). In addition, as noted for the case of analogue systems operating higher linearity power amplifiers, digital systems tend to have increased power consumption when compared to more basic analogue systems.

The use of digital technologies has facilitated operation of equipment in areas where the noise and/or interference levels are higher than would be acceptable to analogue systems. Some digital wireless microphones are now capable of operating at a 9dB SINR (Cambridge Consultants, 2014), which compares with for instance the 15dB quoted as required for the analogue equivalent (ETSI, 2021). Whilst not explicitly increasing the spectral efficiency of PMSE, this development could open up new spectrum in areas of high demand, for example by facilitating use of spectrum closer to DTT transmissions.

5.1.3 Digital Enhanced Cordless Telecommunications (DECT)

Increasingly, PMSE is finding opportunities within the DECT frequency band, 1880 – 1900MHz, as regulated by ERC/DEC(94)03 for licence exempt usage across Europe (CEPT, 1994). Usage of DECT technologies and frequencies is appealing to PMSE due to this cross border standardisation, the technology’s automatic frequency and interference management functionalities and the readily available nature of equipment. Historically, DECT has been used mainly for applications for which latency and audio quality are less critical, due to the comparatively low spectrum availability (20MHz vs up to 224MHz) and latency (~10-20ms vs <4ms) offered when compared to more traditional PMSE equipment in UHF spectrum (CEPT ECC, 2021). Considering latency, DECT operates a time division duplex (TDD) system with timeslots of ~10ms in duration. If the minimum delay is assumed to correspond to 2 timeslots, this introduces a latency of ~20ms, well above the 3-4ms required by a number of PMSE applications.

However, DECT is undergoing two main development paths within ETSI, DECT evolution and DECT-2020. DECT evolution is aiming to improve support for applications requiring improved latency, data-rate and reliability. DECT-2020 is aiming to support new use cases such as ultra-reliable low latency communications (URLLC) and massive machine type communications (mMTC) and is a candidate system for being included in the IMT-2020 family of standards (CEPT ECC, 2021). Development of these features may make DECT technology suitable for a wider range of applications, as currently DECT is seen to be insufficient for live events (Sennheiser, 2021).

5.1.4 Cognitive PMSE (C-PMSE)

Cognitive PMSE, C-PMSE, aims to retain audio quality in the presence of a number of densely spectrally packed radio microphones, although this does not inherently increase spectral efficiency by itself (Cambridge Consultants, 2014). As defined in ETSI TS 102 800 in 2011, and later updated in ETSI TR 102 801 in 2015 (ETSI, 2015), the system features a database that has information regarding the frequencies that can be used by PMSE in a given area. The C-PMSE system takes information from the database, with a number of scanning receivers helping to operate a ‘Listen Before Talk’ protocol to determine which of the available channels is clear in the area as well as to identify any ‘non-cognitive’ PMSE equipment such that it can work around this (ETSI, 2015). This is displayed in Figure 75. Initial frequency assignments are calculated by the system to minimise interference, as well as any subsequent necessary frequency or transmit power changes as a result of changing levels of interference (ETSI, 2021).

The system was originally trialled at Messe Berlin between 2011 and 2013 as part of a project funded by the German Federal Ministry of Economics and Technology (BMWi). The perceived benefits of the system are the potential for higher levels of automation for PMSE planning, as well as the possibility for PMSE to have higher levels of flexibility during an event. Furthermore, C-PMSE systems may allow PMSE to use frequency bands with incumbent users with whom PMSE has not traditionally shared (RADIO SPECTRUM POLICY GROUP, 2017). These are not in themselves improvements to spectral efficiency, however they could improve the access of PMSE equipment to spectrum. However, criticisms of the system are the high levels of complexity required and the large number of local factors that would be unknown to a generic system (Cambridge Consultants, 2014).

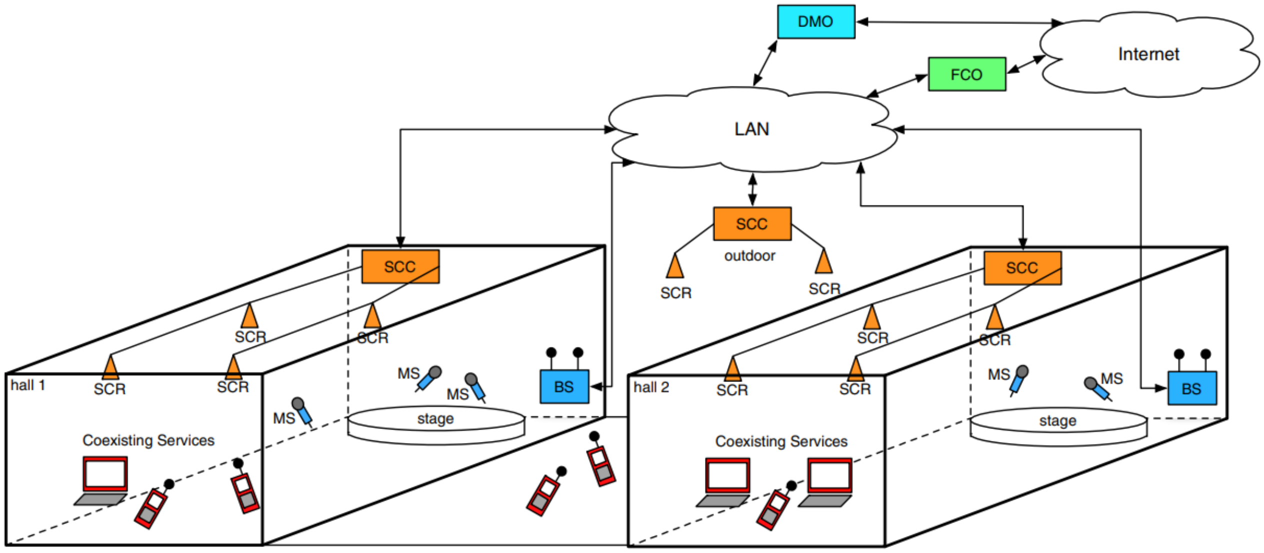


Fig. 1: General overview of the field trial platform

SCR:	Scanning Receiver	MS:	PMSE Mobile Station
SCC:	Scanning Controller	BS:	PMSE Base Station
DMO:	Demonstration Monitor	LAN:	Local Area Network
FCO:	Frequeny Coordinator		

Figure 75 – General overview of the C-PMSE trial held in Berlin.

Source: Beutnagel-Buchner et al., 2011

There appears to be little published information surrounding usage or development of C-PMSE beyond the initial project work, however. It may be that the high level of complexity has prevented the system from being readily useable for many applications, or that the expense and effort in installing sensing receivers has proven too prohibitive for venues to deploy.

5.1.5 Spectrum Management Approaches

At a regulator level, a number of spectrum management approaches are used for PMSE. One of the most common approaches for PMSE is the use of databases to record the usage of certain frequencies for other services. When approached for PMSE authorisation, regulators are able to determine suitable frequencies for usage in a given area based on the information held within the database. This type of approach is also used to provide spectrum access through television white spaces (TVWS), whereby spectrum in the 470-694MHz range that is not being used by DTT is available for usage by some limited set of services, including for Wi-Fi type applications to provide wireless connectivity in underserved areas. Often, particularly in the case of TVWS, these authorisation approaches are becoming increasingly automated, helping to improve the speed and ease of access for applicants.

This type of database approach is an example of a software access system (SAS). A particular development in SAS has been demonstrated through the Citizens Broadband Radio Service (CBRS) approach to spectrum authorisations in the 3.5GHz band in the United States. Typically, the spectrum is used for private mobile networks, however users are able to access the spectrum on a tier based system, with users in the highest tier (Incumbent Access) having priority access to the spectrum when required. A network of sensors determines when this spectrum is being used by those in the highest tier, preventing usage by other tiers at times and in locations where incumbent users require access. The second tier (Priority Access) represents access granted to users through a competitive bidding process, with requirements on usage and limits on the number of licences any licensee can hold. The lowest tier (General Access) allows for open and flexible usage of the sections of the band not allocated to priority users, provided that other tiers are protected (Federal Communications Commission, 2020). These approaches allow for spectrum to be made available for a service in a given area, and dynamically in the case of the CBRS approach. Whilst these types of approaches show promise in helping to make spectrum available in a more tailored and automated way, it is unclear the extent to which such an automated approach has been applied to PMSE.

With regards to planning of PMSE spectrum usage at venue or event level, C-PMSE (as considered earlier within this report) is one example of a frequency agnostic spectrum management system. In the absence of this type of approach, detailed spectrum planning is often required to ensure interference-free operation for all users. As well as the device frequencies themselves, any frequency planning needs to also take into account possible intermodulation products. Manufacturers often provide a list of frequencies to be avoided which, provided all equipment is produced by the same manufacturer, can allow for relatively straightforward planning of the frequencies to be used.

If equipment is sourced from multiple manufacturers, more detailed frequency planning is required, often utilising software tools to determine the intermodulation free frequencies (ETSI, 2021). Some manufacturers now also include access to proprietary software or applications that automate the process, helping to reduce the complexity involved in setting up for events (Sennheiser, 2021). Similarly, these application based equipment sets allow for easier ad hoc changes to frequency usage to be made in the event of interference. It is worth noting however that usage of these tools does not inherently improve spectral efficiency, but their usage allows a more systematic approach to ensuring interference free operation.

5.1.6 Wireless Multi-Channel Audio Systems (WMAS)

Existing PMSE systems, both analogue and digital, are narrowband systems with bandwidths typically in the order of 200kHz, with users occupying separate frequencies. Wireless multi-channel access systems (WMAS) instead utilise a wideband signal, of up to 20MHz bandwidth, with users sharing the same physical RF channel, as shown in Figure 76. Depending on the access scheme, devices are separated into separate audio channels (CEPT ECC, 2021). WMAS is expected to deliver spectral efficiencies ~50% greater than traditional narrowband systems (ETSI, 2017). Work is ongoing on this standard, although it is believed that few to no manufacturers have made equipment commercially available currently (Sennheiser, 2021).

Spectral efficiency gains are achieved by digitally combining the signals from multiple devices into a wider channel, eliminating intermodulation and permitting denser use of the spectrum while lowering the average power spectral density across the channel. However, a potential downside of this is that if too few devices are in operation, the resulting spectral efficiency is lower than when using conventional PMSE equipment. Some manufacturers have recommended to the Federal

Communications Commission within the US that a minimum number of devices be required in order for WMAS to be utilised (between 12 and 24 devices in a 6MHz channel), such that equivalent or improved spectral efficiency can be achieved (Federal Communications Commission, 2021). As such, it may be that the requirement for a minimum number of devices prevents WMAS technology from being applicable to all applications, or at least that the technology achieves a lower spectral efficiency in some instances.

Similarly, whilst WMAS allows for bandwidths of up to 20MHz, for the technology to be used in spectrum shared with DTT, it will need to be able to fit within the current 8MHz raster that is used. In some areas, for example those with many DTT multiplexes in operation, sufficiently interference free 20MHz bandwidth channels may not be present. As such, it may also be that the spectral efficiency gains that can be obtained are also not achievable in all environments. In addition, manufacturers will also need to ensure that WMAS equipment is capable of coexisting with existing PMSE equipment, and any other services sharing the spectrum, to ensure that its usage does not affect other users.

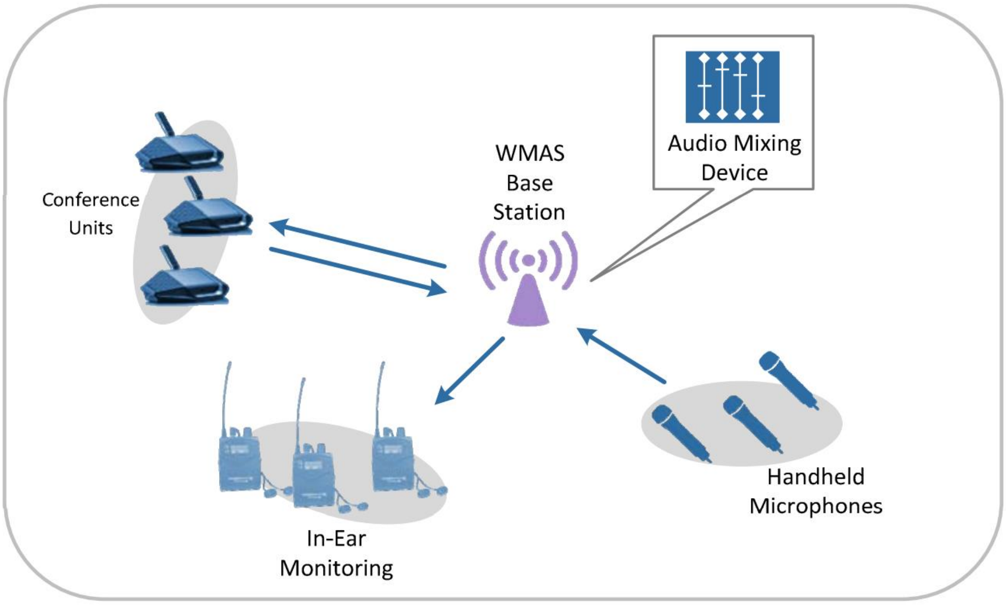


Figure 76 – Exemplary WMAS topology.

Source: ETSI, 2017. © ETSI 2017. All rights reserved.

5.1.7 Use of Alternative Frequency Bands

Audio PMSE has historically made significant use of spectrum within the UHF range, in part because spectrum in this range has suitable propagation characteristics for its use, but also because it is able to share spectrum with the current users, i.e. DTT services, very successfully. However, any changes to the usage of the spectrum, either in moving to a denser usage of the spectrum by DTT as in an SFN typology or through allocation of some portion of the spectrum to an alternative service, could affect the ability of PMSE to continue sharing the spectrum. In addition to the technology developments considered earlier, this section explores the opportunity for audio PMSE to make use of alternative frequency bands.

With successive clearance events, some Member States have made spectrum within the mobile centre gap (700, 800 and 1800MHz bands) available to PMSE. Usage of this spectrum has the benefit that older equipment, i.e. obtained prior to clearance events, is still capable of functioning within the spectrum range. However, studies have found that usage of this spectrum, whilst possible in some cases, is limited by the proximity of base stations and user terminals to PMSE equipment, with minimum separate distances ranging from less than 10m to over 1km (Joint Research Centre of the European Commission, 2014). Similarly, the spectrum available to PMSE is considerably less when sharing with the duplex gap than when sharing with DTT. As such, whilst this is a potential spectrum range for many PMSE applications, it does not fully replace the spectrum lost and there are also use cases for which it is unlikely to be suitable.

There is a move within some countries, primarily the UK, to allow usage of the 960-1164 MHz band for PMSE. This spectrum is shared with aeronautical services in many cases and is far from standardised across Europe (CEPT ECC, 2020). As such, whilst spectrum in this range could prove incredibly useful to PMSE, for example as it has similar propagation characteristics to the existing sub-700MHz UHF spectrum, the ecosystem supporting the usage of this spectrum is not well developed. Furthermore, it is unlikely that a significant ecosystem, and hence usage of the band, will develop if access to the band is not widespread (British Entertainment Industry Radio Group (BEIRG), 2019).

Where sub-1GHz spectrum is in demand from other services, the potential for PMSE to use more of this spectrum may be limited. As such, there is potential for PMSE to migrate to higher frequency bands, for example those increasingly being made available on a locally licensed basis such as frequencies around 3.5GHz and mmWave. However, whilst usage of these bands may, at an administrative level, be possible, there are a number of physical effects that determine the suitability of these higher frequencies for PMSE usage.

The first consideration is that of propagation. Higher frequencies propagate less well in free space, such that a doubling of the frequency increases the path loss by a factor of 4. The effect this has on system range will depend on the exact system in use, but it is important to note that significant increases in frequency, i.e. from sub-700MHz UHF to 3.6GHz, have the potential to significantly decrease the range of PMSE equipment. This may not be an issue for some use cases where, for example, devices only need to be connected over short distances. However, range may be a crucial aspect in some applications and as such usage of higher bands may be less appropriate.

A further consideration is the interaction of PMSE equipment with the human body, particularly as in a number of instances the PMSE equipment will be held or worn in close proximity to a person. A study conducted for OFCOM in Switzerland investigated the effect that frequency had on microphone antenna performance when either held or worn (IT'IS, 2015). The study found that generally as the frequency increases, the shadowing caused by a person increases also. For handheld microphones at ~3.8GHz, the study found the shadowing could be 10-30dB greater than at 750MHz. For body worn microphones, the shadowing could be 20-30dB greater than at 750MHz. The study also found that reflection from the body could contribute to increased performance in some directions. Compared to performance at 750MHz, a handheld microphone could achieve up to 8dB improvement at ~3.8GHz, whilst a body worn microphone could achieve a 10-15dB improvement in performance at ~3.8GHz. The study noted that the effect was highly dependent on the distance of the microphone from the person, and the size of the person. However, it is important to note that the significant nulls in the antenna pattern that are created at higher frequencies could give rise to potentially significant issues that are likely not mitigated by any improvements in performance.

In summary, some use cases may be suitable for higher frequency spectrum ranges. However, usage of higher frequency bands by audio PMSE, particularly microphones and IEMs, will need to carefully consider the effect of decreased range and increased potential for significant body-antenna interactions.

5.1.8 Use of 5G for PMSE

5G has been hailed as a potential alternative technology to cater to the needs of PMSE users. However, there are a number of hurdles that 5G will need to overcome in order for the technology to be suitable. Historically, PMSE users have been hesitant to adopt mobile technologies due to a number of factors, including its ability to offer sufficiently low latency and uncontested access to spectrum. Earlier projects, for example PMSE-xG which concluded in 2017, found that 5G could potentially offer a suitable alternative for some PMSE applications, for example with a potential network topography as shown in Figure 77, but that further development in the standards and engagement from the mobile industry would be needed (PMSE-xG, 2017). Within this section, the progress that has been made with regards to 5G offering a suitable alternative to PMSE is investigated.

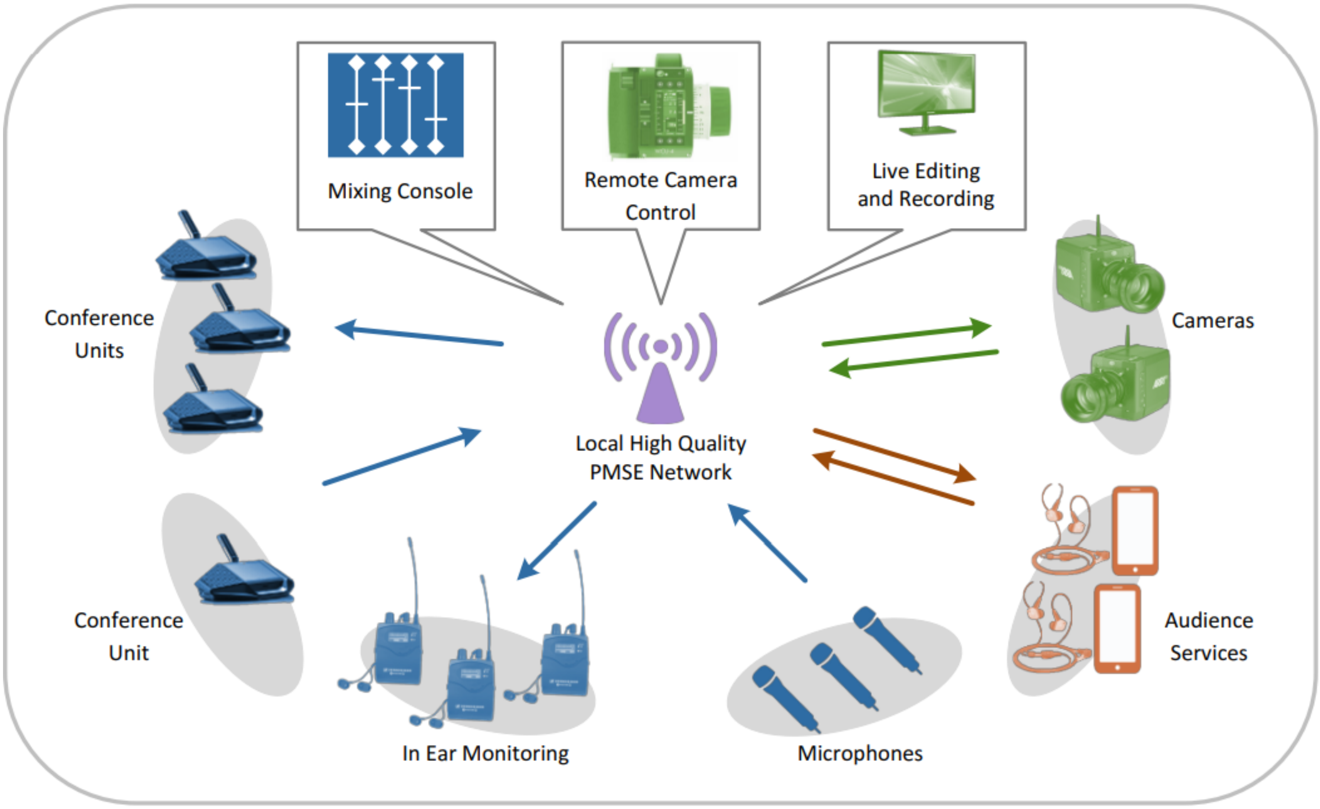


Figure 77 – Example network topography for a 5G network for PMSE use.

