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FUTURE OF TV DISTRIBUTION

A report prepared by the University of Exeter with the University of Leeds, MTM, 3 Reasons and Real Wireless

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Glossary

Aggregator	A company that becomes a conduit to consumers for content from multiple licensors, or a company that negotiates with and supplies a consumer platform with content from multiple licensors.
Algorithms	Computational processes that define a series of steps or instructions in order to produce a desired outcome.
AVOD	Advertising Video on Demand: free to view but consumer has to watch locked in adverts.
BVOD	Broadcaster Video on Demand: provided by broadcasters that also offer linear channels.
CDN	Content Delivery Network: a geographically distributed network of servers that work together to provide fast delivery of internet content.
CTV	Internet connected TV.
DCab	Digital Cable television delivers television via a cable network.
DSat	Digital Satellite television delivers television by relaying it from communications satellite to an outdoor satellite dish on the home.
DSO	Digital Switchover is the process of moving from analogue to digital terrestrial television.
DTT	Digital Terrestrial Television sends television content over radio spectrum to premises where it is received by an aerial.
DVB-I	Digital Video Broadcasting Interface: a standards-based solution for delivering television – digital terrestrial television, cable, satellite and internet delivered television – in one user interface.
DVB-T	Digital Video Broadcasting Terrestrial: original standard for digital terrestrial television broadcasting.
DVB-T2	Digital Video Broadcasting Terrestrial: second-generation standard.
DTT	Digital Terrestrial Television: digital broadcast signal transmitted via the radio spectrum.
FAST	Free Advertising Supported Television: free internet-delivered scheduled television supported by advertising.

FTV	Free TV (as opposed to Pay TV or subscription TV), includes ad-supported digital terrestrial television.
Hybrid Home	Home that uses a variety of methods to consume television including digital terrestrial/satellite/cable and TV delivered over the internet.
Interfaces	Features of software that function to convert the language of binary code, through which computers operate, into images, words and sounds that people can easily understand.
ISP	Internet Service Provider: a company that provides customers with access to the internet.
IPTV	Any TV service delivered over an Internet Protocol network including the public internet. IPTV services include Video on Demand, catch-up video services and linear TV channels. Broadcasters' traditional TV channels delivered live over internet networks, as well as FAST advertised supported scheduled services, are two examples of linear IPTV channels. Three subsets of IPTV described in this report are: **OTT**: includes all the IPTV services outlined above delivered over the open, public internet on a best-efforts basis, with no guarantees on service quality, bit-rate or reliability. It includes services over internet streaming devices like Amazon Fire and Apple TV. **Managed IPTV**: includes IPTV services delivered over an internet network where the service provider and network operator have used specific technologies to provide a guaranteed level of service quality, such as a dedicated core network or multi-cast capacity. **Linear IP:** linear and Video on Demand TV services delivered by Pay TV operators e.g. Sky and Virgin Media as Managed IPTV or OTT services over the internet.
ITU	International Telecommunication Union: an agency of the United Nations responsible for matters related to information and communication technologies.
Linear TV	Scheduled television content delivered via broadcast (digital terrestrial television, satellite, cable) or via the internet.

Metadata	Data that provides information about other data, such as descriptions that classify television content
Pay TV	Subscription-based television services traditionally delivered via satellite, but can include delivery via digital terrestrial television and cable, and via the internet.
PMSE	Programme Making and Special Events: interpersonal radio communications that require use of the spectrum.
PSB	Public Service Broadcaster: BBC, Channel 3 (ITV and STV), Channel 4 and S4C and Channel 5 in the UK.
SaVOD	Subscription Advertising Video on Demand: a service whereby revenue is from subscription and advertising.
Simulcast	Broadcasting of programmes or events across more than one media form.
SFN	Single Frequency Network: a broadcast network that extends the coverage area without the use of additional frequencies.
SVOD	Subscription Video on Demand: internet delivered content made available for a recurring set fee.
TVOD	Transactional Video on Demand: the 'rental' of television content whereby consumers pay a standard retail price to stream the content for a short period.
MFN	Multi Frequency Network: a network of transmitting stations that all use their own frequency to prevent co-channel interference between the transmitters.
VOD	Video on Demand: Umbrella term for services in which libraries of video content are made available for request on demand by viewers.
WRC	International Telecommunication Union World Radio Conference: takes place every 3-4 years to review and, if necessary, revise the Radio Regulations, the international treaty governing the use of the radio-frequency spectrum and the geostationary-satellite and non-geostationary-satellite orbits.

Preface

This research was supported by the R&D Science and Analysis Programme at the Department for Culture, Media & Sport. It was developed and produced according to the research team's hypotheses and methods. Any primary research, subsequent findings or recommendations do not represent Government views or policy and are produced according to research ethics, quality assurance, and academic independence.

The R&D Science and Analysis Programme at the Department for Culture, Media & Sport funds researchers to provide critical evidence for the Department's policy and/or analysis areas. Led by the Chief Scientific Adviser and the Director of Analysis, the Programme aims to build cross-cutting, long term, and experimental evidence to complement other methods of evidence development within the Department, and to do so in a way that facilitates knowledge exchange between Government and independent experts.

Introduction

The UK television landscape is shifting from broadcast to internet distribution. An increasing number of homes have adopted hybrid TV distribution that combines broadcast digital terrestrial television (DTT) and/or satellite with broadband-enabled internet delivery, while some have transitioned to purely internet-delivered TV (IPTV). Internet delivery is now the fastest-growing mode of TV distribution in the UK. This has underpinned a rapid increase of consumption of on-demand and linear content delivered via the internet. Competition among US-based subscription video-on-demand (SVOD) players has been accompanied by rapid uptake of services. At the same time, UK public service broadcasters (PSBs) and other broadcasters have evolved their own internet-delivered services of linear channels and broadcaster video-on-demand (BVOD) offers. Free advertising-funded video-on-demand services (AVOD) and free advertising-supported linear (FAST) channels over internet are also growing in popularity from a low base. Meanwhile traditional Pay TV platforms Sky and Virgin have seen declining subscriber bases as more homes shift to portfolios of over the top (OTT) internet-delivered services and access VOD services directly over the internet. At the same time, the free-to-air digital terrestrial television broadcast platform, Freeview, is proving resilient.

This Future of TV Distribution report examines how these trends in the distribution and consumption of television are likely to develop in the UK up to 2040 without further policy intervention. The research delivery team led by University of Exeter, with University of Leeds as co-investigators, and industry consultants MTM 3 Reasons, Real Wireless and Cartesian, drew on academic papers, industry studies, data sets and new interviews to examine the available evidence in Audience Analysis, Technology, Net Zero Impact, International Comparisons, Spectrum Use and Market Impacts. This report draws together key findings from these domains where evidence exists to describe the Future of TV Distribution in the UK by 2040. It also identifies gaps in the evidence that would benefit from further research.

Key Findings

Most households in the UK already have the capability to watch internet-delivered TV on their main TV set. In 2023, 87% of TV households had an internet-enabled primary TV set and within this cohort, approximately 18% already used the internet exclusively as their TV delivery mechanism on their primary set. In 2023, 17% of households relied on digital terrestrial television.