Source: PMSE xG, 2017

Certain PMSE applications, for example IEMs, require an end to end latency of below ~4ms in order to ensure suitable operation. Earlier mobile technologies were not able to meet the latency requirements, although developments included within the 5G standards offer hope that latency requirements may be able to be met. In particular, the ultra-reliable, low latency communications (URLLC) use case supported by 5G NR aims to achieve network latencies of generally less than 1ms. Recent work utilising a 5G test bed, published in early 2021, achieved two way latency of 7ms for a single user (Nokia Sennheiser, 2021). The project notes that to achieve these latencies, 5G core processing and any application processing would need to be performed locally in proximity to the 5G base station to avoid introducing further latency into the chain. The project utilised 3GPP Release 15 URLLC features, and a software defined radio implementation for the user equipment. It is noted that commercialised equipment may offer superior performance. In any case, the relatively low latencies achieved show that there is potentially promise in the use of 5G for PMSE, however further improvements are likely to be required in order to meet the <4ms latency requirement for applications such as IEMs. Further work would also be useful to determine the effect of multiple users on the resulting latency.

A further requirement of PMSE is reliability, particularly for live productions. Reliability is specified in a number of different ways, including both qualitative and quantitative assessments. ETSI TR 102 546 suggests that current analogue technologies offer ‘better to best’ reliability, equating to reliable line of sight operation over 75-100m ranges. This compares to digital technologies achieving just 'good', or reliable line of sight operation over just 50m (ETSI, 2021). PMSE-xG states that audio requires a reliability of 99.99%, or 10^{-2}. 3GPP defines the minimum requirements for a live production case as a packet error rate of 10^{-6} (3GPP, 2019), and as such should be sufficient to meet PMSE reliability requirements if the standards can be implemented. The same 5G test bed considered previously investigated reliability also, managing to achieve a packet error rate of 10^{-5} (Nokia Sennheiser, 2021), again showing promise for 5G as an enabling technology for PMSE, but demonstrating that further development would be required.

Currently, PMSE users benefit from harmonised spectrum across Europe (the 470-694MHz range). A key benefit associated with this harmonised, often licence exempt, spectrum is that users are able to travel widely with standardised equipment, with minimal retuning and administration required in different areas. 5G handset availability is increasing around the world, however 5G capable PMSE equipment is still limited. For PMSE usage to migrate to 5G, significant development in commercial, off the shelf equipment would need to take place. For this to occur, sufficient demand would need to be in place to ensure it is viable for manufacturers to include the standards within their products. Similarly, sufficient standardisation would need to be in place with regards to the available spectrum bands to ensure equipment could be used widely across the region. It is currently unclear the extent to which this demand and standardisation exists (EBU, 2020), particularly given that many countries are still developing their approach to rolling out 5G networks.

A further concern of 5G usage for PMSE would be the network access arrangements and network suitability in different venues and countries. Use of URLLC requires specialised networks, which will not necessarily be in place in all locations. Similarly, for PMSE users arriving at a new venue or a new country, having to secure access to 5G networks is likely to be an additional administrative hurdle in ensuring that equipment can be used. It may be that private networks managed by venues, or indeed PMSE users themselves, could be utilised to minimise this, however this still adds an additional layer of complexity, cost and effort in being able to use PMSE equipment.

The LIPs project (Live Interactive PMSE Services) operated between 2018 and 2020 and investigated the feasibility of having two distant but connected rooms, to enable interactivity between locations in content production (LIPS, 2020). The project comprised a number of industry stakeholders, and was supported by the German Federal Ministry for Economic Affairs and Energy. In particular, 5G was considered as a potential technology to support the requirements. The project found that 5G private networks offered potential benefits for the field of PMSE, particularly with regards to dedicated uncontested access, helping to deliver on reliability and latency requirements, but also allowing a flexible deployment anywhere. The project noted that spectrum licensed locally for private access could offer a flexible approach to accessing suitable spectrum in a way that would be appropriate for PMSE usage. The project notes this type of approach is demonstrated in Germany, where BNetzA has allowed spectrum in the 3.7-3.8 GHz range to be licensed on a temporary basis for internal use.

It is worth noting that similar locally licensed spectrum regimes exist elsewhere in Europe, with 10 Member States having adopted local licensing models as of March 2022 (VVA, PolicyTracker and LS telcom, 2022). The majority of these are within the 3.6GHz band, although some make use of mmWave spectrum at 26GHz also, and France has made some spectrum available for local licences within the 2600MHz TDD bands (VVA, PolicyTracker and LS telcom, 2022). As these bands are significantly higher frequency than the existing UHF spectrum used for audio PMSE, it may be that they are not suitable for all use cases, however. Similarly, if different spectrum ranges are made available within different Member States, standardisation of equipment may again be made more difficult. A further issue with regards to spectrum access will be the timeliness of any authorisations. PMSE users currently enjoy licence exempt usage in many Member States, and as such having to go through formal authorisation processes may hinder usage. This applies to the length of authorisations as well. PMSE usage is, in many instances, only for a temporary period. This is at odds with the sorts of authorisations often granted for mobile spectrum. As such, for this spectrum to be appropriate for PMSE, it would need to be available on an ad hoc basis in some instances (CEPT ECC, 2021).

In summary then, whilst progress is being made with regards to 5G being used for PMSE, for example in terms of improved latency, reliability and uncontested access to spectrum, there are still developments that will need to occur prior to any widespread adoption. In particular, further improvements in latency are likely to be required for some applications, as well as development of an ecosystem of commercial, off the shelf equipment. In addition, spectrum authorisation approaches or agreements with existing network operators will need to be put in place so as to allow access by PMSE.

5.2 Deployment Developments

5.2.1 Member State Developments Summary

ERC REC 25-10 (CEPT ECC, 2021) proposes standardised bands for PMSE. The proportion of Member States allowing access to each of these bands is shown in Figure 78. All Member States allow PMSE usage within the 470 – 694MHz band, as would be expected following European harmonisation. However, access to the other bands varies considerably across Member States. Usage of the 823 – 832MHz and 1785 – 1805 bands is common (20 and 21 of the Member States respectively), as is usage of the 174 – 216MHz band (19 of the Member States).

Frequencies above 1800MHz are used less commonly across Member States, with just 2 making the 1880 – 1900MHz band available. The same is true for spectrum in the rest of the L-Band (1350 – 1400MHz and 1492 – 1525MHz), with just 5 or 6 of the Member States making spectrum in this range available for PMSE. Usage of the remaining standardised bands (29.7 – 47MHz, 174 – 216MHz, 694 – 790MHz and 863 – 865MHz) is again varied, with between 13 and 19 of the Member States making each available for PMSE.

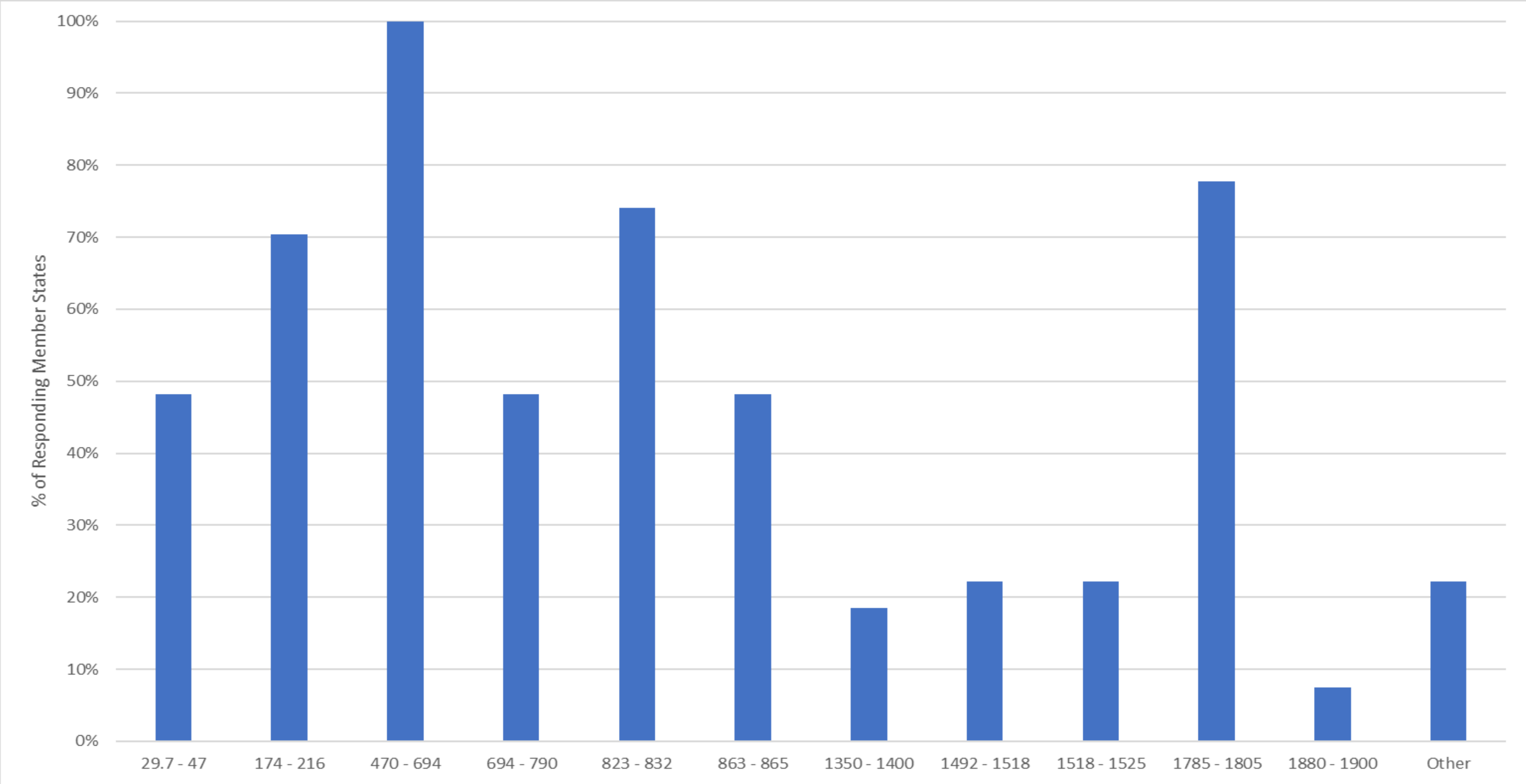


Figure 78 – Percentage of Member States allowing PMSE usage in standardised bands

The total amount of spectrum available for PMSE in each of the Member States (within the bands identified in (CEPT ECC, 2021) for audio PMSE), as well as the amount of this in the 470-694MHz band, is shown in Figure 79, noting that not all of each band is necessarily available for use by PMSE in any given location.

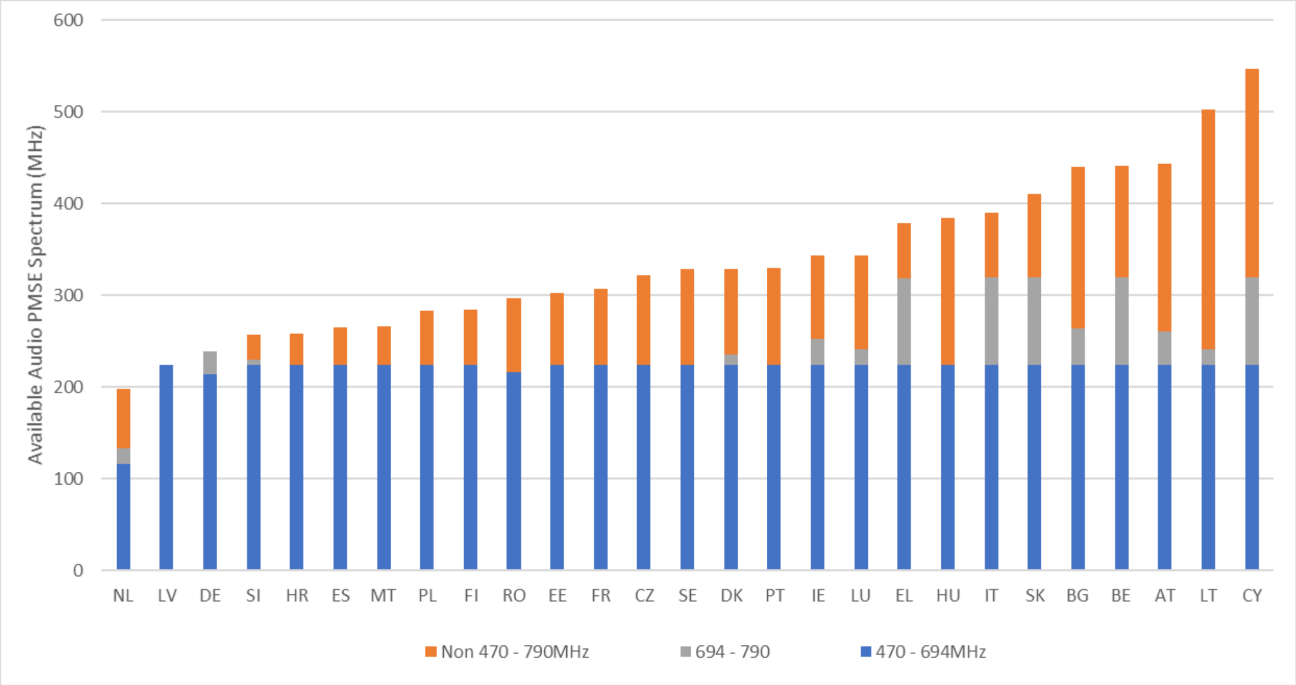


Figure 79 – Available standardised audio PMSE spectrum within Member States, showing how much of the available spectrum is within the 470 – 694MHz and 694 – 790MHz bands.

Note that the values for The Netherlands, Romania and Germany are lower as specific ranges have been identified for use by PMSE in the 470 – 694MHz range. In 25 of the Member States, PMSE spectrum within 470 – 694MHz constitutes at least 50% of the available spectrum. As such, a change in access to this spectrum would likely represent a significant impact for users of PMSE equipment.

24 of the Member States permit usage of PMSE equipment in the various bands on a licence exempt basis. An indication of peak demand is shown in Table 39 however where provided.

Member State	Equipment Authorisations	Channels	Spectrum	Duration	Regularity
Austria	250			1-2 weeks, up to 1-2 months	3 per year
Belgium				Few Days	1 per year
Bulgaria					
Croatia		30 x 250kHz		3 days	20 per year
Cyprus					
Czech Republic		~100		1 week	2 per year
Denmark					5 per year
Estonia					
Finland		100s			2-5 per year
France		605		3.5 weeks	3 per year
Germany					3 per year
Greece					1 per year
Hungary	190			4 days	10 per year
Italy	~300	255		1 week	20 per year
Latvia	10s			2 weeks	2-5 per year
Luxembourg				5 days	
Netherlands	~200			10 days	24 per year
Poland	50				10 per year
Portugal		140	750MHz		
Romania				3-4 weeks	
Slovenia		20			Up to 12 times per year
Spain		30		5 days	1 per year
Sweden				Up to 2 weeks	

Table 39 – Peak spectrum demand in each of the Member States, noting that limited information is available due to licence exempt usage.

Whilst detailed information regarding PMSE requirements is not available for most of the Member States due to licence exempt usage, events that constitute peak demand happen multiple times per year (up to 24), lasting for generally a few days to a few weeks. Typically, these are limited to a specific location, rather than representing a requirement for large amounts of spectrum across a wider area, however. It is noted also that frequency reuse over larger distances is possible also, as interference is unlikely to occur over distances in excess of a few hundred metres (CEPT ECC, 2021). The requirement for PMSE channels in a given location is anything between 30 and ~600, with the amount of equipment authorised ranging from 50 to ~300.

The ETSI reference for audio PMSE, TR 102 546 (ETSI, 2021), suggests that large events such as national events might require as much as 90MHz of spectrum (>64 wireless microphones and 16-24

IEMs), raising to >150MHz for so called ‘mega’ events (>192 wireless microphones, >44 IEMs). As such, the levels of equipment authorised in a number of the Member States’ quoted peak demand scenarios could be expected to require access to significant amounts of spectrum. Taking for example the case of Italy with ~300 equipment authorisations (~75 of which represent radio microphones and IEMs), according to the ETSI reference, 90MHz could be assumed to be required to deliver this sort of event. 96MHz of audio PMSE spectrum is available for use outside of 470-694MHz within Italy, which just meets the estimated requirements. Regulator AGCOM notes that PMSE demand is growing, and that meeting demand for PMSE post 700MHz clearance is difficult. As such, further reduction in PMSE spectrum in this range may further complicate access to spectrum for PMSE users.

5.2.2 Stakeholder Responses

Within this section, the key messages from stakeholder presentations at the workshop (held virtually on the 30th of March 2022, with the presented slides available on the European Commission website (European Commission, 2022)) are presented.

5.2.2.1 Pearle, Belgium

Pearle noted the strength of the content industry within Europe, with over 600,000 companies registered within the EU27. The performing arts industry has shown a sustained 2.9% annual growth between 2013 and 2019 and employed over 1 million people within the EU in 2019. Access to UHF spectrum for PMSE helps to support the industry, as it allows for the best audio quality and latency for production and live events and provides a standardised range that allows touring in different markets.

The sharing of UHF spectrum between DTT and PMSE has been successful for many years and can be viewed as an exceptional model of coexistence. However, the loss of 200MHz of spectrum makes it increasingly challenging to establish a reliable and usable frequency plan for each production and event. Similarly, devices have a typical lifespan of 10-15 years which could result in significant cost to the industry if needing to replace them outside of the normal replacement cycle.

Pearle saw that lessons could be learnt from the COVID-19 pandemic, as the growth in streamed live content had a positive effect on content producers and platforms. Similarly, Pearle saw that government engagement in keeping the sector alive, due to its contribution to economic activity and individual personal wellbeing, was demonstrative of the sector’s importance.

5.2.2.2 Shure, UK

Within Shure’s presentation during the workshop, the strength of the content and events industries within various EU Member States and other countries within ITU Region 1 was highlighted. For example, Shure noted that Germany’s event industry represented a total annual turnover of €129 billion, with 1 million people directly employed by the industry. Shure noted that further reductions in spectrum threatened the strength of the industry within the European Union, but also more widely across ITU Region 1.

Shure noted that new technology, primarily digital technologies, has allowed for greater spectral efficiency, but events are now far more congested. Shure presented the example that the US is now effectively 100MHz worse off with regards to available PMSE spectrum than Europe due to the 600 MHz clearance programme. This has caused issues for the content and events industries. For example, the Superbowl in Los Angeles had to acquire a special licence from the FCC to be able to operate within the 600 MHz band in order to be able to deliver the event. This was complicated by there being little 600 MHz capable PMSE equipment available because usage of this spectrum is illegal for PMSE in the US.

5.3 Summary

As a result of the developments in technology, PMSE equipment is now able to achieve 20-30 audio channels per 8MHz block, achieving broadly acceptable levels of quality. An alternative technology in the form of DECT allows access to more spectrum but may not be applicable to the most latency and quality sensitive applications. Techniques such as C-PMSE and more advanced spectrum management approaches could help to retain audio quality in congested spectrum and could open up possibilities for usage of spectrum in new areas. The extent to which these have been adopted is unclear, however.

Whilst the capabilities of PMSE equipment are growing, the demand for PMSE is growing as well. This is evidenced by the Member State questionnaire responses, where approximately half of the responses indicated an observed growth in PMSE spectrum demand, for example by approximately 10% a year in the Netherlands and 20% a year in Spain. A study by Swiss broadcaster SRF found that the daily requirement for PMSE spectrum, based on the technologies currently within use, varied between 42MHz for small, local events to 115MHz for large events. The requirement for major events was as high as 174MHz. The study found that demand for spectrum is increasing, potentially requiring as much as 224MHz for major events in the future, i.e. the whole sub-700MHz UHF band (SRF, 2022). Of course, in some areas securing access to such large amounts of spectrum would currently be difficult, given that within sub-700MHz UHF at least, spectrum is shared with DTT transmissions which reduces the amount of spectrum available to PMSE. Securing access to sufficient spectrum would be made more difficult given any further potential reduction in the amount of PMSE spectrum available as well.

Fortunately, there are further developments that seek to either improve the spectral efficiency of PMSE or open up new frequency bands or technologies. The innovation demonstrated within WMAS, utilising wideband systems and digital encoding schemes to improve spectral efficiency, shows promise, however it is unlikely to be applicable in all use cases and equipment is not yet widely commercially available. Similarly, usage of alternative frequency bands, whilst potentially opening up new bands that could mitigate any loss in sub-700MHz spectrum, will not be applicable in all use cases due to changes in the propagation characteristics at higher frequencies. In addition, use of alternative frequency bands may require the development and acquisition of new equipment, which will require investment and time.

5G is showing promise as a potential enabling technology for PMSE, with early trials showing that certain network configurations are starting to approach the requirements for some of the most demanding PMSE use cases. However, even if further development is able to ensure requirements such as latency and reliability are met, there are additional issues in the form of ensuring ease of access to 5G networks for PMSE users. If private 5G networks are to be used instead, appropriate spectrum would also need to be made available to PMSE users through appropriate regulatory mechanisms.

In any case, the various alternatives show promise, but it is unclear the extent to which they are able to fully mitigate, at the current time, the impact that a potential significant reduction in sub-700MHz PMSE spectrum might have in some instances.

6 International developments

This chapter considers developments to usage of the band around the world, with a focus on developments within ITU Region 1 outside of the European Union, Region 2[143] and Region 3[144].

6.1 Usage of the Band within ITU Region 1

According to the ITU Radio Regulations (as it relates to usage in the EU Member States and neighbouring countries only), the frequency range 470 – 694 MHz is allocated to the following services:

- Broadcasting (on a primary basis)
- Radio Astronomy (on a secondary basis[145]) (608 – 614 MHz as per footnote 5.149)
- Radiolocation (in Germany, Austria, Denmark, Estonia, Liechtenstein, Czech Republic, Serbia and Switzerland on a secondary basis) (470 – 494 MHz as per footnote 5.291A)
- Land Mobile (on a secondary basis, intended for Programme Making and Special Events, as per footnote 5.296)
- Aeronautical Radionavigation (as per footnote 5.312)
    - in Bulgaria (on a primary basis) (646-686 MHz, 726-753 MHz, 778-811 MHz and 822-852 MHz)
    - in Belarus, the Russian Federation and Ukraine (on a primary basis) (645-862 MHz)

In addition to the above, a number of countries in ITU Region 1 (outside the EU) also use the band for fixed and mobile services as per the following footnotes:

- 5.294: Secondary allocation of 470 - 582 MHz to the fixed service on a secondary basis in Saudi Arabia, Cameroon, Côte d'Ivoire, Egypt, Ethiopia, Israel, Libya, the Syrian Arab Republic, Chad and Yemen; and
- 5.300: Secondary allocation of 582 – 790 MHz to the fixed and mobile, except aeronautical mobile, services on a secondary basis in Saudi Arabia, Cameroon, Egypt, United Arab Emirates, Israel, Jordan, Libya, Oman, Qatar, the Syrian Arab Republic and Sudan.

However, these countries are not neighbours of the EU Members States, and as such any changes to usage within the EU would not impact them.

[143] Americas

[144] Asia-Pacific region

[145] Following ITU Radio Regulations 5.28, 5.29 and 5.30, the stations in a secondary service shall not cause harmful interference to or cannot claim protection from harmful interference from stations of a primary service.

According to the European Common Frequency Allocation Table (ECA)[146], the frequency range 470 to 694 MHz is used for the following purposes:

- Terrestrial television broadcasting
- Programme making and special events (including assisted listening devices)
- Radio astronomy (608 – 614 MHz)
- Wind profiler radars (radars which assess wind speed and direction)

There is also a footnote to the ECA which mentions the need to protect aeronautical use in the frequency range 645 – 694 MHz.

Outside of Region 1, as discussed below, some countries have moved towards the implementation of a 600 MHz mobile band (known as Band n71 in the 3GPP standards). Some countries within Region 1 are already considering implementing this band for mobile services. These are:

- Saudi Arabia, who have already announced their intention to auction the band for mobile services; and
- The United Arab Emirates, who are considering the options available to them but have yet to decide on any specific allocations.

6.1.1 Usage of the Band within Countries that Border the EU

6.1.1.1 Switzerland

DTT within Switzerland has been switched off, as of 2019, as part of cost saving measures agreed between broadcaster SRG and the Swiss Federal Council (DVB, 2018). Less than 2% of households were making use of the DTT service in 2018 prior to its switch off (Golem.de, 2018). The dominant free-to-air broadcast platform in Switzerland remains a DVB-S2 satellite service, although IPTV already had a penetration of ~48% by 2016.

Whilst usage of DTT in Switzerland was low prior to switch-off, usage of DTT (and consumption of the Swiss services) in neighbouring regions in Austria was much higher. As such Austrian cable operator, Lampert, obtained permission from the Swiss regulator BAKOM to establish a transmitter within Switzerland to provide coverage to Austrian households directly via DVB-T, but also feed the cable head end for distribution in Austria (20 minuten, 2019).

Currently, no other primary allocation is identified for the spectrum within the Swiss frequency allocation table. There is a secondary allocation to land mobile (PMSE) and radio astronomy. PMSE is permitted within Switzerland in the following bands on a licence exempt basis:

- 31.4 – 39.6MHz;
- 174 – 223MHz;
- 470 – 694MHz;

[146] https://efis.cept.org/

- 823 – 826MHz;
- 863 – 865MHz;
- 1350 – 1400MHz; and
- 1785 – 1804.8MHz.

6.1.1.2 Liechtenstein

In Liechtenstein, the frequency range 470 – 694 MHz is allocated as shown in the table below.

Frequency Band	National Allocation	Usage
470 – 608 MHz	BROADCASTING Land mobile	Land mobile applications (indoors only) 470 – 518 MHz PMSE (max 50 mW, 250mW 474 – 608 MHz) Wind profile radars (470 – 494 MHz)
608 – 614 MHz	BROADCASTING Radio Astronomy Land Mobile	PMSE (max 50 mW) Radio astronomy protected so no broadcast assignments.
614 – 694 MHz	BROADCASTING Land mobile	PMSE (max 250mW)

Table 40 – Frequency usage in Liechtenstein.

The frequencies available for PMSE (microphones and in-ear monitors) include:

- 31.4 – 39.6 MHz
- 174 – 223 MHz
- 470 – 694 MHz
- 823 – 832 MHz
- 863 – 865 MHz
- 1350 – 1400 MHz
- 1518 – 1525 MHz
- 1785 – 1804.8 MHz

Liechtenstein has only a single national television channel (1FL TV) which is broadcast on cable only, there is no terrestrial television transmitter.

6.1.1.3 UK

Within the UK, there is a primary allocation to Broadcasting, with a secondary allocation to Land Mobile, primarily for PMSE. The UK DTT platform[147] consists of:

- 5 national multiplexes (operating DVB-T MPEG2, carrying SD services);
- 2 national multiplexes (operating DVB-T2 MPEG4, carrying SD and HD services); and
- 1 layer of local multiplexes (operating DVB-T2 MPEG2, carrying SD services).

~40% of households are reliant on DTT, with a further ~40% using DTT in addition to other means of reception. A significant proportion of all television continues to be linear FTA services. Patterns of consumption vary considerably by age, although younger viewers, for whom the emphasis tends to be on-demand viewing, are still observed to watch a significant volume of live television.

Development of the Freeview platform has recognised the need to be demand-led, responding to the emerging needs of viewers. Where technology and spectrum have allowed, the platform has sought to incorporate developments where it has been affordable, appealing to viewers and proportionate to do so. For example, new HD services were accommodated within existing spectrum by migrating multiplexes to the DVB-T2 standard, and additional services have been made available by making use of the HbbTV standard in Freeview Play.

DigitalUK anticipates that, in 10 years, the UK market will continue to be characterised by patterns of viewing that blend live linear TV with on-demand content, with a significant proportion of viewing remaining. The UK Government recently passed legislation to allow regulator Ofcom to renew DTT licences in the UK until 2034.

Audio PMSE within the UK makes use of the following bands (Ofcom, 2015):

- 470 – 703MHz (on a coordinated[148] basis);
- 960 – 1154MHz (on a coordinated basis);
- 823 – 823MHz (on a shared basis);
- 1785 – 1805MHz (on a shared basis);
- 960 – 1154MHz (on a shared basis);
- 173.7 – 175.1MHz (on a licence exempt basis);
- 863 – 865MHz (on a licence exempt basis); and
- 2400 – 2483.5MHz (on a licence exempt basis).

[147] The information contained within this section was provided by DigitalUK. DigitalUK is a joint venture leading the operations and strategy of the UK's DTT platform, Freeview. It is joint owned by the BBC, ITV, Channel 4 and Channel 5, and ensures provision of subscription free access to high-quality TV to all UK homes. Freeview is used in 63% of UK TV homes, and is on the main television set in 11 million UK homes.

[148] Coordinated means that the licence schedule will specify the exact frequency, location and dates of use.

6.2 Usage of the Band within Regions 2 and 3

Usage of the frequency range 470 – 694 MHz in ITU Region 2 (the Americas) and Region 3 (Asia-Pacific) is, the same as within Region 1, with a primary allocation to broadcasting with the following minor differences:

- In Region 2, there are secondary mobile and fixed allocations in the frequency ranges 470 – 512 MHz and 614 – 698 MHz. In particular:
  - Footnote 5.295 states that the Bahamas, Barbados, Canada, the United States and Mexico have identified the frequency range 470 – 608 MHz for IMT services.
  - Footnote 5.308A of the ITU Radio Regulations states that Bahamas, Barbados, Belize, Canada, Colombia, the United States, Guatemala and Mexico have identified the frequency range 614 – 698 MHz for IMT services (i.e. 5G); and
- In Region 3, the whole of the frequency range 470 – 694 MHz has an additional primary allocation to fixed and mobile services, and from 585 – 610 MHz, has an additional primary allocation to Radionavigation.

Some examples of the use of the band for private mobile radio (PMR) in Region 3 include the following:

- In Thailand, at a national level the frequency range from 470 – 510 MHz does not have a broadcasting allocation, only mobile and fixed allocations. At one time it was envisaged that this band might be used for GSM services (designated GSM-480) however this never came to fruition as no equipment was ever manufactured. Instead the band is used for PMR services.
- In Australia, at a national level the frequency range from 470 – 520 MHz does not have a broadcasting allocation, only mobile and fixed allocations. Citizens band (CB) radio operates in the frequency range 476.4125 to 477.4125 (the same CB frequencies are available in Indonesia and New Zealand) and other PMR services are licensed in the remainder of the band.

As was indicated previously, a number of countries are introducing (or are in the process of introducing) new mobile services (5G) in the frequency range 614 – 698 MHz (3GPP Band n71). Within the 600MHz band, the following countries have either assigned the band or are in the process of doing so.

Country	Region	Status
Australia	3	Considering options, although the exact range is yet to be defined
Bangladesh	3	Identified for IMT, although the exact range is yet to be defined
Canada	2	Assigned
Colombia	2	Identified for IMT
Guatemala	2	Assignment planned, although the exact range is yet to be defined
India	3	Assignment planned, although the exact range is yet to be defined
Mexico	2	Assignment planned, although the exact range is yet to be defined
Myanmar	3	Assignment planned, although the exact range is yet to be defined
New Zealand	3	Considering options, although the exact range is yet to be defined
Peru	2	Identified for IMT, although the exact range is yet to be defined
Puerto Rico	2	Assigned
South Korea	3	Considering options, however expected to be cleared of broadcasting in 2022.
USA	2	Assigned
Vietnam	3	Considering options, although the exact range is yet to be defined

Table 41 – 600MHz status in Region 2 and 3 countries.

Source: GSA, 2022.

In many other countries in these regions, the proliferation of terrestrial television services means that there is little scope to re-farm the band for new mobile services.

At the April 2022 meeting of the Asia-Pacific Telecommunity (APT), the decision was taken to adopt a slightly different band plan for the use of the 600 MHz IMT band, providing 2 blocks of 40 MHz of spectrum (as opposed to the 2 blocks of 35 MHz being assigned in Region 2). As Region 3 already has a primary mobile allocation in this frequency range, adopting a new band for IMT services does not require any international regulatory action (such as at the ITU).

The band plan adopted by the APT for the 600 MHz IMT frequency range is identified below, together with the original Americas band (Band n71) and a different proposal for extending the band which was not adopted.

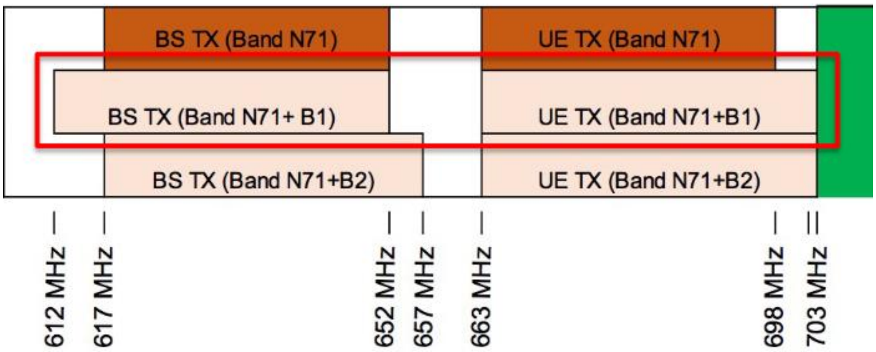


Figure 80 – Band plan adopted by the APT for the 600 MHz IMT band (indicated in red).

Notwithstanding the need for countries to clear the frequency range of existing services, with agreement within the APT regarding the band plan for the use of the 600 MHz band for IMT services, there are a number of steps to be taken before it is implemented:

- Firstly, the revised band plan (which does not align with Band n71 used in the Americas) will need to be accepted by the 5G standards body (3GPP).
- This new arrangement will then need to be implemented in both mobile devices, and made available for operators to purchase from manufacturers.

As such, it seems likely that there will be few implementations of the new band within the next 3 years, and possibly up to 5 years from now. Nevertheless, it seems inevitable that there will be a growing ecosystem of devices and networks in the band.

6.3 International Developments in Audio-visual Consumption Habits

This section summarises findings from international studies on audiovisual consumption. It starts with outlining general trends in global audiovisual consumption habits, before presenting data from global regions where these are available.

Globally, the audiovisual market is highly competitive where players are competing not only on video distribution but in other adjacent industries like programme production based on global scale, while adapting them to localised requirements (OurWorld, 2020).

The growth in content production is driven by strong consumer demand for local content. In addition, the shift towards national films and series is a normal competitive response of locally based OTT platforms, which realise that to better compete with global players they need to leverage indirect network effects as propelled by local content. This is cycle that supports the development of localised programming across the world[149] (OurWorld, 2020).

The COVID-19 pandemic has also been a key driver in changing audiovisual consumption habits on a global scale (Arrieta, 2020).

[149] For example, in Brazil local productions reached 17.7% of pay-TV programme hours in 2017, while in 2019 national films currently represent 6.3% of the libraries of the top seven OTT platforms, and series amount to 23.1% (OurWorld, 2020).

Although no comprehensive comparable statistics are available, and recent data are scarce at times[150], relevant studies exploring a number of global regions (Canada, Asia Pacific, Africa, South America) give an indication on general trends.

The **Asia Pacific** media and entertainment market consists of several players. This industry is viewed as a lucrative investment opportunity due to the huge consumer interest. Companies are investing in future technologies to gain substantial expertise, which would enable them to achieve sustainable competitive advantage. The market is expected to register a CAGR of 7.2% during the forecast period (2021 - 2026) (Yahoo, 2021).

High-speed Internet has become easily affordable in the region, and viewers that prioritise good quality content are preferring smart TVs over other television systems. Also, the growing admiration for OTT streaming in audiovisual content is impacting the overall media and entertainment market in the Asia Pacific (Yahoo, 2021).

Asia Pacific digital consumption habits have also seen steep changes in response to the pandemic (The Drum, 2020). Market analysts also believe that some of the audiovisual consumption behaviours and habits formed during the pandemic will endure, and this will have an impact on the audiovisual industry as well as online retailers in general (The Drum, 2020). For example, the SARS outbreak in the early 2000s compelled JD.com and Alibaba to change their business models, making it the turning point for the Chinese e-commerce market (The Drum, 2020).

With regards to recent data for the Asia Pacific region, the following have been observed:

- It is predicted that with the 5G technology expected to become the most significant next-generation cellular network technology, especially in urban areas, the increasing adoption of OTT content will continue to grow (Yahoo, 2021)
- In some countries, there is substantial financial backing from central governments. An Indian government initiative on digital transformation, such as digitisation of cable TV and Direct-to-Home services, is also favouring the adoption of IPTV. The IPTV scenario in India is changing due to the advent of the network services provider, with the company providing free IPTV live subscriptions to its customers (Yahoo, 2021).
- The market size of the OTT video streaming market of India is forecasted to reach USD 5 billion by 2023, and India is projected to become one of the top 10 global OTT markets by 2022 (IBEF via Yahoo, 2021).
- Somewhat older data from Digital TV Research Ltd (2016) projected that by 2020 Japan's VOD subscriptions would more than double to 20.5 million, by far the most households of any country in the region. It also predicted a notable rise of VOD subscriptions in China up from 900,000 in 2015 to an estimated 12.3 million by 2020. The Digital TV Research Ltd study also predicted significant VOD subscription growth in India and South Korea.

[150] Indeed, a 2018 WIPO study suggests that the audiovisual markets are very important to many African countries (Burkina Faso, Côte d'Ivoire, Kenya, Morocco and Senegal) but that better data are needed to understand their full potential (WIPO, 2018).

However, the Asia Pacific region is not homogeneous in terms of trends.

Although online video consumption skyrockets in countries like China, other Asia Pacific markets like **Malaysia** are adopting the medium at slower pace, with TV maintaining an important role in consumers' daily time spent with media. Two studies carried out by ZenithOptimedia and Epinion suggested a slight decrease in online audiovisual consumption (MediaBuzz, 2016). However, both studies were carried out pre-COVID. Nevertheless, the trend may still be valid since one reason for the continued popularity of offline TV as compared to online video was considered to be the persistent gap in device usage between Malaysia's more sophisticated urban centres and its less-connected rural areas (MediaBuzz, 2016).

At the same point in time (2016), data suggested that in **Singapore** younger consumers are the most avid digital video viewers with more than half (54%) of consumers in Singapore watching digital video. The same research also found dramatic differences in content consumption by age with viewership dropping off sharply among older consumers (MediaBuzz, 2016).

On the **North American** continent, in **the USA**, survey data from March 2020 on audiovisual consumption habits and COVID-19 suggested that family viewers are nearly twice as likely as the overall survey base of audiovisual consumers to consume new streaming services. The study indicated that demographically, the most likely age group that indicated having children was the Millennials (aged 23-39) which composed 49% of the families surveyed. This younger group is already more receptive than older survey takers to digital services – see Figure below (SPGlobal, 2020).

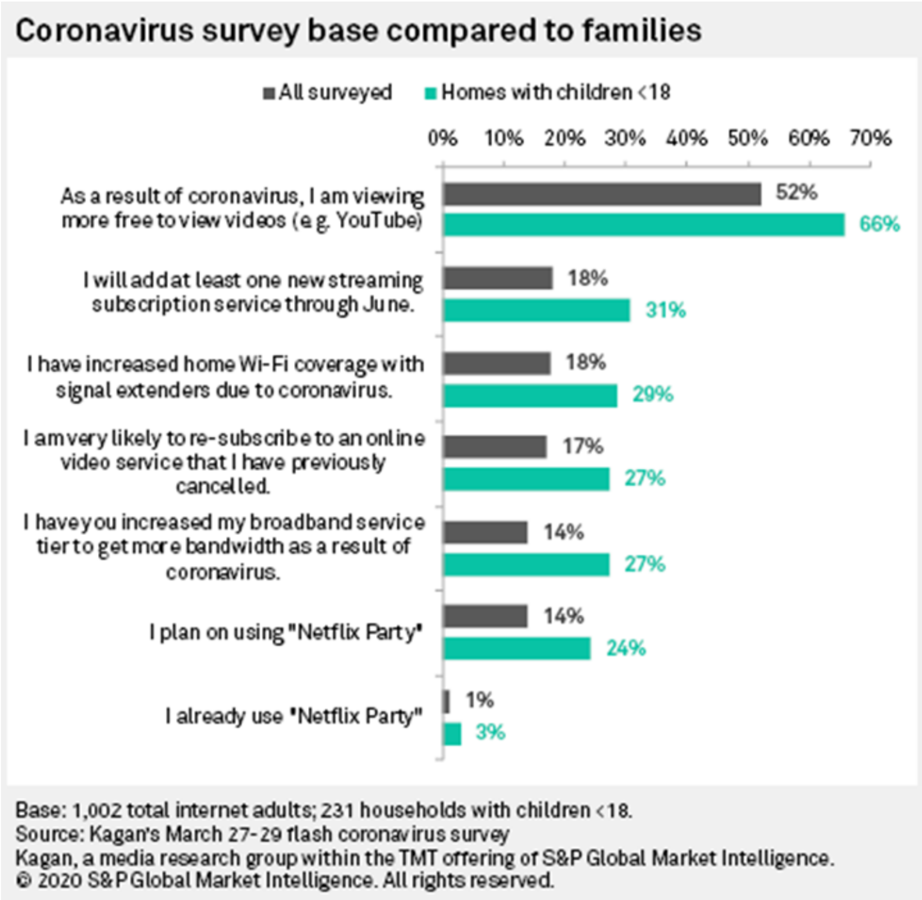


Figure 81 - Coronavirus survey base compared to families (USA), March 2020.