We project, based on existing market dynamics, that by 2040 95% of households will have installed the capability to watch TV over the internet. We expect 71% to rely exclusively on internet delivery and 24% to be hybrid homes combining internet-delivered TV with digital terrestrial television or digital satellite. Superfast broadband will reach at least 99.65% of homes by 2030. However, without intervention, by 2040, 5% of homes (1.5 million) will still rely on digital terrestrial television.

There are strong supply and demand drivers of internet-delivered TV. On the demand side, new and augmented services are available over the internet that are not available on broadcast TV, such as TV series or subscription services like Netflix, as well as innovations in user experiences (e.g. start over, playlists, personalisation, etc.) that can drive viewer engagement. One of the most significant supply side drivers is TV set sales and 3 Reasons anticipates that 100% of TV sets sold will be internet-capable by 2025.

The 17% of households that rely on digital terrestrial television for their TV services in 2023 tend to have lower incomes, are more likely to be disabled, older, living alone, female, and geographically in the north of England, Wales, Scotland and Northern Ireland. Our analysis of the barriers to uptake of internet-delivered TV suggests that in 2040 the 5% of households that remain reliant on digital terrestrial television will continue to share these characteristics. Future research should focus on understanding these barriers and, if there is a case for switching off digital terrestrial television, explore potential interventions to support these households to switch to internet-delivered television.

Technology for internet television delivery is mature and will have the capacity to manage all television viewing via the internet by 2040, but lack of control by service providers over the access network and in-home network may create problems including reliability. Internet-delivered television would require more reliable end-to-end networks to match current digital terrestrial television networks' performance.

The UK's digital terrestrial television network continues to use transmission and encoding technology from the 1990s - DVB-T and MPEG2 – for most of its services. More efficient second-generation technology - DVB-T2 and MPEG4 - is used for Freeview High-Definition channels. In Europe, most countries are retaining digital terrestrial television because of its reliability and the need to maintain access for vulnerable audiences, and are replacing DVB-T and MPEG2 with newer, more efficient technologies to offer higher resolution and/or a greater choice of services.

Digital terrestrial television broadcasting will remain the only primary service in its allocated UHF spectrum until at least 2031 in International Telecommunication Union Region 1 which includes the UK. However, there is increasing pressure to release spectrum currently used for digital terrestrial television for mobile services and the World Radio Conference will consider co-primary use of the spectrum by digital terrestrial television and mobile in 2031.

If digital terrestrial television has a long-term future, the UK should prepare for the potential implications of co-primary use of the spectrum. This would require modernisation of the digital terrestrial television network to mitigate the risk of some loss of spectrum after 2031 and to continue using the available spectrum effectively. The simpler, lower-cost way of achieving this would be to broadcast all channels using DVB-T2 and MPEG4. This technology was introduced for Freeview HD broadcasts in 2009 and most TV sets sold over the last 15 years are already compatible. By giving sufficient advance notice, all households could be ready well before 2031.

Current research suggests digital terrestrial television results in lower emissions than internet-delivered TV, but lack of data on the impact of devices in the home including their embodied carbon makes it difficult to draw a comprehensive comparison. In any case, by 2040, as 5% of households will be reliant on digital terrestrial television without intervention and 24% of households will be hybrid viewers, watching both digital terrestrial and internet delivered television, the impact on emissions of continuing both means of distribution should be considered.

Audience Analysis

In 2023, 87% of UK households had an internet-enabled primary TV and approximately 18% used the internet exclusively as their primary way to watch television. 17% of UK households were dependent on digital terrestrial television for their TV viewing.

- Homes that were dependent on digital terrestrial television included 13,000 homes in areas without fixed-line broadband, 1.7 million homes without broadband access for reasons of affordability or choice, 2.2 million homes with broadband where the TV is unconnected to the internet and 0.7 million with an internet-connected TV whose viewing is more than 80% linear.
- In 2023, 90% of those without a broadband connection were aged over 55. They were more likely to identify as female and to live on their own. 80% of those with no broadband connection were within the C2DE socioeconomic bands. They were also more likely to live in the north of England, Wales, Scotland and Northern Ireland and have a disability.

In 2040, 95% of UK homes will use internet-delivered TV services. Internet delivery-only homes will represent the largest segment of households at 71% of homes. A small minority – 5% of homes – will remain wholly reliant on digital terrestrial television broadcast.

- Broadband will fully cover the UK (by 2030) with superfast broadband (30Mbps or faster) coverage reaching at least 99.65% of homes.
- However, in 2040, 0.4 million homes will opt not to connect to broadband and 1.1 million homes will have broadband but will not connect their TVs in order to use internet TV, making up 5% of homes. These viewers are more likely to identify as female and to live on their own. They are also more likely to live in the north of England, Scotland and Northern Ireland, be on low incomes and have a disability.
- Hybrid viewers who have internet and digital terrestrial television whose share of linear viewing is greater than 80% will decline to c. 0.5 million homes.
- 4.4 million secondary TV sets receiving digital terrestrial television will remain unconnected to the internet, presenting a further challenge.
- For the group without broadband, affordability is likely to be a significant barrier, potentially coupled with perceptions of complexity in setting up and using IPTV technology and services and, for some, an ongoing lack of interest in online services.
- For those with broadband but unconnected TV sets, barriers are likely to include affordability of internet-enabled devices and the perceived complexity of connecting and using these devices.
- For both these groups, lack of digital skills is likely to be a factor.
- High satisfaction with existing and familiar linear channels delivered over digital terrestrial television broadcast, relative to the content delivered over the internet, is also likely to play a role in terms of disincentivising a switch.
- For linear heavy viewers who watch TV on hybrid digital terrestrial television and internet-enabled sets, barriers are less significant as they will already have access to internet-delivered TV services; the challenge is more a behavioural one, for reasons of habit or perceptions of greater reliability.
- Further qualitative and quantitative research is warranted into the unconnected groups of TV viewers to understand their barriers, motivations and preferences in more detail, and to understand what policy interventions may support digital terrestrial television reliant homes to switch to internet-delivered television.

Technology

In 2023 many households were still receiving digital terrestrial television over the original DVB-T standard and MPEG2 compression technologies. However, advancements in technology enable better quality and wider choice for consumers. These are being widely adopted in other European countries.

- DVB-T2 second-generation standard and modern encoding technologies provide at least double the capacity for transmission, which can be used to increase the quality or number of channels.

- There are other options to improve the spectrum efficiency and increase capacity, such as using Single Frequency Network based (SFN) deployment where the same signal is transmitted from multiple transmitter sites on the same frequency across the network. However, migrating to an SFN-based network would require replanning the entire network.
- Countries including France, Italy and Spain have already migrated entirely to the DVB-T2 second-generation standard or have plans to migrate.
- Migrations take a long time to complete as they involve migrating all transmission sites and TV receivers at home.
- Accelerated migration to DVB-T2 will result in higher costs to consumers and broadcasters compared to natural migration. However, making plans with sufficient notice to users, e.g. giving a 5 to 10-year notice period to users, can keep the costs down.