Source: SPGlobal, 2020

On the **African** continent, in Kenya there has been an increased demand for local content on television and on other audiovisual platforms since the digital switch in 2015. As of June 2017, Kenya had 66 free-to-air DTT TV stations. However, many digital platforms have also emerged during this period (WIPO, 2017).

In **Nigeria**, the television and video market grew by 7.49% to $806 million in 2020, up from $732 million in 2018. The market is driven by subscription revenue, which accounted for 72.26% of total revenue in 2018. TV advertising accounts for 21.31% of total revenue while physical home videos account for 5.33%. Subscription-based movie streaming are also very popular in Nigeria, including Netflix, Iroko TV, and Startimes (Trade.gov, 2021).

Analysis on the **Latin American** market is in line with that of other global regions, i.e., it is strongly characterised by the development of multiple content distribution platforms and by the COVID-19 pandemic.

Jung and Melguizo (2021) describes changing consumer patterns, with some segments – mainly the younger generations – perceiving OTT audiovisual platforms as an alternative to traditional pay TV services (cable or satellite). Changes in consumer patterns mean that consumers are gradually substituting traditional pay TV services in favour of audiovisual OTT choices, either because they cancel their subscription, or directly have never used them in the case of younger generations.

In Latin America, Digital TV Research data projects that by the mid-2020s streaming penetration might surpass that of Pay TV (via Jung and Melguizo, 2021).

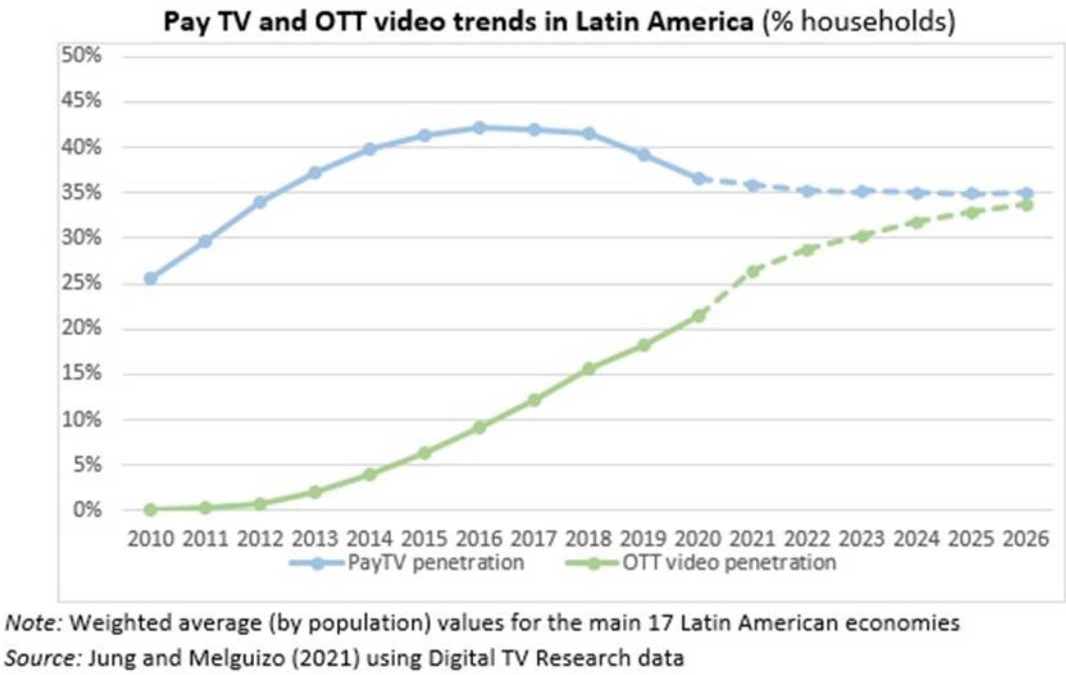


Figure 82 - Screenshot from Jung and Melguizo, 2021 showing Pay TV and OTT video trends in 17 Latin American countries.

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B Acronyms and Abbreviations

3GPP	3rd Generation Partnership Project
4K	Ultra high definition ~4,000 horizontal pixel resolution
ADSL	Asymmetric digital subscriber line
APWPT	Association of Professional Wireless Production Technologies
ARIMA	Autoregressive Integrated Moving Average Model.
AT	Austria
AV	Audiovisual
AVOD	Advertising-based Video-on-Demand/Advertising-financed Video on Demand
BE	Belgium
BEUC	The European Consumer Organisation
BG	Bulgaria
BNE	Broadcast Networks Europe
BVOD	Broadcaster Video-on-Demand
CAGR	Compound annual growth rate
CEE	Central and Eastern Europe
CEPT-ECC	Electronic communications committee of the European conference of postal and telecommunications services
C-PMSE	Cognitive programme making and special events
CY	Cyprus
CZ	Czech Republic
DE	Germany
DK	Denmark
DSL	Digital subscriber line
DTT	Digital terrestrial television
DVB-HB	Digital video broadcasting - home broadcasting
DVB-I	Digital video broadcasting - internet
DVB-T	Digital video broadcasting - terrestrial
DVB-T2	Digital video broadcasting - terrestrial (2nd generation)
EAO	European Audiovisual Observatory
EBU	European Broadcasting Union
EC	European Commission
EE	Estonia
EIRP	Effective isotropic radiated power
eMBMS	Enhanced multimedia broadcast multicast services
EPG	Eletronic programme guide
ERP	Effective radiated power
ES	Spain
ETSI	European Telecommunications Standards Institute
EU	European Union
EUR	Euro

FDD	Frequency division duplexing
FeMBMS	Further enhanced multimedia broadcast multicast services
FI	Finland
FOD	Free on-demand audiovisual services
FR	France
FTA	Free to air
FTV	Free-to-view
FVOD	Free Video on Demand
GE06	Geneva 2006 Conference and Agreement
GR/EL	Greece
HbbTV	Hybrid broadcast broadband TV
HD	High definition
HDR	High dynamic range
HDTV	High-definition television
HEVC	High efficiency video coding
HFR	High frame rate
HPHT	High power, high tower
HR	Croatia
HU	Hungary
IBB	Intregrated broadcast-broadband system
IE	Ireland
IEM	In ear monitor
IMT	International mobile telecommunications
IP	Internet protocol
IPTV	Internet Protocol television
IT	Italy
ITU	International Telecommunication Union
LPLT	Low power, low tower
LT	Lithuania
LTE	Long term evolution (broadly 4G)
LU	Luxembourg
LV	Latvia
MPEG	Moving Pictures Expert Group
MPEG2	Video encoding standard, MPEG2 was the second of several standards developed by the Moving Pictures Expert Group
MPEG4	Video encoding standard, MPEG4 was the fourth of several standards developed by the Moving Pictures Expert Group
MPMT	Medium power, medium tower
MT	Malta
NL	The Netherlands
OTT	Over-the-top
PC	Personal computer

PL	Poland
PMSE	Programme making and special events
PSB	Public Service Broadcasting
PSM	Public service media
PT	Portugal
RO	Romania
ROM	Receive only mode
SD	Standard definition
SE	Sweden
SI	Slovenia
SK	Slovakia
SLA	Service level agreement
SVOD	Subscription Video on Demand
TDD	Time division duplexing
TV	Television
TVOD	Transactional Video on Demand
UHF	Ultra high frequency (~300MHz to ~3GHz)
UK	United Kingdom
VHF	Very high frequency
VOD	Video on demand
VRT	National public-service broadcaster for the Flemish Community of Belgium
VVC	Versatile video coding
WCG	Wide colour gamut
WMAS	Wireless multichannel audio systems
WRC	World Radio Conference
YLE	Finland's national public broadcasting company

C Member State Responses

C.1 Member State Developments in DTT

A questionnaire covering the usage of DTT, as well as spectrum requirements, technological developments, and viewpoints regarding the future use of the UHF band was sent to national regulators in all EU Member States. All Member States provided responses to the questionnaire. This section summarises the responses regarding DTT, with particular regard to technological developments and regulatory viewpoints.

C.1.1 Austria

Austria's DTT platform consists of:

- 4 national multiplexes (operating DVB-T2 MPEG4); and
- 3 local multiplexes in any given area (mostly operating DVB-T2 MPEG4, albeit with some smaller broadcasters utilising DVB-T MPEG2).

Austria moved to DVB-T2 MPEG4 in 2017, with just a small number of local broadcasters still using DVB-T. Indoor reception in urban areas was also targeted with the changes, enabling use of the more recent transmission and encoding standards.

The platform offers 89 programmes (1/3 in high definition, 2/3 in standard definition). Austria's major public and commercial broadcasters (ORF, ServusTV, ATV) offer their programmes in HD on a free-to-view basis (with just two channels offered in SD to ensure backwards compatibility with older receivers), whilst the popular programmes from German commercial broadcasters (RTL, ProSieben, Sat1) are offered only in SD on a free-to-view basis. To access HD content from the German broadcasters, viewers must pay a recurring technical access fee, collected by the platform aggregator. Approximately 6% of Austrian households use DTT as their primary means of reception, with ~2.2% using DTT for secondary reception.

BMLRT (Federal Ministry of Agriculture, Regions and Tourism) expects traditional television to still be important in 2030, with a study by the University of Salzburg finding that linear viewing will still account for 2/3 of audiovisual content consumption. Hybrid TV is expected to become increasingly important, with the DVB-T2 platform operator simpliTV having launched its first generation hybrid DVB-T2/OTT receiver in January 2022. BMLRT expects that 5G Broadcast may be a candidate system to supplement DTT in the future.

BMLRT does not plan to make changes to the use of the band until at least 2030 and will make changes after this point based on future developments in the European position going forward. A number of the current DTT multiplexes will be retendered in 2023, with a 10-year licence term. In addition, BMLRT currently does not see a need for additional sub-1GHz spectrum for mobile services but sees any reduction in broadcast spectrum may reduce the number of programmes available on the DTT platform.

C.1.2 Belgium

DTT within Belgium caters to the three Belgian communities and consists of:

- 2 multiplexes serving the Flemish community (operating DVB-T2 MPEG4, in which programmes are offered in standard definition); and
- 2 multiplexes serving the French community (one national and one local, both are operating DVB-T MPEG2, and programmes are offered in standard definition).

The German community does not have DTT on air and whilst regional multiplexes are foreseen for the future, the plan for multiplexes has not yet been defined.

Within the Flemish community, less than 5% of households are entirely dependent on DTT, although PSM over free to air (FTA) DTT is no longer available for the Flemish community. Instead, PSM DTT is only available over Pay-TV, or via the internet without subscription. Currently DTT in the Flemish community makes use of SFNs, with 2 frequencies used per multiplex to cover the whole area. DTT is targeted toward indoor and mobile reception. The Flemish community DTT platform offers 16 programmes. There are no concrete plans to make additional developments to the DTT platform, although an additional 3 multiplexes are licensed.

No data regarding dependency on FTA DTT is available for the French community, but 4 TV programmes and 5 radio programmes are offered over the FTA platform, with no subscription-based services. The DTT platform serving the French community is expected to migrate to DVB-T2 HEVC in 2023, with all programmes to be offered in high definition. The cost of this exercise is expected to be €4,300,000. At this point, larger SFNs are expected to be deployed also.

In all communities, regulator BIPT (Belgian Institute for Postal Services and Telecommunications) expects that the use of the band will not change within the next 10 years.

C.1.3 Bulgaria

Within Bulgaria, DTT consists of:

- 1 national commercial multiplex (DVB-T MPEG4); and
- 1 local commercial multiplex serving Sofia (DVB-T MPEG4).

There are 6 national services and 5 local services, all of which are offered in standard definition. Public service broadcaster, Bulgarian National Television (BNT), offered programmes in high definition on a further national multiplex until the licence was revoked in 2017. Regulator CRC (Communications Regulation Commission) posted an announcement to authorise a DTT network utilising DVB-T or DVB-T2, but the network operator chose to utilise just DVB-T. CRC intends to go to public consultation with regards to moving to the newer standards, but currently it has not received enquiries about the possibility of moving to newer standards. Currently, there are no plans to change the use of the sub-700MHz UHF band.

C.1.4 Croatia

Croatia's DTT platform currently consists of:

- 2 national FTA multiplexes (operating DVB-T2 HEVC, in which all content is offered in high definition using 1080p);
- 2 national Pay-TV multiplexes (operating DVB-T2 MPEG4, in which content is offered in either standard definition or high definition, 1080i); and
- 1 local FTA multiplex (operating DVB-T2 HEVC, in which all content is offered in high definition using 1080p or 720p).

The FTA multiplexes were migrated to DVB-T2 HEVC in 2020, at the expiry of the FTA multiplex licences. The changes were planned so as to minimise channel changes and thereby minimise the required transmission antenna changes. This also meant that households had minimal need to replace or repoint receive antennas. The switchover was announced in 2017, providing sufficient time for most consumer reception equipment to be replaced as part of the normal TV unit replacement cycle.

The FTA DTT platform is ahead of other content delivery methods within Croatia, with DVB-T2 HEVC chosen to ensure the FTA DTT platform has a technological edge over the commercial services and is able to remain competitive until the end of 2030. The current network topology and technology standards are optimal for the current needs of DTT, and so no further changes are planned. However, the licences are sufficiently flexible that additional developments could be implemented within the scope of the current licences. The move to DVB-T2 HEVC has enabled broadcasters to take advantage of HbbTV, although details have not been provided regarding the uptake of these features.

The terrestrial TV market share is currently high in Croatia (~41% of households dependent on FTA DTT, ~7% of households subscribe to Pay-TV), although regulator HAKOM (Croatian Network Regulatory Agency) expects this to reduce slowly over the coming years. The Pay-TV platform has greatly increased its market share as a result of the switch to DVB-T2. HAKOM sees this as a positive trend, as it will help to keep the whole DTT platform competitive within the Croatian market.

Spectrum within the 700, 800 and 900MHz bands has been licensed to mobile operators within Croatia. HAKOM expects to take a view on the future of the sub-700MHz UHF band after WRC-23, and the current DTT licences expire at the end of 2030. It expects that any reduction in the amount of spectrum available to DTT will risk the extinction of the DTT platform and expects that the platform will remain important in Croatia until at least 2030.

C.1.5 Cyprus

DTT in Cyprus currently makes use of ~25% of the remaining UHF spectrum (470 – 694MHz), and consists of:

- 1 national public multiplex operated by CYBC (operating DVB-T MPEG4, in which the majority of content is offered in standard definition, with one channel offered in high definition); and
- 2 national commercial multiplexes (operating DVB-T MPEG4, in which all content is offered in standard definition).

Each of the national multiplexes operates as an SFN, utilising two frequencies. As such, six channels are utilised to provide the DTT platform. The current multiplex operators are not known to currently be considering improvements to the DTT platform. Whilst dependence on DTT is currently high (~67% of households), regulator DEC (Department of Electronic Communications) expects that in 5 to 10 years, most content will be delivered through the internet. People will view content on various devices, for example televisions and tablets, but these will be connected to the internet.

However, DEC does not expect to change the use of the band within the next 10 years, unless new EU directives decide otherwise. Currently, there is no solid indication from operators that additional sub-1GHz spectrum is required for mobile services within Cyprus. DEC expects to take a regulatory view on the future of the band in the coming years, before 2025.

C.1.6 Czech Republic

The DTT platform within the Czech Republic consists of:

- 4 national multiplexes (operating DVB-T2 HEVC, with programmes offering a mixture of SD and HD);
- 3 regional multiplexes (operating DVB-T or DVB-T2 HEVC); and
- 12 local multiplexes (operating DVB-T or DVB-T2 HEVC).

There are no plans to introduce further developments beyond optimisation of the existing SFN networks used for the PSM DTT network. Regulator CTU (Czech Telecommunications Office) expects that PSM FTA DTT will be operated after 2030, although it expects a further increase of IPTV usage. Current DTT networks allow reception in 53.2% of households, although CTU expects that the proportion of households dependent on FTA DTT is lower (although data is not available). The current DTT licences are valid until 31/12/2030. CTU has not yet reached a view on the future of the sub-700MHz UHF band, although expects the discussion to begin in February/March 2022, with preliminary results expected in mid-2022. CTU's current view is that public mobile services (5G) cannot be satisfied without the 470-694MHz band.

CTU also states that incompatibility between DTT and mobile doesn't allow for independent national solutions, and rather that future solutions will need to fall under a flexible approach allowing deployments that address both national need and a harmonised framework.

C.1.7 Denmark

Within Denmark, the DTT platform consists of:

- One national multiplex operated by the public broadcaster DR (operating DVB-T2 MPEG4, in which the majority of content is offered in high definition); and
- Four national multiplexes licensed to Pay-TV provider Norlys, two of which are broken into eight regions (operating DVB-T2 MPEG4, in which the majority of content is offered in high definition, with the exception of seven programmes which are offered in standard definition).

There are currently no plans to adopt newer transmission or compression standards within Denmark. MNOs have indicated that additional sub-1GHz would be useful but have not provided further substantiation to regulator ENS (Danish Energy Agency) on the requirement. As published in its recent spectrum strategy, ENS expects to ensure that the sub-700MHz UHF band will be available for mobile broadband when the band is no longer relevant for DTT. The decision to cease DTT will be subject to an agreement by the Speakers on Media Policy in the Danish Parliament. ENS expects that less than 1% of the population is currently dependent on DTT as more than 99% of the population has access to >10Mbps fixed broadband. In addition, ENS expects that a fair amount of the remaining population would have access to satellite services if required.

C.1.8 Estonia

The DTT platform within Estonia consists of:

- 2 national multiplexes offering HD services (moving to DVB-T2 HEVC, but currently operating a mixture of DVB-T, DVB-T2, MPEG4 and HEVC); and
- 4 national multiplexes offering SD services (moving to DVB-T2 HEVC, but currently operating a mixture of DVB-T, DVB-T2, MPEG4 and HEVC).

Transmission of the multiplexes is currently in both DVB-T and DVB-T2, using MPEG4 (achieving standard definition of 1080i) or HEVC (achieving 1080i). Across the platform, there are 4 FTA programmes (which are simulcast in both SD and HD) and 43 Pay-TV programmes. Estonia is preparing to migrate all multiplexes to DVB-T2 MPEG4 and HEVC between 2022 and 2025. This will improve image quality and allow for higher levels of spectrum efficiency resulting from larger SFN areas. There are no plans to modify the network topology as the current HPHT network with gap fillers is sufficient.

5.4% of households are dependent on FTA DTT, with 14% dependent on Pay-TV. IPTV is believed to be dominant within Estonia, although data was not available to evidence this. Regulator TTJA (Consumer Protection and Technical Regulatory Authority) expects that FTA DTT will be required until at least 2030, although the emerging trend within Estonia is higher usage of non-linear TV and TV over mobile broadband.

C.1.9 Finland

DTT within Finland is currently undergoing an upgrade programme. It currently makes use of a mixture of DVB-T and DVB-T2. Once the upgrade programme is concluded, the platform will consist of:

- 6 national multiplexes (DVB-T2 MPEG4, offering a mixture of SD and HD services); and
- 3 regional multiplexes (DVB-T2 MPEG4, offering a mixture of SD and HD services).

The current licence period for DTT multiplexes ends in 2027. Regulator Traficom estimates that approximately 20% of households will still be reliant on DTT in 2027. It expects there to be an increase in households receiving content via broadband rather than DTT but expects that the DTT service will be available for as long as needed, albeit with some reduction in the number of services available. Traficom expects that 5G Broadcast is not a widescale alternative to DVB-T2 at the current time. It expects that DVB-T2 will remain the main technology for the DTT platform for the next 10 years at least.

Traficom supports a co-primary mobile allocation in Region 1 for 470 – 694MHz at WRC-23, as it would allow regulatory flexibility. It notes that this could still support DTT within the country, and that there are no plans to cease DTT within Finland. It notes however that DTT and IMT cannot exist in the same spectrum, and as such there would need to be a separation between the two were mobile deployed in the sub-700MHz UHF band. It has not considered what the best arrangement for this would be and has not studied the demand for DTT beyond 2027.

C.1.10 France

DTT within France consists of:

- 6 national multiplexes (mostly operating DVB-T MPEG4); and
- 1 layer of local multiplexes (mostly operating DVB-T MPEG4).

In metropolitan areas, 28 out of 30 national services are available in HD, and 40 out of 42 local services available in HD. A public consultation undertaken by the regulator authority in 2017 found the audio-visual sector within France showed a strong interest in delivering both enhanced quality (higher resolution, frame rate, improved audio) and interactive services. As such, the French parliament has made additions into law to allow the regulatory authority to authorise existing DTT services to be delivered in improved formats on a dedicated multiplex with a simplified selection process. In addition, receivers capable of receiving these enhanced services have also been provided with a new label for easy recognition by consumers.

4K programmes have been broadcast over DTT since 2018 to various major towns and cities to test various improvement options (with a mandated DVB-T2 HEVC format). Studies investigating broadcasting UHD content nationally are currently underway, with further discussions also underway in the sector to determine the detailed path towards adopting the newer standards. Regulator ANFR (National Frequency Agency) anticipates this could start with a first multiplex offer in the coming years.