By 2040, core network capacity will not be a barrier to widespread viewing of television over the internet, but research is needed to understand reliability of internet-delivered TV relative to digital terrestrial television, particularly within the home network, which is outside the control of internet service providers.

- Internet-delivered television technology is mature. Core network capacity is growing rapidly and rollout and uptake of superfast and ultrafast access network connections will continue.
- The exponential nature of the growth of network capacity means peak traffic in the core network is not a significant risk – if all homes are reliant on internet-delivered TV by 2040, network operators should be capable of delivering television services through the core network reliably.
- Internet delivered television's biggest challenge is the lack of control that service providers have over the access network and in-home network, compared with digital terrestrial television delivery. This could lead to a high degree of variability of user experience depending on each household's technology.
- We have not found any research quantifying the reliability of internet delivered vs. digital terrestrial television, and further research is needed to develop a better understanding of their relative reliability. This should be considered both from a Critical National Infrastructure point of view (critical failure of the telecoms network versus critical failure of the digital terrestrial television network) and from a user experience view (frequency and duration of "normal" failures and ease of resolution).

Net Zero Impact

Researchers have applied coherent methodologies to assess the climate impact of internet-delivered television compared with digital terrestrial television suggesting internet delivery results in higher emissions due to its

distribution infrastructure (including data centres) and in-home devices (modems and routers).

- However, publicly available data on the net zero impact of internet-delivered and digital terrestrial television is limited, particularly for devices in the home and for embodied carbon and better data needs to be made available by service providers and device manufacturers.
- Researchers also need to consider data for the current situation where television is distributed by both digital terrestrial networks and by the internet, and the impact on carbon emissions of continuing to do both.
- The long-term trajectory of the impact of internet-delivered television is uncertain. We should be prepared for non-linear growth patterns, where seemingly small shifts in technology or behaviour could have significant consequences.
- A research gap exists in prioritisation of energy efficiency strategies and tracking how internet delivered television interacts with broader energy trends (network demand, energy sources and device trends) since this understanding will be crucial in determining the scale and pace of change.

International Comparisons

There are no directly comparable territories to the UK in terms of indicating a parity timeline for transition from digital terrestrial television to internet-delivered TV. However, Spain, Italy and France provide some useful comparisons in terms of high digital terrestrial television usage.

- Digital exclusion and the responsibility to maintain access for vulnerable audiences are a widespread concern that informs digital terrestrial television preservation policy in each country.
- The continuing evolution of digital terrestrial television to full High Definition and Ultra-High Definition in different territories and the recent investment in full conversion in some territories to DVB-T2 second-generation standard, indicates a longer-term expectation in many markets that digital terrestrial television will remain a key broadcast system well into the 2030s and potentially beyond.
- The likelihood of a long timeframe until full transition to internet-delivered television is supported by several reports from prominent organisations such as the Radio Policy Spectrum Group (RSPG), the European Broadcasting Union (EBU), Broadcasting Networks Europe (BNE) and Broadcast 2040+.
- Comprehensive comparative data, or data collected through a uniform methodology, is not available for Europe or the rest of the world. While European data does exist in comprehensive form, it is not publicly available.

Spectrum Use

Digital terrestrial television broadcasting, which is allocated part of the UHF spectrum, frequency band 470–694 MHz, will remain the only primary service

in this band until at least 2031 in International Telecommunication Union Region 1, which includes the UK. However, there is increasing pressure to release the 600 MHz band for mobile services.

- UHF spectrum is globally harmonised and used for digital terrestrial television transmission. The propagation characteristics of this spectrum band enable achieving a near universal coverage with acceptable sized antennas, making the UHF band the most attractive spectrum band for TV transmission.
- The UHF spectrum also has properties that are useful for wireless communications systems.
- The World Radio Conference will consider the co-primary use of the spectrum by digital terrestrial television and mobile in International Telecommunication Union Region 1 (Europe, Middle East and Africa) in 2031. Any decision made in 2031 is likely to take several years to implement. However, additional costs or disruption could be reduced by taking policy steps to mitigate the likely impact.
- If further spectrum is released for mobile services, the Programme Making and Special Events (PMSE) sector will also lose access, as this sector can only share the spectrum used by TV broadcasting. The Programme Making and Special Events sector needs a predictable allocation of spectrum to develop compatible equipment.

Market Impact

The shift in viewing habits towards digital platforms is challenging the traditional TV advertising model, leading to a decline in broadcast advertising revenues and new global subscription video-on-demand providers taking share of Pay TV and subscription revenue.

- Proliferation of subscription video-on-demand services makes the Pay TV landscape significantly more competitive because subscribers can switch with greater ease than they can with traditional linear Pay TV. This in turn drives greater returns to scale, so revenue is funnelled away from local players towards global services like Netflix and Amazon.
- As online streaming services increasingly offer advertising-supported services to bring in more cost-conscious customers, this significantly increases the supply of tier 1 advertising inventory, which further increases the pressure on traditional broadcast advertising revenues.

1 Audience analysis

This section presents an overview of the trends impacting UK TV audiences in the UK and forecasts these dynamics to 2040. Specifically, it analyses the groups likely to face the greatest barriers in making the switch from broadcast TV delivered by digital terrestrial television (DTT) to TV services delivered over Internet Protocol (IP) networks and presents a future-looking view of their potential evolution in the context of a changing market.

We conclude that 28.0 million (c. 95%) UK homes will be capable of using IP-delivered TV services by 2040 through internet-connected sets and devices, and that these households will adopt video-over-IP technology on an organic basis (i.e. without policy intervention). We also identify a small but significant minority of c. 1.5 million homes (5.2% of TV homes), that will remain reliant on DTT broadcast, either because they do not have broadband access or because, despite having broadband, they have yet to connect their TV set to the internet. A further group will use internet-connected DTT sets (a 'hybrid' platform) to watch TV, but a minority of these viewers ('linear heavy') will still strongly favour linear viewing and therefore potentially be more reliant on DTT broadcast. In addition, we project that c. 4.4 million secondary DTT TV sets will remain unconnected in 2040, presenting a further challenge. These projections are based solely on current trends and industry dynamics and exclude any analysis or consideration of policy intervention.

These groups present different challenges in terms of enabling a potential shift from DTT to IP-delivered TV. For the group without broadband access, affordability is likely to be a significant barrier, potentially coupled with perceptions of complexity and, for some, an ongoing lack of interest in online services. For those with broadband but unconnected TV sets, barriers are likely to include affordability of internet-enabled devices and the perceived complexity of connecting these devices. For both of these groups, lack of digital skills is likely to be a factor. High satisfaction with existing and familiar linear channels delivered over DTT broadcast, relative to the content delivered over IP, is also likely to play a role in terms of disincentivising a switch. For the 'linear heavy' viewers who watch TV on 'hybrid' DTT sets, barriers are less significant as they will already have access to IP-delivered TV services on their sets; the challenge is more a behavioural one, i.e. a potential lingering affinity for broadcast vs. linear IP streaming, for reasons of habit or perceptions of greater reliability.

While we make no recommendations for policy interventions in this section, we believe that further research is warranted. Qualitative research into the unconnected groups of TV viewers, to understand their barriers, motivations and preferences in more detail, and to understand what specific policy remedies may be most effective, should be a priority.

Section 1.1 sets out current trends in the UK TV market and a view of how these are likely to play out to 2040, in terms of the installed base of TV sets (platforms and user interfaces), and in terms of types of TV viewing. Section 1.2 presents recent research on UK TV audience segments from Ofcom/TRP and the Routes to Content

project, highlighting the existence of a group of viewers who heavily favour linear broadcast viewing.

Section 1.3 analyses four sub-groups of the UK TV audience who are likely to face barriers in switching from broadcast DTT to IP-delivered services. Three of these sub-groups have DTT sets that are not connected to broadband, and the fourth, while using broadband-connected sets, remain heavy consumers of linear content. These groups have significant demographic commonalities: they are more likely to be older; of lower socioeconomic status; living in single-person homes; living in the North of England or in Scotland, Wales, or Northern Ireland; and to identify as being disabled.

Section 1.4 examines the barriers that are likely to be impacting these sub-groups' take-up of IP-delivered TV services, focused around broadband access, connected TVs and devices, TV user interfaces and electronic programme guides (EPGs), and attitudes to content. Finally, section 1.5 lays out a view of how these barriers might evolve to 2040 and presents forecasts for the potential evolution of the four groups.

1.1 Current trends and forecast changes in TV viewing habits

In this section, we examine the dynamics driving the shift toward IP (Internet Protocol) enabled delivery and consumption of TV content in the UK and lay out some forecasts for how this transition is likely to evolve to 2040. The analysis is grounded in the comprehensive UK TV market model created and managed by 3 Reasons, a London-based media strategy consultancy and part of MTM.[1]

In the UK there are: 'unconnected' homes, which rely solely on broadcast TV; 'hybrid' homes, which are using both broadcast and IP delivery; 'linear-IP' homes, where the TV set receives both linear and on-demand content through a platform or interface that centres on the linear schedule delivered over IP, with no broadcast component; and 'OTT-only' homes, which rely entirely on IP.

In summary, the UK TV platform universe is shifting from broadcast to IP-enabled technologies. This is driving a transition from 'unconnected' homes, which currently number c. 3.9 million, to 'hybrid' homes, which are growing rapidly from a low base, 'linear-IP' homes and 'OTT-only' homes. While linear viewing still represents the majority of viewing time, the shift toward IP has driven growth of viewing to VOD (video on demand) content, as well as a nascent shift from linear viewing over broadcast to linear viewing over IP.

By 2040, we project that a significant majority of homes will solely use IP-delivered services to watch TV on their primary TV sets (i.e. Linear-IP or OTT-only homes), while 'unconnected' homes will have declined to a small minority of homes. Hybrid homes (mainly a combination of DTT and IP delivery) will represent just over a quarter of TV homes. In terms of viewing, linear will have declined to just over a

[1] 3 Reasons is one of the leading sources for forecast data on the size of the UK TV marketplace, and it prepares detailed analysis and projections for the long form video market in the UK every 6 months. Its client base has included nearly all the major players in the market for over 15 years.

quarter of TV viewing time and VOD (both SVOD (subscription VOD) and BVOD (broadcaster VOD)) will represent a clear majority.

Therefore, despite the majority shift toward IP-delivered TV services, we estimate that c. 3.9 million homes are 'unconnected' in 2023, and project that this number will decline to c. 1.5 million by 2040. The following sections will examine this group, and those in the 'hybrid' group who rely heavily on linear viewing, in greater detail.

We also note the issue of secondary TV sets – i.e. those used in other parts of the home in addition to the primary set. Currently we estimate c. 29 million secondary sets in the UK, of which just under 7 million are likely to be unconnected to the internet (virtually all of them DTT sets). By 2040, we project a total of 30.3 million secondary sets, of which c. 4.4 million are likely to remain unconnected.

The shift to IP-enabled TV platforms

This section will set out the shifts in the UK TV landscape in the past 10 years that have profoundly impacted audiences' access to technology and services, and in turn, their viewing habits.

- Fundamentally, the UK TV landscape is shifting from broadcast (one-way) to IP (Internet Protocol) enabled distribution, made possible by:
    - Growth of broadband coverage and uptake, especially superfast broadband
    - Proliferation of IP-connected TVs and streaming devices
    - Rapid growth of IP video services.
- As a result, an increasing number of homes have switched from purely relying on platforms like DTT and satellite to 'hybrid' models that combine broadcast with broadband-enabled IP delivery, while some have transitioned to purely IP-delivered TV services. IP-delivery is now the fastest-growing TV 'platform' in the UK.
- This has underpinned a rapid increase of consumption of on-demand and linear IP content:
    - Competition among US-based SVOD players has driven rapid uptake of services, led by Netflix, Amazon Prime Video, and Disney+, plus a range of niche services like Apple TV, Paramount+, etc.; all of which were boosted by the pandemic. Packaging of SVOD services like Netflix into Sky and Virgin bundles also helped increase penetration.
    - At the same time, UK public service broadcasters (PSBs) and other broadcasters have evolved their own IP-delivered services of linear channels and BVOD offers including the BBC (iPlayer), ITV (ITVX), Channel 4, etc.

    - Free advertising-funded VOD services (AVOD) such as Amazon Freevee and Pluto TV are also growing, albeit from a low base, and some SVOD players have introduced lower-cost advertising funded tiers (SaVOD).
    - Free advertising-supported (FAST) linear channels over IP are also growing in popularity from a low base.

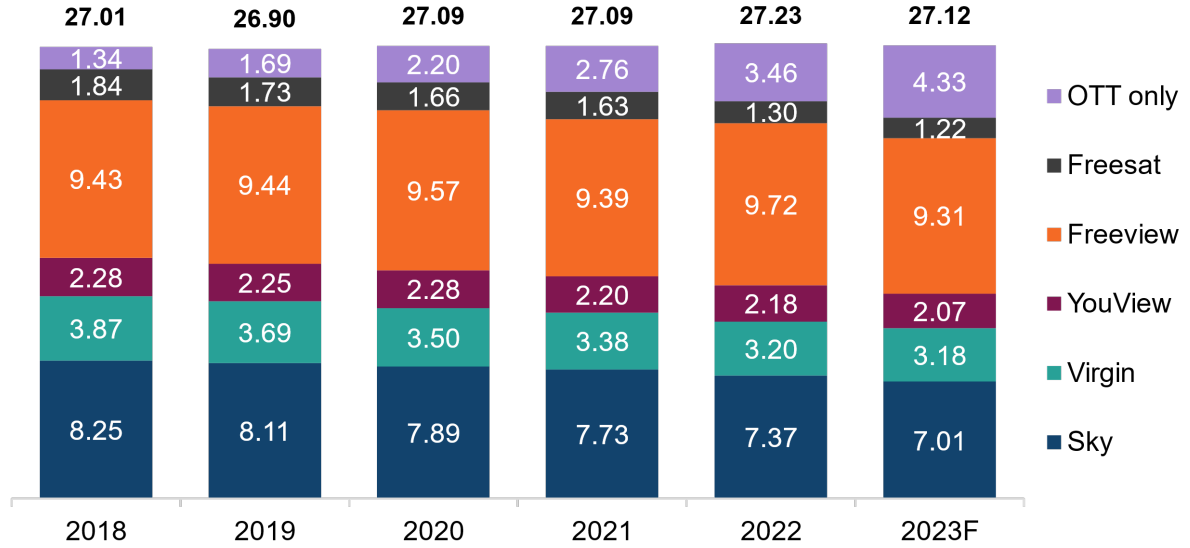
- In this context, traditional Pay TV platforms Sky and Virgin have seen declining subscriber bases as more homes shift to portfolios of 'over the top' (OTT) IP-delivered services and access VOD services directly over the internet.
- At the same time, the free-to-air DTT broadcast platform, Freeview, is proving resilient, with many viewers valuing its ease of use, convenient reception throughout their home, no need for a broadband connection, and its low cost compared to Pay TV – and a growing number are combining it with a range of VOD services. Freeview Play offers VOD and recording functionality on top of the basic Freeview offer and has seen growing uptake.