21.2% of households are entirely dependent on DTT. DTT spectrum is heavily used within France, with a large proportion of the network already operating in SFN mode. As such, ANFR expects there is little room for further network optimisation.

ANFR has no plans to change the use of the band before 2030 as French law guarantees its use until at least 31/12/2030. The Government will need to report on the perspectives for TV services at least 5 years prior to this. ANFR believes that some additional spectrum may be useful for IMT, but the availability of spectrum would be dependent on the evolution of the needs of broadcasting, as the primary user of the band. IMT spectrum demand growth will depend on the evolution of traffic (~30% growth per year), densification of IMT networks and the continued improvement of spectrum efficiency through progressive technology generations in the bands below 1GHz.

C.1.11 Germany

DTT within Germany consists of:

- 6 national multiplexes (operating DVB-T2 HEVC, offering mostly HD programmes); and
- 1 local multiplex (operating DVB-T2 HEVC, offering mostly HD programmes).

DTT within Germany is used by approximately 6.7% of households, and regulator BNetzA (Federal Network Agency) sees that there is no expectation from viewers for higher quality services on DTT than the current HD offering. There are no current plans for future upgrades. BNetzA has not yet made decisions regarding the future usage of the band going forward, although notes that there is interest from broadcasting, mobile broadband, PPDR and PMSE for the spectrum. There have been a number of 5G Broadcast trials within Germany (5G MEDIA2GO, 5G Today), but currently there are no plans for widespread implementation.

C.1.12 Greece

DTT within Greece consists of:

- 5 national multiplexes (operating DVB-T MPEG4, offering a mixture of SD and HD programmes); and
- 24 local multiplexes (operating DVB-T MPEG4, offering SD programmes).

There are no plans currently to upgrade the platform to newer standards or change to alternative network topologies. The network currently makes use of an SFN topology, targeting fixed reception. Prior to any change in the network, for example a migration to DVB-T2, Greek law requires that a minimum of 18 months' notice is given to allow viewers to update their reception equipment. 5G Broadcast was trialled in Athens in 2021 but was interrupted due to interference from a mobile network provider.

DTT penetration is ~99% within Greece, and ~74% of households are estimated to be dependent on DTT. As such, even though IPTV is growing, regulator EETT (Hellenic Telecommunications and Post Commission) does not expect dramatic changes within the next 10 years. EETT does not expect to take a regulatory viewpoint on the future of the 470-694 MHz band until after WRC-27. However, it sees that a migration to DVB-T2 would be required if DTT spectrum reduced, for example through implementation of a dedicated 600MHz mobile band, in order to maintain the programme and quality offering. Furthermore, it sees that co-ordination with the 5 neighbouring countries would be a significant effort in changing the usage of the band.

C.1.13 Hungary

DTT within Hungary consists of:

- 2 national FTA multiplexes (operating DVB-T MPEG4, offering a mix of SD and HD programmes);
- 3 national prepaid multiplexes (operating DVB-T2 HEVC, offering a mix of SD and HD programmes); and
- 32 local multiplexes (offering a single SD programme).

The current licences are valid until 6 September 2032. Regulator NMHH (National Media and Infocommunications Authority) does not intend to change regulation regarding the sub-700MHz UHF band within the next 10 years, although has observed that there is a trend for declining viewership of the DTT platform (currently 10% of households are dependent on FTA DTT, with 2% of households taking a Pay-TV service). There are no plans to further update the transmission technology, although NMHH believes there is an increasing need to transmit programmes in high quality, noting that on the DTT platform there is currently insufficient capacity to transmit more HD or 4K programmes. Currently, 6 FTA programmes are simulcast nationally in HD and SD, with the remaining 57 Pay-TV programmes and 32 local programmes available in SD.

NMHH notes that further reductions in broadcast spectrum would need to be managed carefully to minimise cross border interference and co-ordination efforts, particularly under scenarios in which DTT and IMT operate in adjacent countries utilising the same spectrum.

C.1.14 Ireland[151]

DTT within Ireland consists of:

- 2 national multiplexes (DVB-T MPEG4).

The platform offers 12 national services (2 in HD, 10 in SD), having added a new service in late 2021. Approximately 12% of households are entirely dependent on DTT, although this also includes households dependent on FTA satellite (Saorsat). ~36% of households have aerials capable of receiving DTT signals. The current DTT multiplexes are licensed until December 2031. The legislation allows for use of DVB-T2, but there are currently no plans to migrate to newer standards.

Spectrum regulator ComReg (Commission for Communications Regulation) will commence a study in 2022 to consider the current and future spectrum requirements of broadcasting services in Ireland in the sub-700MHz UHF range. Given Ireland’s challenging demographic and geographic characteristics (for example a significantly higher proportion of the population, 72%, lives in rural areas than the EU average, 22%, and Ireland has twice the EU average road density), ComReg finds that access to sub-1GHz spectrum is particularly important for the provision of widespread mobile coverage due to its favourable propagation characteristics.

Content regulator BAI (Broadcasting Authority of Ireland) expects that online platforms will eat into viewership figures for FTA TV in the coming years. A national broadband plan will provide access to high speed broadband to homes in rural areas over the next 5 years. However there is a concern that older viewers may not make the decision to adopt broadband even when it passes the home, and as such some households may still be reliant on DTT.

C.1.15 Italy

Italy is currently undergoing a major DTT reorganisation exercise, with a move from DVB-T MPEG2 to DVB-T MPEG4 planned for the 8th March 2022. National service providers are able to simulcast in the older current standards (DVB-T MPEG2) until 31st December 2022 (although this provision does not apply to local or regional service providers). Ultimately, Italy will migrate to DVB-T2 HEVC in 2023. Following completion of the exercise, DTT in Italy will consist of:

- 12 national multiplexes (operating DVB-T2 HEVC, although these will operate on DVB-T MPEG4 as an interim);
- 26 regional multiplexes (operating DVB-T2 HEVC, although these will operate on DVB-T MPEG4 as an interim); and
- 47 local multiplexes (operating DVB-T2 HEVC, although these will operate on DVB-T MPEG4 as an interim).

[151] Note that this section has been produced using responses from ComReg (spectrum regulator), BAI (broadcast regulator) and DTAGSCM (Government Department of Tourism, Culture, Arts, Gaeltacht Sport and Media).

In any one area, it is planned that between 2 and 6 layers will be available (including at least 1 regional multiplex). The current system consists of 245 national FTA programmes (284 when including HD simulcasts), and 18 services available for a fee. 30 regional services are available in all regions. When assigning capacity in the new plan, future capacity was assigned at a rate of ½ current capacity, i.e. a provider owning all the capacity on a DVB-T multiplex would be awarded ½ the capacity on a new DVB-T2 multiplex. Providers owning all capacity on a multiplex were then able to operate this multiplex, with any multiplexes not having singular ownership arranging ownership between themselves. This filled 10 of the available 12 DVB-T2 multiplexes, with capacity on the new additional 2 multiplexes filled via the use of a competitive bidding, beauty contest approach. Assignment of capacity is ongoing on a single multiplex.

The costs of the exercise are estimated to total ~€76.8 million, with an estimated spend of €0.5 million in FY 2019, €24.1 million in each of the financial years FY 2020 and 2021, and €28.1 million in FY 2022. Within Italy, only receivers capable of decoding DVB-T2 HEVC are allowed to be sold. An estimated ~50% of all DTT households in Italy (~91% of the population, ~24 million households) were believed to possess at least one DVB-T2 HEVC capable receiver in March 2021, which was estimated to increase to ~62% in September 2021.

Networks in Italy are almost all already utilising SFNs, and there are no plans to cater to alternative reception modes. Regulator AGCOM (Communications Authority) notes that clearance of the 700MHz band in Italy has already affected the broadcasting system significantly, with 8 national multiplexes and ~90 local multiplexes operating on the spectrum affected. This equated to ~5,700 transmitters, representing approximately one third of the total amount of transmitters operating within the UHF band in Italy. The DTT licences were assigned in 2019 and are valid for ten years. As such, AGCOM has not made decisions regarding the future use of the band as yet. Mobile network operators have not expressed an effective and immediate need for further sub-1GHz spectrum to regulator AGCOM at this point.

C.1.16 Latvia

DTT within Latvia consists of:

- 5 national multiplexes (DVB-T MPEG4, offering a mixture of SD and HD services);
- 1 regional multiplex (DVB-T MPEG4, offering a mixture of SD and HD services); and
- 1 local multiplex (DVB-T MPEG4, offering a mixture of SD and HD services).

The platform offers 53 national services (7 of which are FTA, 46 of which are accessible only with a subscription), 4 regional services (all of which are accessibly only with a subscription) and 1 local service (available FTA). 51 of these programmes are available in SD, with the remaining 7 available in HD. There are currently no plans to migrate to newer standards.

Regulator NEPLP (National Electronic Mass Media Council of Latvia) sees that according to global forecasts, additional sub-1GHz spectrum may be required in the future to meet demand. This is particularly highlighted when considering the increasing traffic in rural areas and that use of additional low band spectrum may help to offload traffic from existing bands without the need for additional base station deployment.

C.1.17 Lithuania

DTT within Lithuania consists of:

- 2 national multiplexes (operating DVB-T MPEG4, offering a mixture of SD and HD programmes); and
- 11 local/regional multiplexes (operating DVB-T MPEG4, offering a mixture of SD and HD programmes).

Approximately 35-37% of households in Lithuania make use of DTT. Licences are awarded on a technology neutral basis, and as such licensees are free to move to more updated technologies as they see fit. TV and set top box manufacturers are encouraged within Lithuania to include support for DVB-T2 and HEVC, but currently regulator RRT (Communications Regulatory Authority for the Republic of Lithuania) does not plan to mandate migration to more updated standards. RRT anticipates that a significant portion of the cost of any upgrade programme would be the cost to upgrade user reception equipment, and that forced migration to new technologies may push viewers away from the platform. RRT expects that the platform not upgrading will not be detrimental, but that if the available spectrum were reduced, technology upgrades would be required.

RRT anticipates that the introduction of IMT supplementary downlink (SDL) within an 8MHz channel raster would be compatible with DTT usage in neighbouring countries (particularly non-EU countries) and satisfy some of the needs of mobile operators. In the longer term, RRT views that replanning the 700MHz and 600MHz bands, or the whole band sub-1GHz UHF band, would be the most efficient. However, RRT also notes that reduction in the amount of spectrum might mean insufficient spectrum to satisfy the requirements of broadcasters, and that harmonisation with non-EU countries would be challenging.

C.1.18 Luxembourg

DTT within Luxembourg uses 3 UHF channels, and consists of:

- 3 national multiplexes (operating DVB-T MPEG2).

DTT covers approximately 90% of the population within Luxembourg, but no-one is entirely dependent on DTT. 2 services are offered in HD, with the rest in SD. There are currently no plans to move to newer technologies or different network topologies. Cable TV is the main method for TV reception in Luxembourg, followed by satellite TV and IPTV. Regulator ILR (Institut Luxembourgeois de Régulation) expects that cable, satellite and IPTV usage will grow in the coming years, to the detriment of DTT.

C.1.19 Malta

DTT within Malta uses 5 UHF channels, and consists of:

- 5 national multiplexes (operating DVB-T MPEG2, with all services offered in SD).

0.8% of households are reliant on FTA DTT in Malta, with 86.1% of households taking a Pay-TV service. The operator of the commercial DTT Pay-TV service is in the process of migrating services to a fixed IPTV network. The current commercial DTT licences expire at the end of February 2023, and no interest has been expressed to continue offering commercial DTT by the same, or alternative, network players.

Currently regulator MCA (Malta Communications Authority) has no plans to repurpose the sub-700MHz UHF band, although such plans may be considered due to a lack of market interest for DTT spectrum and taking into account any decisions adopted at WRC-23. The 800 and 900MHz bands have been deployed for IMT within Malta, although MNOs have not yet expressed interest for the 700MHz band. PPDR operators were also not interested in a dedicated spectrum assignment in the 700MHz band. As such, MCA considers that currently no additional sub-1GHz spectrum is required for Malta.

C.1.20 The Netherlands

DTT within The Netherlands consists of:

- 5 national multiplexes (operating DVB-T2 HEVC, offering services in HD); and
- 5 local multiplexes (operating DVB-T2 HEVC, offering services in HD.

The platform offers 3 national free to air services, 12 regional FTA programmes (with 1 offered per region), and ~27 Pay-TV programmes. It is believed that less than 3% of the population is reliant on FTA DTT, with PSM content consumed in much greater amounts over fixed broadband, although exact figures for this are not provided. There are no known plans to deliver content in resolutions beyond HD, or to make other technological developments to the platform.

Regulator Agentschap Telecom (Telecom Agency) expects that the market share of DTT will decrease going forward, with the main distribution channels being cable and IPTV, as is currently the case. It expects that if 5G Broadcast were to be deployed, the focus of the service would primarily be to target tablet and smartphone reception. It expects to take a regulatory view on the future of the sub-700MHz UHF band in 2022. It recognises that it will need to take into account a number of factors. On one hand whilst DTT is licensed until 2030, its market share is small (<3%) and decreasing, and as such there is a question as to whether DTT is economically viable after 2030. On the other hand, there is a legal obligation for PSM to broadcast FTA within The Netherlands.

C.1.21 Poland

DTT within Poland is undergoing an improvement exercise, with multiplexes currently utilising a mixture of DVB-T/DVB-T2 and MPEG4/HEVC moving to DVB-T2 HEVC on 27th June 2022. Four local multiplexes will remain operating DVB-T MPEG4. DTT within Poland, after this development exercise, will consist of:

- 4 national multiplexes (operating in UHF spectrum, utilising DVB-T2 HEVC);
- 1 national multiplex (operating in VHF spectrum, utilising DVB-T MPEG4);
- 1 local multiplex (operating in UHF spectrum, utilising DVB-T2 HEVC); and
- 4 local multiplexes (operating in UHF spectrum, utilising DVB-T MPEG4).

The platform currently offers 28 national FTA services, 27 national Pay-TV programmes and 8 local FTA programmes. Following completion of the upgrade, all services will be available in HD, with the potential for some to be available in 4K, although there are not concrete plans for this at the moment.

There is spectrum available within the plan (in the sub-700MHz UHF band) to accommodate two further national DVB-T2 multiplexes. SFNs have already been more widely deployed as a result of the 700MHz clearance programme.

There are remaining issues with the rollout of the 700MHz band for IMT in Poland that need to be resolved before regulator UKE (Office of Electronic Communications) is able to take a view on the need for additional sub-1GHz spectrum for mobile within Poland. Currently, UKE has no plans to change the use of the band within the next 10 years and has not reached a regulatory viewpoint on the future use of the sub-700MHz UHF band. It expects to begin preliminary work in this area following WRC-23. ~35% of households are dependent on FTA DTT, although this is decreasing. UKE expects that the audience share for FTA DTT will still be strong in 2030.

C.1.22 Portugal

DTT in Portugal consists of:

- 1 national multiplex (covering Portugal mainland, operating DVB-T MPEG4, offering services in SD); and
- 2 regional multiplexes (covering the Azores Islands and the Madeira Islands, operating DVB-T MPEG4, offering services in SD).

Around 5% of households are estimated to be dependent on FTA DTT. Regulator ANACOM (National Communications Authority) believes that DTT viewers do not expect to be able to use catchup and on demand services, and do not have expectations of being able to receive services in HD. The current DTT licences (RUF – 'Right of Use of Frequencies'), which are all held by the same operator, expire on 9th December 2023. ANACOM expects that it will take a regulatory viewpoint on the future use of sub-700MHz UHF spectrum in 2023, as the current DTT operator will need to inform ANACOM a year prior to the expiry date whether or not it intends to renew the licence.

ANACOM expects that if the DTT licences are renewed, the network topology of DTT will need to change, although details are not provided of the expected required changes. ANACOM has not currently received requests for additional sub-1GHz spectrum for mobile services, although is currently reviewing the frequency usage of PPDR within Portugal, with the 700MHz duplex gap or guard bands as potential candidates.

C.1.23 Romania

DTT within Romania consists of:

- 1 national public multiplex (operating DVB-T2 MPEG4); and
- 1 regional commercial multiplex (operating DVB-T2 MPEG4).

There are 9 national programmes, and 1 regional programme, all of which are offered free to air. Regulator ANCOM (National Authority for Management and Regulation in Communications of Romania) estimates that no households are entirely dependent on DTT within Romania. There are no plans to upgrade to newer standards, and ANCOM does not expect the extent to which DTT is used to change significantly in the future.

ANCOM has not taken a viewpoint regarding the future usage of the band but is investigating the possibility for DTT to operate in 470-590MHz in order that additional spectrum could be allocated to mobile. ANCOM sees that DTT in Romania could be replanned to accommodate the introduction of a dedicated 600MHz mobile band, but that sharing between DTT and IMT (as could occur with the introduction of an optional sub-band or a co-primary allocation of the whole 470-694MHz range) would result in interference that would be difficult to manage.

C.1.24 Slovakia

DTT in Slovakia is currently undergoing an improvement exercise. National and local multiplexes currently utilise a mixture of DVB-T, DVB-T2, MPEG2, MPEG4 and HEVC. It is planned that all national multiplexes will move to DVB-T2 HEVC in 2023/2024. At this point, DTT in Slovakia will consist of:

- Four national multiplexes (operating DVB-T2 HEVC, offering a mixture of SD and HD services); and
- 64 local multiplexes (mostly operating DVB-T, with a mixture of MPEG2 and MPEG4, offering mostly SD services).

Regulator Teleoff (Regulatory Authority for Electronic Communications and Postal Services) estimates that 10-13% of households in Slovakia are dependent on FTA DTT. All national networks are already operated as SFN, with some gap fillers deployed as needed. DTT is intended for fixed reception in Slovakia, and there are no plans to adopt alternative reception modes.

Teleoff does not see any need for additional sub-1GHz spectrum for mobile services at this time. The current multiplexes are licensed until 9th September 2029. Usage of the band after this date will be set out in line with the outcomes of WRC-23 and relevant European Commission and CEPT decisions. Teleoff estimates based on the available data and trends from the past few years that the use of FTA DTT will gradually decrease, remaining stable at 10-13% in the next 5 to 10 years, as other distribution technologies advance.

C.1.25 Slovenia

The DTT platform in Slovenia consists of:

- 2 national multiplexes (operating a mixture of DVB-T and DVB-T2, MPEG4, offering a mixture of public HD and SD services);
- 1 regional multiplex (operating DVB-T MPEG4, offering SD services); and
- 2 local multiplexes (operating DVB-T MPEG4, offering SD services).

Only 0.9% of households watch DTT, and the most popular programmes have left DTT. Regulator AKOS (Agency for Communication Networks and Services of the Republic of Slovenia) sees that viewers of DTT do not have high expectations of the platform. There are no plans to move to more recent standards as DVB-T MPEG4 offers sufficient capacity for the current needs of the DTT platform. AKOS expects that the DTT share will remain stable or decrease. Cable and IPTV shares are high and growing. 99% of households are covered with a minimum of 10Mbps downlink and 2Mbps uplink by 3 mobile operators.

AKOS sees a benefit in extending the current 700MHz band from 694 – 791MHz to 688 – 791MHz (affecting UHF channel 48), to provide additional spectrum for PPDR. Note that AKOS' allocations in this region include IMT in 703 – 733 and 758 – 788MHz, supplementary downlink (SDL) in 738 – 753MHz, PPDR in 698 – 703, 733 – 736, 753 – 758 and 788 – 791MHz and PMSE in 694 – 703 and 733 – 758MHz.

In addition, AKOS supports opening up of the rest of the band for IMT but notes that there are issues with such an allocation with regards to co-existence with DTT and the GE06 plan, particularly around its border with Italy. As such, AKOS notes that maintaining GE06 until at least 2030 would be preferable so as to facilitate flexibility for Member States but also avoid the significant administrative burden required to modify it, with the exception of its proposed modifications to UHF channel 48. However, it expects that use of an 8MHz raster, as specified in GE06, for other services will be hampered until equipment is commercially available. Equipment vendors will not offer equipment that fits the GE06 8MHz channel raster unless there is a harmonised EU position on the topic.

In any case, AKOS sees a benefit in operators having access to greater amounts of sub 1GHz spectrum, both in terms of coverage in rural areas, but also facilitating mMTC for IoT, V2X applications, connectivity to trains and broadband PPDR applications. AKOS sees that if more UHF spectrum were made available to mobile, the spectrum would be auctioned with broadcasters free to enter into the auction. Award of certain ranges of the spectrum would come with a requirement to ensure that viewers could access FTA PSM content without subscription. These ranges would also come with a reduction in spectrum costs.

C.1.26 Spain

DTT within Spain consists of:

- 7 national multiplexes (operating DVB-T MPEG4, offering a mixture of SD and HD services);
- 18 regional multiplexes (operating DVB-T MPEG4, offering a mixture of SD and HD services), equating to 1 national layer; and
- 282 local multiplexes (operating DVB-T MPEG4, offering a mixture of SD and HD services), equating to 1 national layer, with a further 9 local multiplexes planned.