Overall, in the past five years the take-up of TV platforms has seen a noticeable shift toward IP delivery.

- The most evident change has been in the growth of homes that rely solely on IP for TV to their main set. The number of OTT-only homes (which do not use any conventional broadcast delivery method) has almost tripled in the last five years.
- Sky and Virgin Media homes are in decline as the traditional Pay TV model comes under pressure from cheaper and more flexible SVOD offers.
- DTT homes using Freeview have been resilient (with some homes using VOD services as a complement to it), while YouView homes have seen a slight decline.

Figure 1 shows the traditional platform view of the UK TV landscape, and the various ways viewers choose to access TV content on their primary set.

Figure 1: TV households by platform type on main TV set, 2018-23F (millions)

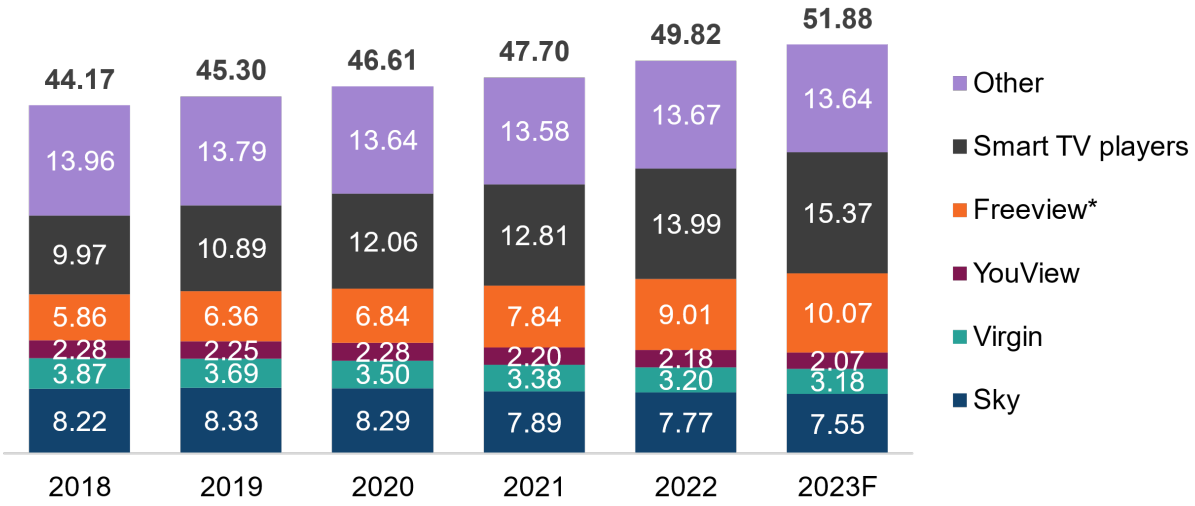


Source: 3 Reasons

A key factor has been the proliferation of IP-enabled smart TV sets as well as IP-enabled devices from players like Google, Amazon, Roku and a host of smaller players, to the point where there are now over 50 million IP-connectable interfaces available on primary sets across the 27 million TV homes in the UK.

Figure 2 describes the UK TV landscape according to IP platform. Consumers often use multiple IP capable devices to access TV content, therefore the UK TV landscape needs to consider internet connectible devices and smart TVs.

Figure 2: Connected TV devices[2] by type, 2018-23F (millions)



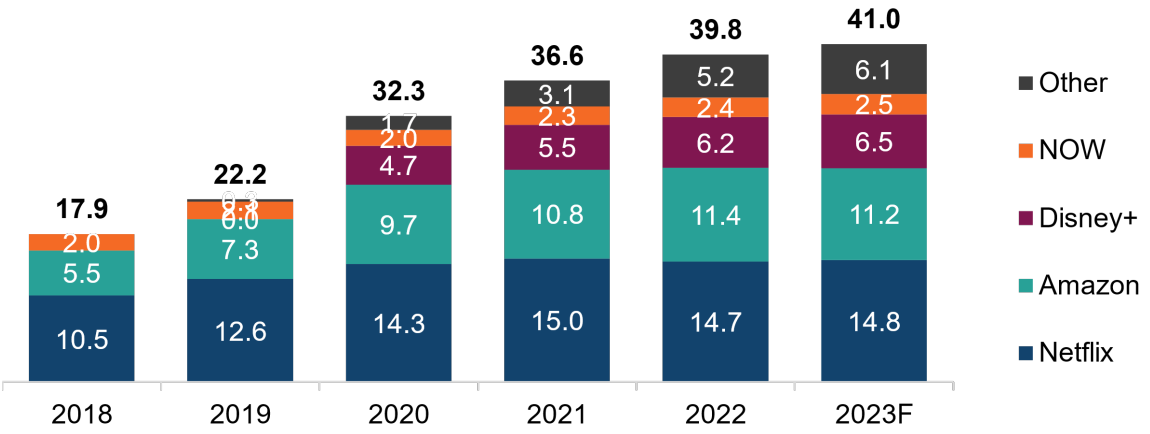
[2] Devices connected to the main TV set in the household only

*Freeview Play and Freesat smart TVs are duplicated for multiple interfaces per device; 'Other' includes games consoles and other streaming devices such as Roku, Fire TV Stick, Chromecast.

Source: 3 Reasons

Another significant factor has been the growth of video on demand (VOD) viewing, driven both by broadcaster (BVOD) offers as well as subscription (SVOD) offers. In the last five years, total SVOD subscriptions in the UK have grown from 17.9 million in 2018 to 41 million in 2023, with the average SVOD subscriber taking over 2.2 services.

Figure 3: Total SVOD users, y/end by service, 2018-23F (millions)



Source: 3 Reasons

There is also growth in viewing of IP-delivered live and linear channels, driven by the number of FAST channels and of scheduled BBC programmes that are available in UHD (ultra-high definition) through iPlayer, both delivered only over IP networks.

However, despite the growth of IP connectivity, its distribution among TV homes is still highly variable depending on the specific platforms and interfaces available.

3 Reasons identifies four distinct types of 'user interfaces', the basic technologies through which audiences consume long-form TV, depending on the TV platform they use and its degree of IP connectivity.