From 2023, HD will be mandatory for all services. Some UHD trials are also ongoing, making use of DVB-T2 HEVC. There are no concrete plans for a move to DVB-T2 HEVC, however TV sets over 40 inches purchased in Spain after March 2020 must include support for DVB-T2 HEVC to support any future technology upgrades. HbbTV functionality is available to 72% of households with a broadband connection.

Approximately 64% of households in Spain are reliant on FTA DTT, with DTT counting for approximately 74% of all audiovisual viewing time in 2020. MINECO (Ministry of Economic Affairs and Digital Transformation) foresees that the trend towards a growth in subscriptions to pay-TV services (IPTV, OTT, cable etc.) will continue, decreasing the proportion DTT makes up of total audiovisual viewing time. However, pay-TV bundles in Spain often include the FTA services broadcast over DTT, suggesting that viewing of these services will not necessarily decrease as viewers move to pay-TV bundles. MINECO also notes that there will an upper limit on the number of households willing to pay for pay-TV bundles, as there is a cultural resistance to pay for access to services that have traditionally been free.

5G Broadcast has been trialled by RTVE and Cellnex, however MINECO does not currently see 5G Broadcast as a potential replacement for the Spanish DTT market. This is because DTT within Spain is predominantly received via rooftop antennas, whilst 5G Broadcast is intended for mobile reception. Other alternatives (satellite, IPTV etc.) are not considered an alternative to FTA DTT as either households do not have the necessary reception equipment or a charge is levied for access.

The regulator expects that DTT will continue within Spain beyond 2030, given its intrinsic advantages in terms of spectral efficiency and widespread availability. It does not see the possibility for sharing with other services within the current 470-694MHz band given the currently significant usage by DTT in Spain. Similarly, the introduction of a dedicated mobile band would, even with a transition to DVB-T2, limit potential future upgrades to UHD and ultimately require significant replanning and modification of the DTT networks within Spain. MINECO notes there has not been clear signs within Spain of a bandwidth shortage for IMT within sub-1GHz spectrum, and that demand for mobile services could potentially be met by spectrum in other bands, for example 3.8-4.2 GHz.

C.1.27 Sweden

DTT within Sweden consists of:

- 6 national multiplexes (operating a mixture of DVB-T and DVB-T2, MPEG4, offering services mostly in HD, with a small number in SD).

Approximately 20% of households in Sweden are entirely dependent on DTT, with 5.2% of households taking a paid DTT service. There are no current further plans to upgrade the DTT network in Sweden. Regulator PTS expects that the reliance on DTT will decrease in the coming years, noting that 73% of the population in Sweden already have access to a smart-TV and 70% have access to streaming services for TV and VOD.

Spectrum for DTT is guaranteed in Sweden until the end of 2025. The next licence period begins in 2026, however PTS notes that further analysis is needed in order to develop a position regarding the approach to distributing PSM beyond this point. The analysis will need to consider a number of factors, including:

- The availability of PSM content in an increasingly internet-based distribution environment;
- The requirement to distribute important emergency information when fewer people make use of DTT;
- The development of the terrestrial network and its importance for public service and commercial broadcasters;
- The expansion of broadband and the development of new technical solution for the reception of radio and television; and
- Net neutrality and the need for efficient spectrum management.

Within Sweden, all sub-1GHz spectrum has been licensed to operators, and PTS sees that there is a need to create regulatory flexibility for the band. As such, PTS supports the co-primary allocation of the sub-700MHz UHF range to mobile at WRC-23. Teracom has trialled the use of LTE Broadcast signals to access handheld customised mobile terminals and is considering further trials on later versions of the standard. PTS notes that if there were a decrease in the demand for DTT transmission in Sweden, 5G Broadcasting could make use of parts of the existing band.

C.2 Member State Developments in PMSE

A questionnaire covering the usage of PMSE, as well as spectrum requirements, technological developments, and viewpoints regarding the future use of the UHF band was sent to national regulators in all EU Member States. This section summarises the responses regarding PMSE, with particular regard to technological developments and regulatory viewpoints. Only audio-based PMSE has been considered, as it is this which is the occupant of sub-700 MHz spectrum and thus is under consideration.

C.2.1 Austria

Within Austria, the following bands can be used for PMSE equipment under a light licensing regime:

- 470 – 694MHz;
- 694 – 703MHz;
- 733 – 758MHz;
- 788 – 790MHz;
- 823 – 826MHz;
- 826 – 832MHz;
- 1350 – 1400MHz;
- 1427 – 1518MHz; and
- 1518 – 1525MHz.

The following bands are made available under a general authorisation regime:

- 863 – 865MHz; and
- 1785 – 1804.8MHz.

Due to Austria's licensing regime, they do not regularly collect information regarding the demand for PMSE spectrum. Peak demand is usually during sporting events such as the Formula 1 GP, Moto GP and Skiing World Cup, typically lasting 1-2 weeks, and cultural events such as the 'Bregenzer Festspiele', which lasts 1-2 months. These events happen several times a year in different locations across Austria. A previous piece of work calculated the demand for the Austrian Formula 1 GP in 2018 and 2019, as shown in Table 42.

Year	470 – 790MHz (Mics, IEMs, talkback, camera data)	1 – 2GHz (STLs, telemetry, vision links, mics)
2018	251	7
2019	246	18

Table 42 – Austrian Formula 1 GP PMSE equipment usage.

Regulator BMLRT finds that the demand for PMSE spectrum is increasing. It expects that consumer PMSE equipment will begin to use alternative technologies such as short-range devices (SRDs) and Wi-Fi, noting that some applications still rely heavily on more traditional PMSE equipment due to the quality of service it offers. It finds that 5G is currently not ready to be used for PMSE on a wide scale.

C.2.2 Belgium

Within Belgium, the following bands can be used for PMSE equipment:

- 29.7 – 47MHz;
- 174 – 216MHz;
- 470 – 789MHz;
- 823 – 832MHz;
- 863 – 865MHz;
- 1492 – 1518MHz; and
- 1785 – 1804.8MHz.

All bands are permitted to be used on a licence exempt basis, with the exception of the 174 – 216MHz and 470 – 790MHz bands which both require individual licensing. Peak demand for PMSE spectrum occurs for large events such as the Formula 1 Belgian GP, requiring all available spectrum in a localised area for a few days, or the 'Tour de France', requiring all frequencies for a few days. Events of this scale happen every year in Belgium. Regulator BIPT has not observed any change in the demand for PMSE spectrum over recent years but expects that the numbers of wireless microphones used during events is increasing. As it foresees the spectrum available for PMSE reducing, it expects that PMSE will make use of 4G and 5G in the future.

C.2.3 Bulgaria

The following bands are available for audio PMSE in Bulgaria on a licence exempt basis:

- 29.7 – 47MHz;
- 174 – 216MHz;
- 470 – 694MHz;
- 723 – 753MHz;
- 778 – 786MHz;
- 823 – 832MHz;
- 1350 – 1400MHz;
- 1492 – 1518MHz;
- 1518 – 1525MHz; and
- 1785 – 1805MHz.

Because the bands are used on a licence exempt basis, regulator CRC does not have information regarding the demand for PMSE spectrum and whether it is expected to grow in future years.

C.2.4 Croatia

Within Croatia, PMSE equipment currently makes use of the following bands:

- 470 - 694MHz (with individual licensing, but no fee);
- 823 - 832MHz (under a general licence); and
- 1785 – 1805MHz (under a general licence).

Regulator HAKOM states the peak demand is typically for music events, which require 30 channels of 250kHz. These sorts of events all require spectrum in the 470 – 694MHz range, and last up to 3 days. HAKOM finds that there are up to 20 of these sorts of events in Croatia per year, but there has not been any major change in the requirement for PMSE spectrum over recent years. As such, it does not expect PMSE within Croatia to require any additional spectrum within the next 5 to 10 years.

HAKOM finds that users within Croatia tend to prefer analogue technology for PMSE, which has resulted in the 1785 – 1805MHz band remaining empty. HAKOM anticipate that the most useful impact of migrating PMSE to 5G would be the availability of large amounts of spectrum.

C.2.5 Cyprus

Within Cyprus, radio PMSE equipment be used within the following bands:

- 29.7 - 47MHz;
- 169.8125 - 261MHz;
- 470 - 789MHz;
- 823 - 832MHz;
- 863 - 865MHz;
- 1350 - 1400MHz;
- 1492 - 1525MHz; and
- 1785 - 1804.8MHz.

PMSE equipment in Cyprus that conforms to the technical specifications outlined in ERC/REC 25-10 and ERC/REC 70-03 is generally permitted to be operated on a licence exempt basis. As such, much of the PMSE usage within the sub-700MHz UHF spectrum is licence exempt within Cyprus. Whilst regulator DEC does not have information regarding the usage of the sub-700MHz UHF band, it is not aware of any changes in spectrum demand for the PMSE service.

C.2.6 Czech Republic

PMSE within the Czech Republic can make use of the following bands (APWPT, 2021):

- 174 - 216 MHz;
- 470 - 694 MHz;

- 863 – 865 MHz;
- 1785 – 1804.8 MHz;
- 1880 – 1900 MHz; and
- 2400 – 2483 MHz.

Licence exempt usage is possible in these bands, subject to compliance with various technical parameters, for example power limits. Peak demand for PMSE spectrum within the Czech Republic occurs typically at racing circuits or skiing arenas, with such demand typically required for one week. Such events take place twice a year, with ~100 frequencies being authorised by regulator CTU in the PMSE spectrum between 400 – 2600MHz range. CTU has not observed a significant change in the amount of PMSE spectrum required over recent years.

C.2.7 Denmark

PMSE equipment within Denmark can be used in the bands identified in Table 43.

Frequency Band (MHz)	Maximum Transmission Power (mW ERP)	Maximum Bandwidth (kHz)	Comments
32-39,4	2	50	Only certain frequencies in the band may be used.
138,250-142,070	50	200	Only certain frequencies in the band may be used.
169,4000-169,5875	500	50	Radio system for use by the hearing impaired.
169,8250-173,9625	10	50	Radio system for use by the hearing impaired. Only certain frequencies in the band may be used.
180,5-222,5	2	50	Radio system for use by the hearing impaired. Only certain frequencies in the band may be used.
470-695	50	200	Only "white spaces " may be used.
695-703	60	200	
733-736	60	200	NB: May only be used until 31 December 2021.
823-832	As specified in Table 1 of Radio Interface 00 025 of the Executive Order on Radio Interfaces.	200	
863-865	10	200	
1785-1804,8	10	200	

Table 43 – Audio PMSE bands in Denmark.

Audio PMSE equipment is generally permitted to use spectrum on a licence exempt basis, although a few large events require licensed spectrum, or higher powers than permitted under the licence exemption. Video PMSE equipment is generally required to be licensed, although a limited number of licences are issued, mainly to broadcasters.

Regulator ENS finds that peak spectrum demand is required at a small number of major events, for example the UEFA European Cup. Events requiring this level of spectrum happen just a handful of times per year, and ENS does not find that the demand for PMSE spectrum has significantly changed over recent years. ENS is hosting a workshop in March 2022 with industry stakeholders to gauge the needs of PMSE going forward. ENS anticipates that video PMSE could take advantage of 5G, but it is less certain of the applicability of 5G to audio PMSE. It anticipates that the current PMSE technology, i.e. licence exempt or dedicated spectrum, and 5G will work in tandem.

C.2.8 Estonia

Within Estonia, PMSE equipment is permitted to use the following frequencies:

- 37.6 – 38.6MHz;
- 174 - 216MHz;
- 470 - 694MHz (on a secondary basis, with a 50mW ERP limit);
- 823 - 832MHz;
- 863 - 865MHz; and
- 1785 – 1804.5MHz.

PMSE usage is licence exempt, and as such regulator TTJA does not have information regarding usage. However, it has not received information suggesting that there is a scarcity of available spectrum.

C.2.9 Finland

Within Finland, audio PMSE is permitted to use the following bands:

- 174 – 195MHz;
- 216 – 225MHz;
- 470 – 694MHz;
- 823 – 832MHz;
- 863 – 865MHz, and
- 1785 – 1804.8MHz.

Access to these bands is on a licence exempt basis within Finland. Regulator Traficom notes that in many rock festivals, the demand is for hundreds of PMSE channels. This scale of demand happens annually, and there has been a slow increase in the demand primarily at rock festivals and concerts. Demand in other areas, for example churches and theatres, has remained broadly stable.

Traficom expects the demand to remain stable, albeit with some increase in the size of some productions and festivals. It notes that the use of digital microphone systems is more spectrally efficient than analogue systems, and that whilst many alternative PMSE systems are being studied, a number have not been accepted by the PMSE community as sufficient for their needs.

C.2.10 France

Within France, radio microphones are permitted to be used in the following bands:

- 174 – 223MHz;
- 470 – 694MHz;
- 823 – 832MHz; and
- 1785 – 1805MHz.

Usage of these bands by radio microphones is licence exempt. The peak demand for PMSE spectrum usually occurs during the 'Tour de France', which lasts for 3.5 weeks. During the 2021 'Tour de France', a total of 605 channels was in use (14 channels in the range 174 – 223MHz, 581 channels in 470 – 694MHz and 10 channels in 823 – 832MHz). ANFR anticipates that demand may exceed this in specific events, for example the Olympic Games (Paris 2024). The 'Tour de France' occurs once per year, but ANFR anticipates that events such as '24H Le Mans' or 'Roland Garros' have comparable spectrum demands. Each of these happens at least once per year.

ANFR observes that demand for spectrum in the 470 – 694MHz has increased over recent years. It does not have information about the requirements for PMSE spectrum in the next 5 to 10 years, but it does not exclude the possibility of a PMSE regulation update, for example the identification of new bands or technical conditions, in accordance with European harmonisation of PMSE bands. Within France, an experimental framework has been set up to promote innovation, making it possible to obtain experimental frequencies, but this has not yet been applied to PMSE. Audio PMSE can be delivered through alternative existing technologies, for example WiFi[152], 5G or DECT, but ANFR does not expect this to reduce the spectrum demand within the UHF spectrum.

C.2.11 Germany

Audio PMSE within Germany can be used in the following bands:

- 470 – 608MHz (on a licence exempt basis if the EIRP remains below 50mW);
- 614 – 694MHz (on a licence exempt basis if the EIRP remains below 50mW); and
- 733 – 758MHz (with an individual licence).

Regulator BNetzA (Federal Network Agency) notes that peak demand typically occurs several times a year during major or occasional events, and mostly applies in cities. For these sorts of events, the entirety of the 470-694MHz band and other unoccupied frequencies above 694MHz are required for PMSE. There has been a constant gradual growth in demand for PMSE, however BNetzA does not expect the spectrum needs to change in the next 5 to 10 years as a result of expected improvements in technology. These include a migration to digital PMSE equipment, and more efficient use possible through better planning.

[152] Note that no WiFi based radiomicrophones have been identified, however there are some devices which operate in the 2.4 GHz unlicensed band using proprietary technology.

C.2.12 Greece

Audio PMSE within Greece makes use of the bands shown in Table 44.

Frequency Band (MHz)	Bandwidth (kHz)	Maximum ERP for Licence Exemption
29.7 – 47.0	50	10mW
174 - 216		50mW
470 - 786		50mW
786 - 789	200	12mW

Table 44 – Audio PMSE bands in Greece.

Peak demand for PMSE spectrum was demonstrated during the Olympic Games in Athens in 2004. However, events of this scale are rare. Smaller events occur approximately once per year, although regulator EETT (Hellenic Telecommunications and Post Commission) does not have sufficient data to predict changes in demand going forward due to most PMSE usage within Greece being exempt from licensing.

C.2.13 Hungary

PMSE equipment can be used in Hungary in the following bands:

- 174 – 216MHz;
- 470 – 694MHz;
- 823 – 832MHz;
- 863 – 865MHz;
- 1350 – 1400MHz;
- 1492 – 1525MHz; and
- 1785 – 1805MHz.

All of these bands are generally licence exempt for the purposes of audio PMSE, with the exception of 1492 – 1525MHz. Licences for other bands are required if, for example, higher transmission powers are required than is allowed under the licence exemption. Due to the licence exemption, regulator NMHH does not have information regarding spectrum demand. However, based on spectrum monitoring data, the highest observed peak demand was at the 4-day Formula 1 Hungarian GP 2021, for which ~190 radio microphones and in ear monitors (IEM) were registered. Generally there are ~10 events requiring such large amounts of PMSE spectrum each year in Hungary, although NMHH expects this to increase.

NMHH is aware of technology developments that help to improve spectral efficiency that are already widely used, for example digital radio microphones. There are other developments that may increase spectrum efficiency, for example cognitive technologies (C-PMSE) and wireless multichannel audio systems (WMAS), but NMHH acknowledges that adoption of such developments would place a burden on operators as they may need to purchase new equipment. NMHH anticipates that solutions such as licensed shared access (LSA) may help to improve spectral efficiency.

C.2.14 Ireland

Audio PMSE usage within Ireland is permitted, primarily on a licensed basis, within the bands shown in Table 45.

Frequency Band (MHz)	Maximum Transmission Power for Licence Exemption	Comment
174 – 230	50mW ERP	Radio microphones (licence exempt in 173.965 - 174.015 MHz at max 2mW only)
470 – 703	50mW ERP	Radio microphones
733 – 753	50mW ERP	Radio microphones
823 – 826	20mW EIRP 100mW EIRP (body worn equipment)	Radio microphones
826 - 832	100mW EIRP	Radio microphones (licence exempt in 863-865 MHz only at 10 mW)
1785 – 1785.2	20mW EIRP 50mW EIRP (body worn equipment or spectrum sharing procedure, SSP, equipment)	Radio microphones
1785.2 – 1803.6	20mW EIRP 50mW EIRP (body worn equipment or spectrum sharing procedure, SSP, equipment)	Radio microphones
1803.6 – 1804.8	20mW EIRP 50mW EIRP (body worn equipment or spectrum sharing procedure, SSP, equipment)	Radio microphones
1804.8 - 1805	N/A	

Table 45 – Audio PMSE bands in Ireland.

Peak demand within Ireland was demonstrated by the Giro D'Italia in 2014, during which demand was across multiple frequency bands for a period of 1 month. Regulator ComReg notes that these sorts of events do not occur frequently in Ireland, and that demand for PMSE spectrum has not changed over recent years, with the exception of the COVID-19 pandemic during which demand reduced.

C.2.15 Italy

Other than those pieces of spectrum available on a licence exempt basis, audio PMSE equipment within Italy is most commonly used in the frequency range 470 – 790 MHz only.

Use of the spectrum is subject to a general authorisation being granted, with individual rights of use and payment of a fee. In the case of radio microphones up to 50mW ERP, payment is only required to cover administrative fees, depending on the quantity of radio microphones.

Peak demand for PMSE spectrum in Italy is generally at sporting events of major interest, for example:

- Formula 1 Italian GP in Lombardy, during which 255 channels (150 simplex or duplex channels for walkie-talkies, 75 channels for radio microphones or in ear monitors (IEM) with an ERP greater than 50mW, and 40 channels for radio cameras) and 229 wireless microphones (with an ERP up to 50mW) were authorised;
- Four EURO 2020 Football Matches in Rome (Stadio Olimpico), during which 133 channels (80 simplex or duplex channels for walkie-talkies, 13 channels for radio microphones or IEMs with an ERP greater than 50mW, and 40 channels for radio cameras) and 110 wireless microphones and 42 IEMs (with an ERP up to 50mW) were authorised; and
- ELMS Motor Race at the Monza circuit, during which 268 simplex or duplex channels for walkie-talkies were authorised.

PMSE spectrum is mainly required at large racetracks within Italy (for example Monza, Imola, Mugello and Misano), representing usage over a limited area and for a duration typically not greater than 1 week. However, there are exceptional events such as the 2021 World Ski Championships in Cortina that require spectrum for longer durations (20 days). There are at least 20 annual events that require such large levels of spectrum, not including the exceptional events.

Regulator AGCOM finds that demand for PMSE spectrum has been growing in recent years, due to growth both in the number of events requiring spectrum and the bandwidths required. For example, in 2020 AGCOM authorised ~2,000 radio channels for PMSE, which increase to 3,626 radio channels in 2021, i.e. an 80% increase. AGCOM notes however that spectrum in the 2GHz band is no longer adequate to meet the spectrum needs of radio cameras using bandwidths of up to 20MHz, which will be increasingly used for HD or 4K. In addition, the introduction of the DVB-T2 standard, and the change in use of the 700MHz band, has reduced the frequencies available for PMSE, such that it is very difficult to meet the needs of radio microphones for major events.

AGCOM notes a particular development in PMSE technology in the form of so-called ‘backpacks’, which are becoming increasingly widespread. These facilitate uplink of live content through equipment housed in a wearable backpack, exploiting up to 7 phone SIM cards (3G/4G), WiMAX or Wi-Fi, 2 LAN connections or 2 satellite BGANs, to create a reliable uplink by joining together multiple bandwidth limited channels. Whilst this may offer an alternative to PMSE, AGCOM notes the need to carefully analyse the RF exposure of such systems.