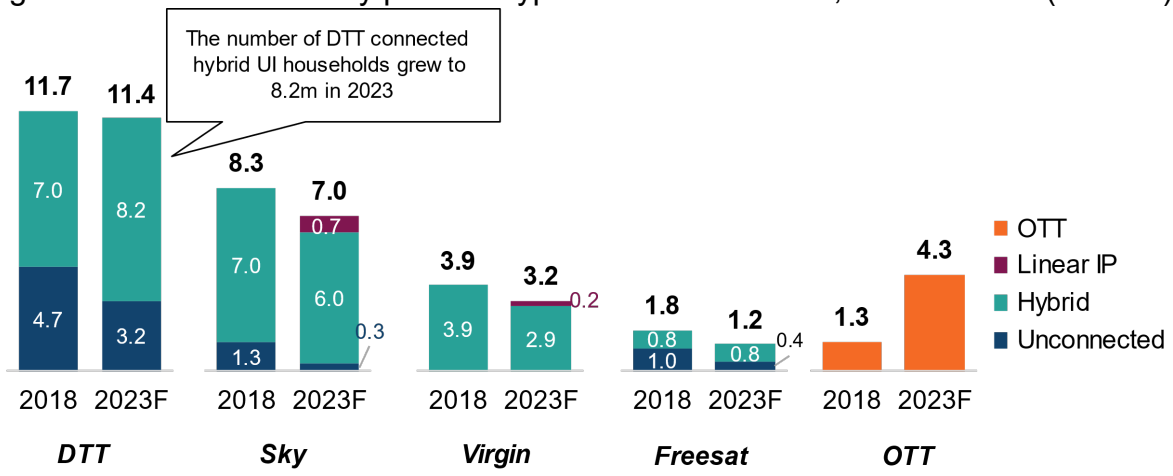
Figure 4: TV User Interfaces

User Interface	Characteristics
Unconnected	TV set has no connection to IP-delivered video and relies entirely on linear broadcast delivery, mainly from DTT or Freesat.
Hybrid	TV set receives linear broadcast programming through a distribution mechanism like DTT or Sky satellite, but is also connected to the internet and can receive VOD services and IP-delivered linear channels alongside.
Linear-IP	TV set receives both linear and on-demand content through a Pay TV platform like Sky or Virgin, but over IP only (i.e. no broadcast component). These platforms have incentive to give prominence to linear channels because a key revenue stream is linear Pay TV packages, esp. sports
OTT-only	TV set has no broadcast delivery and relies entirely on IP, delivered through a combination of VOD and linear services. Includes IP-delivered platforms from a variety of tech & hardware players (Google, Roku, streaming devices like Fire & Apple TV, etc).

Source: 3 Reasons

Each of these types of user interfaces drives distinct types of viewing behaviour, as we discuss below. The distribution of user interfaces has been shifting in the last five years, driven by the proliferation of broadband-delivered IP services.

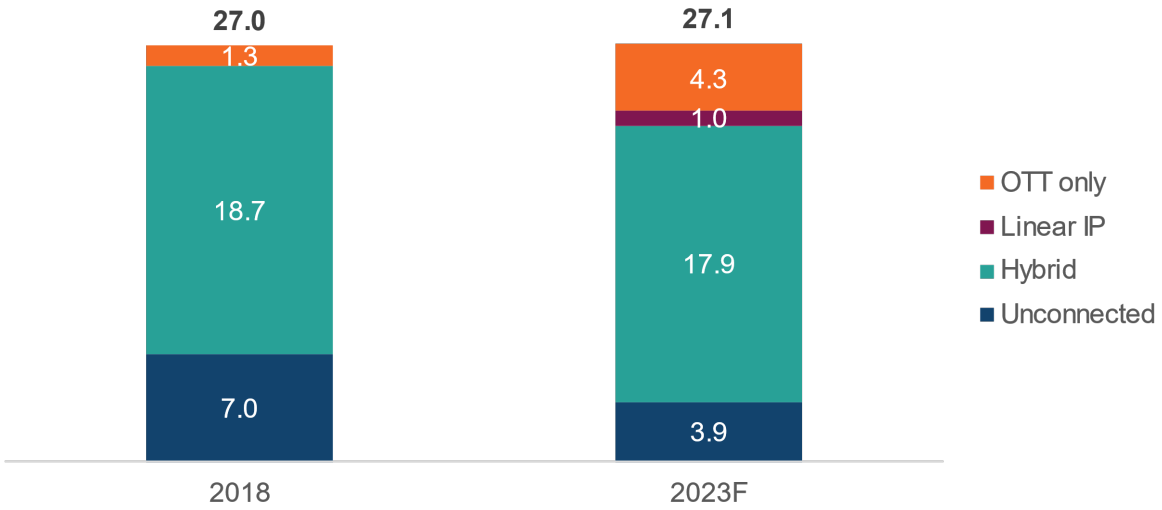
Figure 5: TV households by platform type and user interface, 2018 vs. 23F (millions)



Source: 3 Reasons

On aggregate, this means that the overall user interface landscape has begun to shift, with a marked increase in OTT only/Pure IPTV homes. Notably, there is still a relatively large group of homes that remain unconnected to IPTV. These amount to c. 3.2 million DTT homes in 2023 (c. 13% of total homes), with a further 0.7 million unconnected satellite homes.

Figure 6: Total TV households by TV user interface type, 2018 vs. 23F (millions)



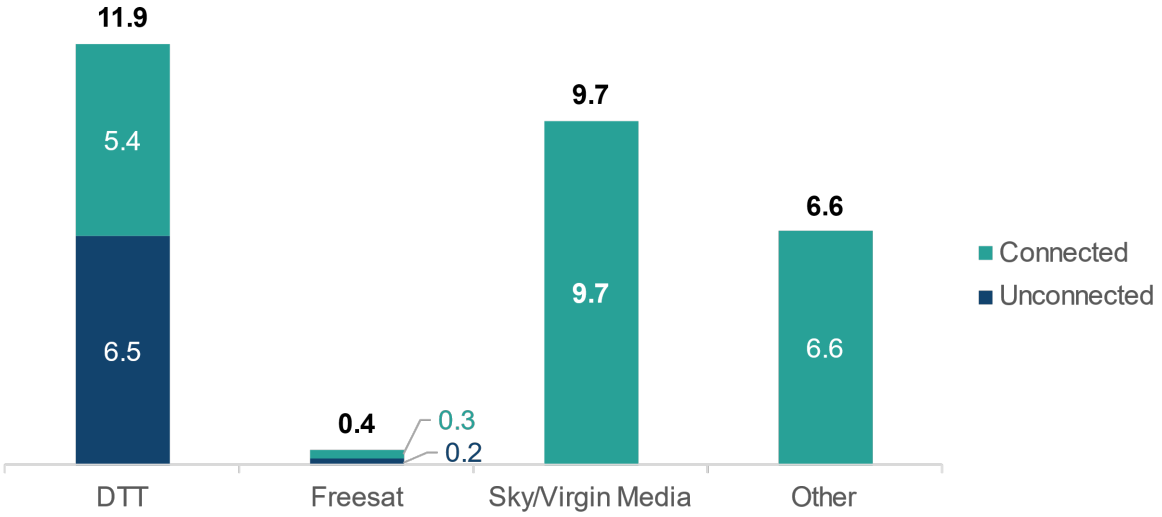
Source: 3 Reasons, MTM analysis

Secondary TV sets

While most viewing takes place on the main (primary) set in the home, other (secondary) sets in the home are also significant.