C.2.16 Latvia

PMSE equipment within Latvia is used only within the 470-694MHz band. Usage within this band is authorised by individual permit, with peak demand being represented by tens of devices at sports arenas. Events requiring such high amounts of equipment last for typically up to two weeks and occur 2-5 times annually. Regulator NEPLP sees that the pressure on current PMSE spectrum has increased due to the reduction of available spectrum, i.e. the clearance of the 700MHz and 800MHz bands. In addition, NEPLP sees that large events are being organised more frequently, which also serves to increase the demand.

C.2.17 Lithuania

Audio PMSE within Lithuania is permitted in the following bands:

- 30.01 – 30.3MHz;
- 30.5 – 32.15MHz;
- 32.45 – 37.5MHz;
- 174 – 216MHz;
- 470 – 694MHz;
- 736 – 753MHz;
- 823 – 832MHz;
- 1164 – 1260MHz;
- 1350 – 1400MHz;
- 1492 – 1525MHz; and
- 1785 – 1805MHz.

Audio PMSE spectrum is made available on a licence exempt basis. As such regulator RRT (Communications Regulatory Authority for the Republic of Lithuania) does not keep information regarding peak usage. However, RRT does not expect the spectrum needs for PMSE to change going forward. RRT sees that 5G could potentially be an alternative in some use cases, but that replacing all PMSE with 5G would not be ultimately beneficial as the European PMSE industry would shrink, leading to increased market monopolisation.

C.2.18 Luxembourg

PMSE equipment within Luxembourg makes use of the 470-694 MHz range. However, PMSE is licence exempt within Luxembourg, and as such regulator ILR (Institut Luxembourgeois de Régulation) does not hold detailed information on usage of the band. ILR expects that peak demand occurs at events such as the ‘Tour de Luxembourg’, and large concerts and music festivals. These sorts of events take place throughout the year, with a peak duration of 5 days. ILR estimates that demand for PMSE spectrum has remained stable over recent years and will continue to do so going forward.

C.2.19 Malta

PMSE equipment within Malta is used in the following bands:

- 470 – 694MHz (with the exception of 40MHz of spectrum used for DTT);

- 29.7 – 34.9MHz;
- 37.5 – 40.98MHz;
- 823 – 832MHz; and
- 1785 – 1805MHz.

These bands are made available under an apparatus general authorisation regime, subject to compliance with certain technical parameters, for example a transmit power limit. As such, regulator MCA does not have information regarding the demand for PMSE spectrum, although it notes it has not received explicit interest for PMSE spectrum within the last year, and that events requiring individual assignment of PMSE spectrum (for example using higher transmit powers than accommodated in the general authorisation regime) are uncommon in Malta. MCA understands that alternative adequate frequency bands would need to be made available in the event that the allocation of sub-700MHz UHF spectrum for PMSE were reduced.

C.2.20 Netherlands

PMSE equipment within The Netherlands can be used in the bands shown in Table 46 under a licence exemption. The 608 – 614MHz, 1350 – 1400MHz and 1518 – 1525MHz ranges can be used, although this requires a licence.

Frequency Band (MHz)	Maximum Transmission Power	Maximum Bandwidth (kHz)
36.6 – 36.8 37.0 – 37.2 37.8 – 38.0 38.2 – 38.4 38.6 – 38.8	10 mW ERP	200
37,480 - 37,600	10 mW ERP	50
87,5 - 108	50 mW ERP	200
195-202	50 mW ERP	200
470 - 556 558 - 564 566 - 572 574 - 580 582 - 588 590 - 596 598 - 604 614 - 694	50 mW ERP	600
736 – 753	50 mW ERP	
823 - 826	20 mW ERP (for handheld equipment) 100 mW ERP (for body worn equipment)	
826 - 832	100 mW ERP	
863 - 865	10 mW ERP	
1785 - 1805	20 mW ERP (for handheld equipment) 50 mW ERP (for body worn equipment)	

Table 46 – Audio PMSE bands in The Netherlands.

Peak spectrum demand within The Netherlands usually takes place at hotspots such as concentrated media production locations and particular events, for example sports events. Regulator Agentschap Telecom finds that the core band for such usage is 470 – 694MHz, and the geographical area is limited to the event or studio area. Typical event durations vary from a few days to 10 days. A particular example is the Hilversum Mediapark which, as a result of housing multiple studios in a relatively small area, regularly experiences limited spectrum availability without intensive frequency co-ordination. Large events with 24-150 microphones and 12-30 IEMs take place approximately once per week. Extraordinary events with >150 microphones and >30 IEMs take place once or twice a month, particularly during Summer.

Agentschap Telecom notes that the PMSE sector claims a growth of ~10% per year due to the growth of the cultural sector and changes in the deployment of wireless devices. Agentschap Telecom expects this level of growth to continue, noting that developments in co-ordination tools and equipment have helped to reduce intermodulation products, thereby making more efficient use of spectrum. It notes that 5G could be a potential alternative technology when sufficiently low latency and sufficiently flexible deployment of multiple PMSE channels can be achieved. In addition, to mitigate the impacts of PMSE's loss of access to spectrum in the 700MHz and 800MHz bands, Agentschap Telecom has made spectrum in the 1350 – 1400MHz and 1518 – 1525MHz available, although these are not yet commonly used.

C.2.21 Poland

PMSE equipment within Poland is mainly used in the following bands:

- 29.7 – 47MHz (audio PMSE);
- 174 – 216MHz (audio PMSE); and
- 470 – 694MHz (audio PMSE, with channels for PMSE equipment are chosen individually so as to avoid potential interference to and from DTT).

Generally, audio PMSE applications are licence exempt. The peak demand for PMSE spectrum within Poland occurs primarily during international sport events. For example, the Stadion Narodowy in Warsaw, required ~50 audio PMSE authorisations (in the 470 – 694MHz band) and ~10 video PMSE authorisations (in the 2200 – 2400MHz band). Such high PMSE spectrum requirements occur up ~10 times per year. Regulator UKE observes that the demand for PMSE spectrum has remained unchanged over recent years and does not expect changes in the coming 5 to 10 years.

UKE notes that the PMSE has invested heavily in the development of new, more spectrally efficient technologies, including cognitive PMSE systems (C-PMSE), wireless multichannel audio systems (WMAS) and frequency management approaches (using software to calculate the best frequency for PMSE in a given location). UKE follows the work of standardisation organisations and research bodies regarding delivering PMSE applications via 4G/5G public and/or private networks. It expects that these alternative methods would allow for greater spectral efficiency and a reduction in the cost of PMSE implementations, as well as generating new business and increasing the possibility to integrate vertical industries.

C.2.22 Portugal

Audio PMSE equipment within Portugal can be used in the bands shown in Table 47 without a licence, noting that if the power exceeds the quoted limit, a licence is required:

Frequency Band (MHz)	Maximum Transmission Power	Use
174 - 223	≤ 50mW ERP	Radio microphones and in-ear monitor systems
470 - 694	≤ 50mW ERP	Radio microphones and in-ear monitor systems
823 - 826	≤ 20 mW EIRP	Radio microphones
823 - 832	≤ 100 mW EIRP	Radio microphones (body-worn audio PMSE equipment)
863 - 865	≤ 10 mW ERP	Radio microphones
1785 - 1795	≤ 20 mW EIRP (≤ 50 mW EIRP for body worn equipment)	Radio microphones
1785 - 1795	≤ 50 mW EIRP	Radio microphones (body-worn audio PMSE equipment)
1795 - 1800	≤ 20 mW EIRP (≤ 50 mW EIRP for body worn equipment)	Radio microphones
1800 – 1804.8	≤ 20 mW EIRP (≤ 50 mW EIRP for body worn equipment)	Radio microphones
1880 - 1900	≤ 250 mW EIRP	DECT equipment

Table 47 – Audio PMSE bands in Portugal.

The peak demand for PMSE spectrum within Portugal occurred during the Formula 1 Portuguese GP 2021 at Autódromo Internacional do Algarve. From 28/4/2021 – 02/05/2021, regulator ANACOM assigned 85 frequencies for radio microphones and IEMs, 119 frequencies for private mobile radio (PMR) and 71 frequencies for wireless cameras and other video and data connections. ANACOM notes that an additional 76 frequencies were used by equipment under the licence exemption, although usage was co-ordinated with licensed equipment. This constituted ~400 frequencies, amounting to ~750MHz of spectrum, in use by ~1890 pieces of equipment in a single event. 140 of these frequencies were within the 470 – 694MHz range.

ANACOM notes that whilst Formula 1 constitutes the largest peak demand, other events occur which have significant spectrum requirements also, for example music festivals and other sporting events. With music festivals, for example, the increasing size of the festivals as well as the increasing requirements of each performer amount to an increasing need for PMSE spectrum.

ANACOM notes that the number of permanently licensed PMSE users in Portugal has remained constant over recent years. However, there has been a considerable increase in the demand for PMSE spectrum for limited periods of time, namely during large-scale events, which have been increasing in regularity over the years in Portugal. However, the impact of COVID-19 on future large-scale events is currently unknown.

C.2.23 Romania

Audio PMSE within Romania can make use of the following bands:

- 29.7 – 30.3MHz;
- 30.5 – 32.15MHz;
- 32.45 – 33.1MHz;
- 33.6 – 34.975MHz;
- 37.5 – 40.02MHz;
- 40.66 – 41.015MHz;
- 44.5 – 45.2MHz;
- 174 – 216MHz;
- 470 – 574MHz;
- 582 – 694MHz;
- 823 – 826MHz;
- 826 – 832MHz;
- 863 – 865MHz; and
- 1785 – 1804.8MHz.

Equipment complying with relevant interface requirements are permitted to operate under a licence exemption. For equipment with an EIRP of 50mW or more, an individual licence is required. Peak demand for PMSE spectrum occurs during sporting events, with demand primarily within the UHF band, requiring tens of frequencies for a maximum duration of 3-4 weeks. Regulator ANCOM (National Authority for Management and Regulation in Communications of Romania) sees that the demand for PMSE spectrum has grown over recent years, but states that it is unclear how this will develop going forward.

C.2.24 Slovakia

PMSE equipment, in particular radio microphones, within Slovakia can make use of the following bands:

- 27.75 - 27.9MHz;
- 36.4 - 38.5MHz;
- 149.400 - 149.475MHz;
- 149.500 - 149.550MHz;
- 174.3 - 174.7MHz;

- 863 – 865MHz;
- 823 – 832MHz;
- 1785 - 1805MHz;
- 174 – 216MHz; and
- 470 - 790MHz.

Most PMSE frequency bands in Slovakia are subject to general authorisations, with the exception of the 174 – 216MHz and 470 – 790MHz frequency ranges, which require individual authorisation. Peak demand for PMSE spectrum was observed at the 2019 IIHF World Championships in Bratislava, which lasted from 10/05/2019 to 26/05/2019. No details were provided however regarding the number of assignments made by regulator SVK. Such events happen on an irregular basis.

SVK expects that the demand for audio PMSE spectrum will increase over the coming years, driven by the increasing production of non-linear content intended for non-terrestrial platform consumption. However, SVK expects that the amount of spectrum available for PMSE will decrease, with equipment manufacturers therefore being required to produce equipment that is more spectrally efficient.

C.2.25 Slovenia

Audio PMSE equipment in Slovenia is permitted to use the following bands on a licence exempt basis:

- 470 – 694MHz;
- 694 – 698MHz;
- 736 – 738MHz;
- 1518 – 1530MHz; and
- 1785 – 1800MHz.

Peak demand within Slovenia is observed during events such as skiing competitions, Giro d'Italia and football matches, typically requiring 20 audio PMSE channels. These types of events occur around 12 times per year, with roughly 5 large events and 10 small to medium events occurring annually. AKOS has not observed the demand for PMSE spectrum changing in recent years.

Broadcaster RTV Slovenia has conducted trials using 4G for PMSE. AKOS notes that there is a need for traffic prioritisation and latency of less than 40ms. RTV Slovenia has reported a positive experience using the technology, primarily for video cameras, noting that latency has only become an issue when roaming between mobile operator groups. It expects to trial 5G when networks are fully rolled out also.

C.2.26 Spain

The most commonly used frequency bands for audio PMSE within Spain are:

- 174 – 181MHz;
- 470 – 694MHz;
- 823 – 832MHz; and

- 1785 – 1805MHz.

Spectrum is made available through a mixture of licence exemptions (without a fee, and typically with an EIRP of <50mW) and individual licensing (subject to a fee). The maximum number of channels requested for an event in Spain was 30 channels within the 470 – 694MHz band, covering an area of 5km^2, with a required duration of 5 days. MINECO (Ministry of Economic Affairs and Digital Transformation) finds that events of this scale occur at least on an annual basis, and that the demand for PMSE spectrum has been growing at a rate of 20% per year for the past 5-6 years. It expects that the rate of growth will increase in the future as the effects of the pandemic pass.

C.2.27 Sweden

Audio PMSE in Sweden can make use of the following bands:

- 41.3 – 43.6MHz;
- 174 – 240MHz;
- 470 – 694MHz;
- 823 – 832MHz;
- 863 – 865MHz; and
- 1785 – 1805MHz.

Regulator PTS finds that maximum demand is observed during international sporting events and the 470 – 694MHz range is the most commonly used. Such peak demand lasts for up to two weeks but does not occur very often. PTS finds that the demand for PMSE spectrum has remained stable over recent years and does not expect this to change going forward.

D Stakeholder Validation for Consumer Evolution Trends

Below is a list of interviewees with whom the main outputs of the consumer behaviour evolution forecast have been discussed:

Interviewee(s)	Coverage	Organisation type	Organisation name	Interview status
Jaume Pujol, Jean-Pierre Faisan, Lars Backlund	EU 27	Industry association	Broadcast Networks Europe	Complete
Elena Puigrefagut	EU 27	Industry association	European Broadcasting Union	Complete
Agustin Reyna, Claudio Teixeira, David Martin	EU 27	Consumer Association	BEUC	Complete[153]
Johannes Kottkamp, Frank Giersberg	Germany	Industry association	VAUNET	Complete
Carolina Lorenzon, Alessandro Capuzzello	Italy	Industry	Mediaset	Complete
Eladio Gutiérrez	Spain	Industry association	iCmedia	Complete[154]

[153] Written feedback collected from members.

[154] Written feedback.

E Stakeholder Responses to the Study

During the work to collect questionnaire responses from Member States, a number of stakeholders sought to provide contributions to the study. The main points expressed within these contributions are summarised within this section.

E.1 BNE, Belgium

Broadcast Networks Europe (BNE) represents Europe's terrestrial network operators in Europe and internationally. BNE's 18 members are operating in 20 European countries: Austria, Belgium, Croatia, Czech Republic, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Monaco, Norway, Poland, Romania, Serbia, Spain, Switzerland, UK and Sweden.

BNE highlights the European Parliament and the Council Decision (EU) 2017/899, providing a long-term guarantee for the broadcasting sector within the European Union until at least 2030. The guarantee is the counterpart of the orderly and timely clearance process of the 700 MHz band. This process has set the European Union apart from other sub regions of ITU-Region 1 by enabling a concerted roll out of a 5G pioneer band. Therefore, BNE sees that this same guarantee greatly contributes to the objectives of the 2030 Digital Compass communication.

BNE observes that clearance of broadcasting from the 700 MHz band has been completed in most Member States as of 2020/2021 and will be fully completed by 30 June 2022. Assignments are progressively being carried out by Members States (61% as of October 2021). Further, in most cases, MNOs show demand for the FDD spectrum in 700MHz, however there are instances for which MNOs do not show demand for the full amount, for example in Portugal where 2x5MHz at 700MHz has been unsold. BNE also notes that supplementary downlink (SDL) options (on the 700MHz but also on the 1.4GHz) have demonstrated a lack of interest from mobile industry for down link only spectrum.

BNE states that in terms of providing rural coverage, it is worth noting that in most of the European countries spectrum licenses in the 800MHz and 700MHz bands include specific coverage and service obligations. These obligations, accepted when participating into the auction, are there to overcome the digital divide and provide service to rural areas. Indeed, to solve the rural coverage problem, there would be a need for more investment in infrastructure rather than more spectrum.

E.2 EBU, Switzerland

The European Broadcasting Union (EBU) made the following contribution within the project workshop (held virtually on the 30th of March 2022):

"The EBU is the world's leading alliance of PSM. PSM is broadcasting made to inform, educate and entertain all audiences. EBU Members, as PSM, have the public remit of:

- Universality (to make all their content and services available to the entire population wherever they are);
- Free to view/listen (no recurring charges for access to services); and
- The ability to reach the whole population in emergency situations.

DTT in the UHF band remains crucial for PSM remit because of its efficient delivery of linear services to very large audiences, its near-universal reach, its free-to-air focus, and its resilience in times of crisis. Both public service and commercial channels are provided via DTT, contributing to healthy competition in the media sector and generating commercial value alongside the considerable public/social benefits.

Present in all countries, the relative importance of DTT varies from one country to another. For example the Finish situation is very specific to Finland – there is a strong penetration of DTT (48% of households using DTT). At the same time, there is very good broadband coverage and penetration with affordable unlimited data caps.

However, there is a wide diversity across European markets and it is currently too early for any EU Member State to foresee whether and by when online delivery of media content might be as resilient, as universally available, as sustainable, and as affordable for all EU citizens as DTT is. Current use by DTT and PMSE maximizes public value and innovation in the UHF band."

E.3 Yle, Finland

Yle is the public service media (PSM) provider in Finland. Yle offers three national television channels. Yle also offers access to its linear and video on demand (VOD) content through online services. Currently, consumption of video content published by Yle is dominated by DTT distribution, although Yle expects the share of online viewing to increase significantly in the future, with viewing through IP-enabled screens expected to surpass viewing through broadcast receivers, noting that the number of non-broadcast devices has already exceeded that of broadcast devices.

Yle expects that internet publishing will become the main publishing platform of the company by approximately 2025. They see that although linear broadcast channels will still be responsible for the majority of viewing for several years, broadcast delivery will gradually move to a limited role, as a major part of Yle´s content will not be available through broadcasting networks. Yle states that the current HPHT network, or any DVB-Tx or 5G Broadcast network on sub-700MHz spectrum, cannot serve the Finnish audience sufficiently, as Yle's entire content selection cannot be provided to viewers.

Yle sees that the key challenge going forward will be to secure wireless broadband capacity during peak viewing moments in rural and sparsely populated areas. As such, Yle presented the opinion to the Finnish Government in 2020 that, provided the availability of Yle's content can be secured for the entire Finnish audience, the sub-700MHz band can be allocated to 5G networks. Yle believes that a well-managed and planned transition of media content delivery from broadcasting to broadband networks creates a demand for high-speed broadband subscriptions, thus justifying the needed network investments. The delivery of audio-visual media through broadband networks can, in this way, act as a tool to help Member State governments achieve the targets set out in the '2030 Digital Compass' communication.

F Post Workshop Report

This section documents the outcomes of the workshop held virtually on 30th March 2022, particularly focusing on the questions that were asked by workshop participants and the responses provided to them during the meeting. The title of the workshop was “Workshop on the Use of the Sub-700 MHz Band”, and there were approximately 300 registered attendees.

F.1 Workshop Agenda

The workshop followed the agenda shown in Table 48.

Time (CEST)	Session	Notes
10:00 – 10:10	Introduction and Welcome from the Commission	Chair: Anamarija Jesenko
10:10 – 10:15	Introduction to the Study and Workshop	Chair: Richard Womersley
10:15 – 11:00	International Developments in the use of the sub-700 MHz spectrum	Chair: Richard Womersley “The view from Asia Pacific”, Scott Minehan, Windsor Place Consulting Kenny Concannon, ComReg
11:00 – 11:45	Current Status and Future Development of DTT in the EU including 5G Broadcast	Chair: Oli Mercer “DTT Developments in Italy”, Annalisa Durantini, AGCOM “5G Broadcast Trial in Vienna”, Michael Wagenhofer, ORS
11:45 – 12:30	Changes in Linear TV viewing habits in the EU	Chair: Patrisia Costenco Tobias Lindberg, Media analyst, Nordicom, University of Gothenburg Sebastiano Trigila, Fondazione Ugo Bordoni
12:30 – 13:30	Break	
13:30 – 14:15	The importance of DTT for delivery of Public Service media	Chair: Francesco Pitton Janne Holopainen, YLE Fernando Ojea, CIRCOM
14:15 – 15:00	Current Status and Future Development of PMSE in the EU	Chair: Richard Womersley Anita Debaere, Pearle Tuomo George-Tolonen, Shure
15:00 – 15:30	Wrap-up and Closing Session	Chairs: Richard Womersley / Anamarija Jesenko

Table 48 – Workshop Agenda

F.2 Workshop Activities

This section will summarise the presentations and questions that made up each of the sessions of the workshop. The slides used for each of the sessions are available on the European Commission website[155].

F.2.1 Introduction and Welcome from the Commission

Introduction from Anamarija JESENKO, EC DG CNECT

Ms. Jesenko welcomed participants to the workshop and provided background information to the study being conducted. In particular the recommendations from the Lamy report and the provisions from the UHF Decision (EU) 2017/899, and the Commission's responsibility under Article 7 thereof, were highlighted.