Current 3 Reasons estimates suggest there are approximately 28.6 million secondary sets in the UK. Of this, the majority of the 6.5 million unconnected sets are assumed to be sets that use DTT as their means of receiving TV services.

Figure 7: Secondary TV sets by connectivity, Q2 2023, 000s [3] (millions)



Source: 3 Reasons

The shift from linear to on-demand viewing

Overall long-form TV viewing is in decline in the UK, as audiences, especially younger demographics, increasingly use short-form and social video from platforms

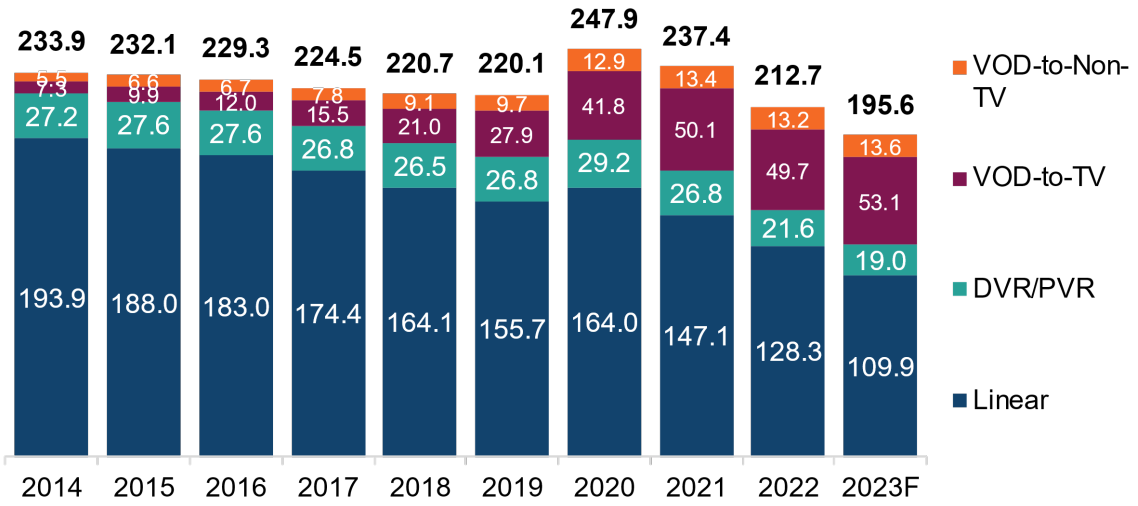
[3] "Other" refers to OTT only sets.

like YouTube, TikTok and other social media platforms (which is outside the scope of this project) alongside traditional TV content.

Within long-form television viewing, there are multiple shifts contributing to an overall decline in broadcast viewing: from linear viewing to on-demand; and within linear, viewing via broadcast channels is shifting towards IP-delivered (though it remains low at present).[4]

Overall, linear viewing has declined from c. 82% to c. 54% of total viewing from 2014-2023, while VOD viewing (to TV and non-TV devices) has grown from 5.5% to c. 33.8%.

Figure 8: Average minutes viewing per person per day via all devices, 2014-23F

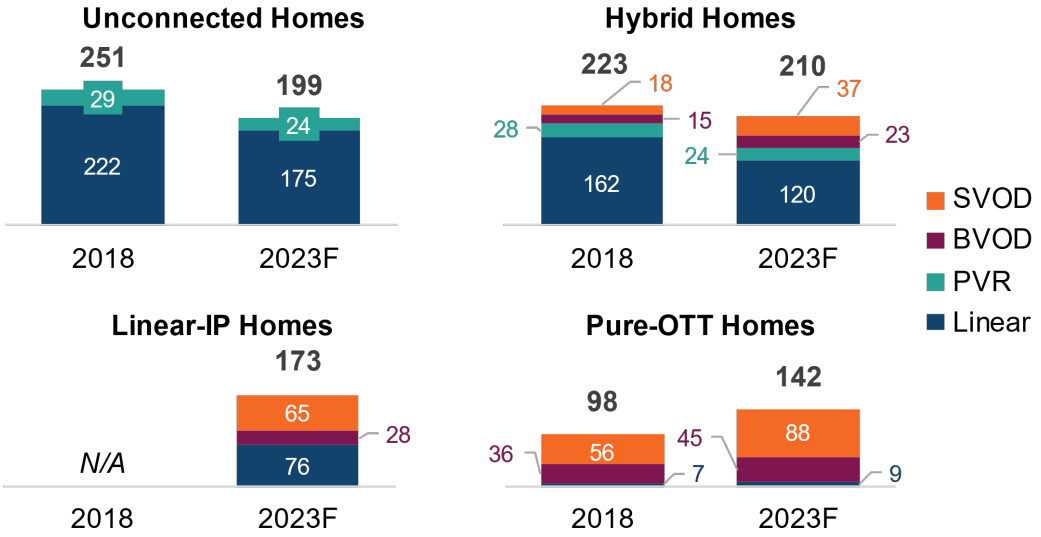


Source: 3 Reasons

However, viewing patterns vary significantly by the type of user interface in each home, with Unconnected homes watching almost exclusively linear broadcast TV (with some time-shifted personal video recorder (PVR) viewing), and viewing in OTT-only homes almost exclusively SVOD and BVOD. Viewers in Hybrid and Linear-IP homes have more mixed viewing patterns.

[4] For the purposes of our analysis, 'linear' viewing refers to viewing to live scheduled TV content delivered via broadcast (DTT, satellite, cable) or IP.

Figure 9: Average minutes viewing per person per day, by user interface type, 2018 vs. 2023F



Note: Viewing includes all viewing (including on secondary sets); individuals are categorised based on primary set platform
Source: 3 Reasons

Dynamics and drivers impacting the UK TV platform landscape to 2040

We assume that a number of significant market dynamics will play out over the next 10-15 years, impacting the UK's TV platform landscape and, in turn, audience viewing behaviour.

- Broadband rollout will continue across the UK, with increasing availability of superfast services, leading to a closing of the gaps in coverage and uptake. Modelling by 3 Reasons and MTM forecasts that by 2030, 90% of UK homes will be fixed-line broadband subscribers while a further 6.1% of UK homes will access broadband but only via wireless technologies. Over 99% will live in places covered by ultrafast broadband (100 Mbps or above), with ultrafast uptake at 83.3% of homes. By 2040, broadband penetration is forecast to have reached at least 98.6%, and ultrafast coverage will have reached all of these homes. We forecast that by 2040 92.6% of homes will have at least superfast fixed-line broadband (30Mbps or above) connection, and an additional 4.9% will have a VOD capable mobile connection.[5] While a small proportion of homes will still be without broadband, this is forecast to be a small minority at 1.4%.
- Internet-connected TVs (CTVs) and other IP-connectable devices will see a growing share of the installed base in UK homes, which will reach 100% of TVs sold by 2025. 3 Reasons forecasts that by 2030, 94% of TV homes will have an IP-connectable CTV as their primary set, and we project that by 2040 that will have risen to 99%.