F.2.2 Introduction to the Study and Workshop

Introduction from Richard WOMERSLEY, LS telcom

Mr. Womersley provided an overview of the project objectives, as well as the workshop structure and purpose. In particular, it was noted that the purpose of the study is to gather information, rather than conduct analysis or produce conclusions or recommendations.

F.2.3 International Developments in the use of the sub-700 MHz spectrum

Introduction from Richard WOMERSLEY, LS telcom

Mr. Womersley provided an introduction to the session, aiming to consider the developments in the sub-700MHz spectrum in other areas of the world, raising the example of a number of countries outside of the EU that have made parts of the sub-700MHz band available to IMT (International Mobile Telecommunications), e.g. Saudi Arabia, Hong Kong and Mexico. In addition, it was noted that there is an agenda item at the next WRC (World Radio Conference) looking at the use of the UHF band. Mr. Womersley then introduced speakers Mr. Scott Minehane and Mr. Kenneth Concannon.

Presentation from Scott MINEHANE, Windsor Place Consulting, 'The View from Asia Pacific'

Mr. Minehane provided an overview of the developments in the Asia Pacific region, focussing on the need to secure the second digital dividend (the 600MHz band) in the region, the use of TV whitespaces, transition away from legacy CDMA systems in the 450MHz band, and other uses and proposals for the UHF band.

Presentation from Kenneth CONCANNON, ComReg, 'TASK GROUP 6/1 – PREPARATION FOR WRC-23 AGENDA ITEM 1.5'

Mr. Concannon provided background information regarding usage of the sub-700MHz band within CEPT, before moving onto the structure of Task Group 6-1, the work being conducted within the group, and the possible methods being considered to satisfy WRC-23 AI (agenda item) 1.5.

Q&A

[155] https://digital-strategy.ec.europa.eu/en/library/presentations-workshop-sub-700-mhz-band

1. **ITU WRC-23 AI 1.5 only applies to Region 1. Do you believe the countries in Region 3 will involve themselves?**

Mr. Minehane: There is still a focus on digital switchover rather than the rest of UHF. It could be expected that countries may involve themselves in work relating to the issue of 6GHz rather than AI 1.5.

2. **You showed a number of different 600MHz band plans – is it sensible to have different band plans in different regions, or is there a de-facto band plan now because the US has taken a certain direction?**

Mr. Minehane: There is slightly more spectrum available in the Asia Pacific region, and it looks like there is support for a separate APT 600MHz band. There will be a high degree of overlap with the US band plan, with an extra 2x5 MHz spectrum, helping to maximise the amount of important sub-1GHz spectrum.

3. **Historically in the 3.6–3.8 GHz part of the C-band, there was a secondary mobile allocation in ITU Region 1 but a primary mobile allocation in the European Common Frequency Table. Do you think there are localised solutions for the UHF band that can be found at a European level rather than at the ITU level?**

Mr. Concannon: Potentially, but this depends on the European viewpoint. There is a strong broadcasting industry within Europe, and all stakeholders' views will need to be considered. While it is possible, decisions around the band will still need to be consensus based.

4. **We seem to be putting together a plan for the UHF band in a piecemeal way, assigning different sections at different times. A study, conducted by Aetha, showed that by considering the band as a whole, there could be significant benefits. Is there scope to think bigger within the current process?**

Mr. Concannon: The remit of TG6-1 is to look at the whole band. CEPT have formed a view that no changes are needed above 694 MHz, so there is a currently a preference to focus just on 490–694 MHz.

Mr. Minehane: Not in any foreseeable future. Licences have only recently been assigned, and there has been huge investment in devices. Coming out of the COVID-19 pandemic, it can be expected that there would be limited willingness from governments to reconsider this. Instead, it can be expected that the focus is on getting more spectrum available to bridge the digital divide. The difficulty in Asia, but also likely to be everywhere, is that incumbents are hesitant to give up spectrum at the end of the licence, let alone during the licence term.

5. **Many legacy networks, for example 2G and 3G, are now in the process of sunsetting across Europe. As this will release spectrum, could any need for additional spectrum, potentially for 5G, be met by this freed up spectrum?**

Mr. Minehane: Sunsetting in Asia is transitioning at pace, driven by government or operators. In Asia, there is also a challenge on mid-band spectrum, but as there has not been a second digital dividend, it can be expected that the focus will be achieving the digital dividend rather than spectrum in other ranges.

Mr. Concannon: This has not been explored in depth within TG6-1 to date, but it is certainly a factor that should be taken into account.

6. **A common question raised when thinking about the EU is that there are a number of vastly different markets. Is a one-size-fits-all approach something that will be of benefit to Region 1 countries, or are we now at the point that spectrum usage is so different between countries that reaching agreement will be difficult?**

Mr. Concannon: The UHF band is a difficult issue with strong political implications, for example the cultural value associated with the spectrum. The EU guidance needs to be taken into account, i.e. the spectrum should be reserved for broadcasting until at least 2030. There may not be a one size fits all solution, but efforts to reach convergence should be made where possible.

Mr. Minehane: There are definitely benefits to harmonisation. Because in Asia Pacific the second digital dividend isn't concluded, the region has not yet fully seen the interplay between countries with varying amounts of continued DTT (digital terrestrial television) usage. Some countries have such high usage of television that there is not sufficient spare spectrum to, for example, move to digital. For other countries, the low band spectrum will be vitally important for non-DTT uses. It can be expected that flexibility will be important but having a harmonized view will also be very important in allowing people to plan.

F.2.4 Current Status and Future Development of DTT in the EU including 5G Broadcast

Introduction from Oliver MERCER, LS telcom

Mr. Mercer presented an overview of the study findings so far relating to the technological developments within DTT, as well as the uptake of these within the EU Member States. Mr. Mercer then introduced 5G Broadcast, before introducing speakers Ms. Annalisa Durantini and Mr. Michael Wagenhofer.

Presentation from Annalisa DURANTINI, AGCOM, 'Digital Terrestrial Television in Italy'

Ms. Duratini presented an overview of the situation within Italy, where DTT is transitioning from using DVB-T2 MPEG2 to DVB-T2 HEVC over a number of years. Ms. Duratini presented key learnings surrounding the planning, regulation and uptake of the upgraded DTT systems.

Presentation from Michael WAGENHOFER, ORS, '5G BROADCAST TRIAL IN VIENNA'

Mr. Wagenhofer presented an overview of the 5G Broadcast trials that have been conducted by ORS recently. In particular, key learnings around coexistence with DTT, network density and ecosystem maturity were presented, along with future work to be conducted.

Q&A

1. **What has the response of viewers been to the need to retune, acquire new equipment?**

Ms. Duratini: Transition has not been quick. Viewers are hesitant to invest in new equipment, even with grants from the state. ~92% of households use DTT, although only ~50% of these had acquired DVB-T2 receivers at the point of the workshop.

2. **What do you think a commercial deployment of 5G Broadcast in Austria might look like?**

Mr. Wagenhofer: Broadcasters are facing increasing CDN (content delivery network) and streaming costs which rise significantly during big events. 5G Broadcast can be viewed as an alternative to a CDN network, as it provides the benefits of streaming without scaling the costs with high consumption. Alternatively, self-driving cars will likely be ubiquitous by the time 5G Broadcast is deployed, which facilitates further use cases for 5G Broadcast in the form of mobile TV.

F.2.5 Changes in Linear TV viewing habits in the EU

Introduction from Patrisia COSTENCO, VVA

Ms. Costenco presented an overview of the study findings so far relating to the evolution in the consumption of broadcasting content (e.g. linear, on-demand, catch-up) since 2017 for the adult/young population. Ms. Costenco also presented an estimation of trends for the mid- (5 years) and long-term (10 years). Ms. Costenco then introduced the speakers Mr. Tobias Lindberg and Mr. Sebastiano Trigila.

Presentation from Tobias LINDBERG, Media analyst, Nordicom, University of Gothenburg, 'The Swedish Broadcasting Landscape'

Mr. Lindberg presented an overview of the viewing trends in Sweden covering average viewing times per week, including a breakdown of TV and online viewing, streaming habits and viewing trends with regards to educational attainment.

Presentation from Sebastiano TRIGILA, Fondazione Ugo Bordoni, 'An Outlook of AV/TV market evolution in Italy'

Mr. Trigila presented an outlook of the AV/TV market evolution in Italy. The presentation began with an introduction to current trends in the Italian market, before proceeding to introduce the evolution of broadcast TV (the DTT transition) and broadband TV (OTT services). Broadband vs broadcast trends were discussed, as were content consumption trends.

Q&A

1. **Use of OTT services and VoD data in the report.**

There was a clarification from the study team on the extent to which OTT services data has been taken into account in the study analysis. The study team explained that the OTT data available covered some Member States but not others and that the data was to be considered a snapshot (and not indicating longer terms trends). With regards to data on VoD, it was clarified that the study indicated that the number of subscribers is increasing and that VoD will become a main subscription service for many EU 27 countries but that subscribers were very unevenly spread between Member States.

2. **Is there a potential change in viewing habits in the EU considering that linear TV services availability of DTT is still quite high compared to the broadband market?**

Mr. Trigila: One should distinguish between different types of users in the sense that one might be able to receive linear and broadcast TV services, but this does not imply the user is actively viewing content.

Almost 95% of the Italian population can receive linear TV services but not all of them spend time watching. This is particularly the case among young people. This is worrying because of the implications in terms of competition and presence in the market. There is also an impact on the culture imprint on new generations. Most of the content comes from global players. At the regulatory level, something must be done and broadcasters also have to better publicise their IP services.

Italy is currently focused on DTT transition, which takes most of the resources. It should be noted that all broadcasters have very interesting VoD offers, including partly linear IP – especially catch-up TV, but they are also developing new VoD offers. However, the users are not fully aware.

F.2.6 The importance of DTT for delivery of Public Service media

Introduction from Francesco PITTON, VVA

Mr. Pitton presented an overview of the study findings so far on the role of DTT for delivery of Public Service media. The presentation covered PSM requirements, distribution options, and PSM delivery on alternative platforms. Mr. Pitton then introduced the speakers Mr. Janne Holopainen and Mr. Fernando Ojea.

Presentation from Janne HOLOPAINEN, YLE, 'The role of broadcasting delivery of Public Service video in Finland, compared to broadband delivery'

Mr. Holopainen presented an overview of the situation in Finland with regard to the role of broadcasting delivery of Public Service video in Finland and compared this to broadband delivery. The presentation discussed some of the challenges that internet publishing has created for the public service media company Yle.

Presentation from Fernando OJEA, CIRCOM, 'The importance of DTT for delivery of Public Service Media'

Mr. Ojea's presentation covered the importance of DTT for delivery of Public Service Media from the regional perspective. It presented the regional outlook on DTT and summarised some new DTT developments.

Q&A

1. **What is the environmental impact of delivering broadcasting services (e.g. DTT vs IP)?**

Mr. Ojea: According to a EBU study, the impact of DTT is less in terms of energy spent compared to IP delivery.

Mr. Holopainen: The carbon footprint issue is important. At YLE, we require all our subcontractors to be carbon neutral. But from our perspective it is not the technology that matters but the end result.

The carbon footprint is created by electricity production which is ultimately is a national and international issue to ensure that the electricity produced is carbon neutral.

2. **EBU statement**

The European Broadcasting Union (EBU) is the world's leading alliance of public service media (PSM). Public service media (PSM) is broadcasting made to inform, educate and entertain all audiences.

EBU Members as PSM have the public remit of:

- Universality (to make all their content and services available to the entire population wherever they are);
- Free to view / listen (no recurring charges for access to services); and
- The ability to reach the whole population in emergency situations.

DTT in the UHF band remains crucial for PSM remit because of its efficient delivery of linear services to very large audiences, its near-universal reach, its free-to-air focus, and its resilience in times of crisis. Both public service and commercial channels are provided via DTT, contributing to healthy competition in the media sector and generating commercial value alongside the considerable public/social benefits.

Present in all countries, the relative importance of DTT varies from one country to another. For example the Finish situation is very specific to Finland – there is a strong penetration of DTT (48% of HH using DTT). At the same time, there is very good broadband coverage and penetration with affordable unlimited data caps.

But there is a wide diversity across European markets and it is currently too early for any EU Member State to foresee whether and by when online delivery of media content might be as resilient, as universally available, as sustainable, and as affordable for all EU citizens as DTT is. Current use by DTT and PMSE maximizes public value and innovation in the UHF band.

F.2.7 Current Status and Future Development of PMSE in the EU

Introduction from Richard WOMERSLEY, LS telcom

Mr. Womersley provided an overview of the technological developments in PMSE and the findings of the study so far with regards to spectrum usage for PMSE within each of the responding Member States. Mr. Womersley then introduced the speakers Mr. Tuomo Tolonen and Ms. Anita Debaere.

Presentation from Anita DEBAERE, Pearle, 'Current Status and Future Development of PMSE in the EU'

Ms. Debaere provided an overview of the PMSE industry within Europe, highlighting the importance of the industry to the European economy. Ms. Debaere then presented the importance of latency, audio quality, spectrum characteristics, and equipment lifespan and ecosystem to the PMSE industry.

Presentation from Tuomo TOLONEN, Shure, 'Technology Issues Related to PMSE'

Mr. Tolonen highlighted the importance of PMSE to the European content industry, noting some potential developments in PMSE technology. Mr. Tolonen then presented the issue of changes in PMSE spectrum and the effect this may have on the industry.

Q&A

1. **In for example, the US, with a number of digital dividends, there is obviously less UHF spectrum available. How is PMSE coping in this situation?**

Ms. Debaere: It is difficult to compare Europe and the US, not least because the density of venues and the topology of the country is very different. However, there are reports that in certain cities, certain events are unable to take place due to a shortage of PMSE spectrum. For example, larger festivals and events are being organised only in areas where sufficient spectrum is available.

Mr. Tolonen: New technology, primarily digital technologies, has allowed for greater spectral efficiency, but things are far more congested. The US is 100MHz worse off than Europe due to 600 MHz clearance. For example, the Superbowl in Los Angeles had to acquire a special licence from the FCC to be able to operate within the 600 MHz band in order to be able to deliver the event. This was complicated by there being little 600 MHz capable PMSE equipment available because usage of this spectrum is illegal for PMSE in the US. This resulted in the event needing to import equipment from elsewhere.

2. **There is spectrum between the uplink and downlink of mobile networks, i.e. the duplex gap. Why is this not the right spectrum for PMSE?**

Mr. Tolonen: This spectrum is too limited for large events. PMSE has a wide range of users, ranging from semi-professional users such as clubs and houses of worship, to professional users such as Eurovision and the Superbowl. The duplex gaps are already being used for less professional applications, but it is not suitable for professional uses as it is not wide enough, and it is 'dirty' spectrum. The gap is there for a reason for mobile usage, and for this same reason it is not suitable for PMSE.

Ms. Debaere: It is seen that this is only used for very small events, but it cannot be used for very professional events.

3. **When the 800MHz band clearance was suggested, the PMSE industry claimed it would struggle but was able to cope. The same occurred with 700MHz clearance. Are we now at a point that there would be a real pinch point with further reductions in spectrum?**

Ms. Debaere: The industry had to cope, thanks in part to developments by manufacturers. What will likely become difficult now is the growth in demand for PMSE spectrum at these events. An average event requires 100MHz of spectrum, increasing to 140MHz of spectrum for larger events. Further reductions in spectrum may risk a similar situation as observed in the US. Europe currently has a competitive advantage because of the larger amounts of spectrum.

Mr. Tolonen: The industry is definitely on the verge of having too little spectrum. Within the last 10 years, PMSE usage has grown significantly. Events requiring 40-60 channels 10 years ago may use

>100 channels today. A loss of spectrum below 694MHz without sufficient alternatives would result in the quality of content being degraded.

F.2.8 Wrap-up and Closing Session

Introduction from Anamarija JESENKO, EC DG CNECT

Ms. Jesenko welcomed participants to the final session, which would involve a Q&A session to capture anything not covered in earlier sessions. Ms. Jesenko clarified the purpose of the study, noting that it is looking at the current usage of the sub-700MHz band but does not make conclusions about what the band will be used for afterwards. Similarly, during WRC-23 the discussion will purely be about the possible allocation of the band to other services. Any change in allocation would not necessarily affect usage of the band within the EU, because use of the band for broadcasting and PMSE is protected until at least 2030 by the UHF Decision.

Mr. Womersley agreed and reiterated that the purpose of the study was in gathering and providing information, not generating conclusions.

Q&A

Study Questions

1. **When will the study be published?**

Ms. Jesenko: The end date for the study is the end of August, so it is expected that the study will be published around this time.

2. **How do people input to the study?**

Mr. Womersley: Slides will be provided on the Commission website, and the email addresses for team members are available on the slides to provide information or organise a discussion.

3. **Why does the study consider only the sub-700MHz band, rather than the whole of the UHF band?**

Ms. Jesenko: Article 7 requires the production of a report just on sub-700MHz band, rather than the whole range.

4. **Why has PPDR not been considered? Is this being considered in the various working groups?**

Mr. Concannon: PPDR has been discussed at TG6-1 and PTD. In the working document for WG1, there has been a section dedicated to spectrum requirements for PPDR. It is being discussed, but is more of a forecast in nature rather than explicitly stating that a certain amount of spectrum is needed for PPDR.

5. **Should any other sectors be included in the reassessment of the use of the sub-700MHz UHF band?**

Mr. Concannon: There are sectors wishing to gain more prominence in the discussions at both PTD and TG6-1. There hasn't yet been a significant input from PTD to TG6-1, but there are meetings ongoing. If there are concerns that services may potentially be overlooked, it is recommended that stakeholders make contributions to PTD, which may be taken to subsequent TG6-1 meetings.

5G Broadcasting

6. **To what extent will 5G Broadcast be able to support streaming, and how is it envisaged that it would support broadcasting?**

Mr. Wagenhofer: 5G Broadcasting is streaming over the air, via a broadcast mode. It is IP based and receivable by any device which carries the relevant hardware and application. It can help to offload capacity from mobile networks. There has been an explosion of demand for mobile networks, particularly during the pandemic. This growth will be even greater when the metaverse, augmented reality and virtual reality are more ubiquitous. Even with 5G, mobile broadband networks may not be sufficient. So 5G Broadcasting will be very interesting to help offload capacity to other networks.

From a business perspective, the costs are driven by peak demand. Peak time consumption is during events which are consumed live. During live events, for example coverage of news events or sports events such as the Olympic Games or FIFA World Cup, demand can be offloaded fully from the mobile network. This represents a big driver in the capex planning for mobile operators.

7. **5G Broadcast cannot be a replacement of DTT – what characteristics of DTT can 5G Broadcast not replace, and can the two co-exist?**

Mr. Wagenhofer: From the current technical status of the standard, 5G Broadcast is less efficient and can carry fewer programmes than DTT. But 5G Broadcasting is subject to ongoing innovation, and it can be expected that the characteristics will be similar to DTT in the long term, dependent on the network and the reception mode.

The Vienna trial showed that coexistence of DTT and 5G Broadcasting is possible. Austria already uses the full amount of the available spectrum for DTT and to introduce new technology creates another pressure on the spectrum. For widespread adoption of the technology, either DTT multiplexes would need to be switched off or a whitespace approach would need to be adopted.

The Importance of DTT for Delivery of Public Service Media

8. **Any further comments from YLE on the situation in Finland?**

Mr. Holopainen: Public service broadcasting has developed based on linear radio channels, linear TV channels etc. Up until 20 years ago, PSB and PSM was effectively equal to linear channels. For YLE, this is history. Currently, the Finnish society asks YLE to provide information and entertainment to the entire audience, which is not possible using just broadcasting or broadband. YLE cannot publish all of its content through broadcast but can through broadband. YLE expects that its future is in no way tied to broadcasting networks or DTT. The value it provides to audience is through content.

PMSE

9. **If 5G Broadcast (or other uses) makes use of TV whitespaces, what spectrum would be used by PMSE?**

Mr. Tolonen: PMSE prefers that there is no change to the use of spectrum. It has shown it is able to share spectrum with broadcasting as it is predictable and stable. Under a scenario where PMSE operates in whitespaces left by the IMT community, PMSE sees that this likely would not be feasible.

Mr. Wagenhofer: Broadcast is dependent on the output from PMSE spectrum usage. ORS is in continued cooperation with PMSE users in Vienna. For example, when launching their 5G Broadcast trial, they worked with local venues to ensure compatibility of the solutions. However, this sort of sharing would not be possible with IMT.

Closing Remarks

Ms. Costenco noted that this workshop was aiming to widen the discussion about the use of the sub-700MHz band. Comments received on the work to date have indicated that some stakeholders believe some of the work to date may have been too narrow, so the workshop was very useful to ensure the study takes sufficient breadth into account. The conclusions so far have been useful to ensure alignment with the Lamy report.

Finally, Ms. Jesenko thanked participants and speakers for their time in taking part in the workshop, reiterating that evidence from the workshop would feed into the study. Ms. Jesenko noted that the study is the first step in producing the report, which will consider other aspects also. Mr. Womersley echoed thanks to participants and speakers, noting the lively and useful debate in the chat alongside the scheduled panel sessions.

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