[5] VOD capable mobile broadband is defined as homes that access the internet via a smartphone connection, tethering, USB dongle or 5G/wifi with speeds above 30 Mbps.

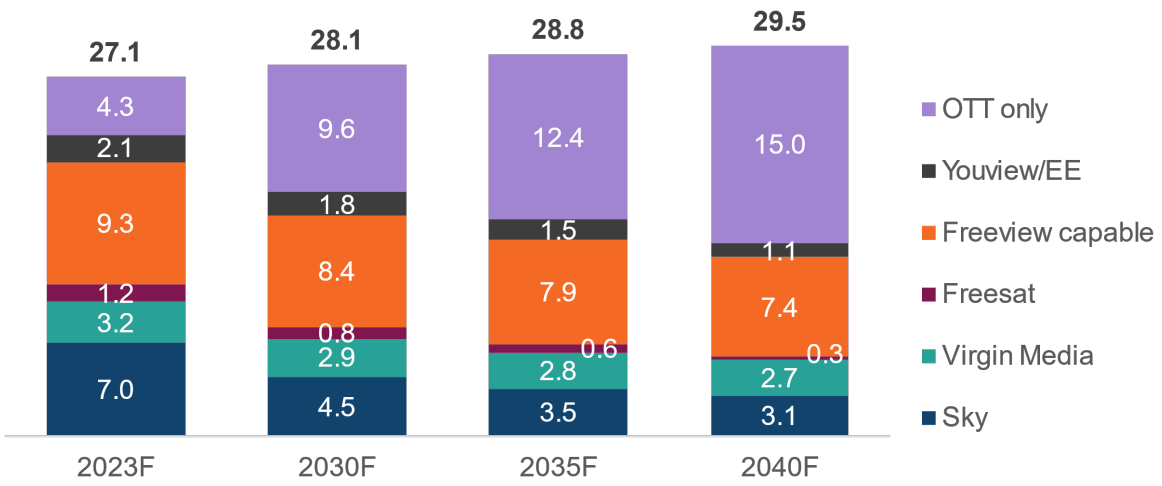
- The increasing availability of linear content and channels over IP, especially from the PSBs. All the PSBs are now making their linear content available via IP. We assume that they will continue to expand IP delivery of their content.
- The growth of linear-IP content via conventional linear EPGs, effectively allowing IP-delivered linear content from PSB channels and others to reach viewers who prefer to use more traditional user interfaces. Key players include Sky's Stream and Glass offers, Virgin's Stream product, and EE TV. A key variable here is the launch of Freely in 2024, a free IP-based offer from Everyone TV, the consortium of PSB channels and other players behind Freeview. Freely is a hybrid platform enabling delivery over both DTT broadcast and IP, which combines linear-IP and VOD services over broadband alongside DTT distribution.
- The growth of SVOD services is likely to continue, albeit at a slower pace, as SVOD players mature, with more homes taking up services and 'stacking' multiple services, either as an 'a la carte' option or potentially bundled by aggregators. By 2028, 3 Reasons forecasts that 72.8% of broadband homes will have at least one SVOD subscription and subscribe to an average of c. 2.3 services.
- In the Pay TV arena, we assume that Sky is likely to maintain focus on their linear Pay TV offer, led by sports, which is their core competitive differentiation, rather than pivot aggressively to becoming an aggregator of IP content; and that their subscriber base will be affected adversely as a result.
- For the purposes of these forecasts, we assume that there is no material change to DTT distribution or to the Freeview content offer before 2040.
- We have also refrained from making assumptions about any material changes from the upcoming Media Bill, including its impact on the prominence of PSB BVOD services and potential loosening of requirements on commercial PSBs.

Evolution of UK TV platform landscape to 2040

As a result, platforms and user interfaces will continue to evolve toward greater connectivity. By 2040, we project that 'OTT-only' homes will represent the largest segment of households, at c. 15.0 million, followed by Freeview[6] with 7.4 million. Sky and Virgin are forecast to have declined to 3.1 million and 2.7 million homes, respectively.

[6] Freeview includes projection of Freely adoption in MTM/3 Reason primary set platform categorisation

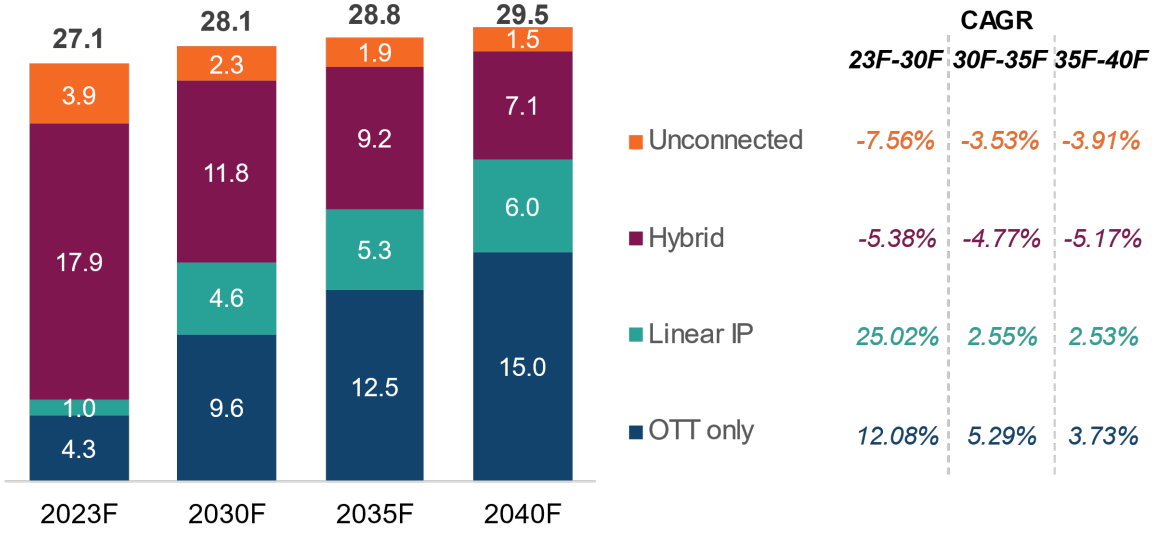
Figure 10: TV households by platform type on main TV set, 2023F-40F (millions)



Source: 3 Reasons

In terms of user interfaces, a large and growing proportion of UK TV homes will have IP connectivity to their TV sets, either exclusively or alongside broadcast delivery. By 2040, we forecast that 15 million homes will have OTT-only IP delivery, and another 6.0 million will be linear IP homes, receiving IPTV services from Sky, Virgin, or a Freely set that isn't connected to an aerial. Approximately 7.1 million homes will have a hybrid DTT, Digital Satellite (DSat) or Digital Cable (DCab) interface. Critically for the purposes of this analysis, we forecast that c. 1.5 million DTT homes (and another c. 0.05 million Digital Satellite (DSat) homes will still be unconnected to IP.

Figure 11: TV Households by type of TV user interface, 2023-2040F (millions)



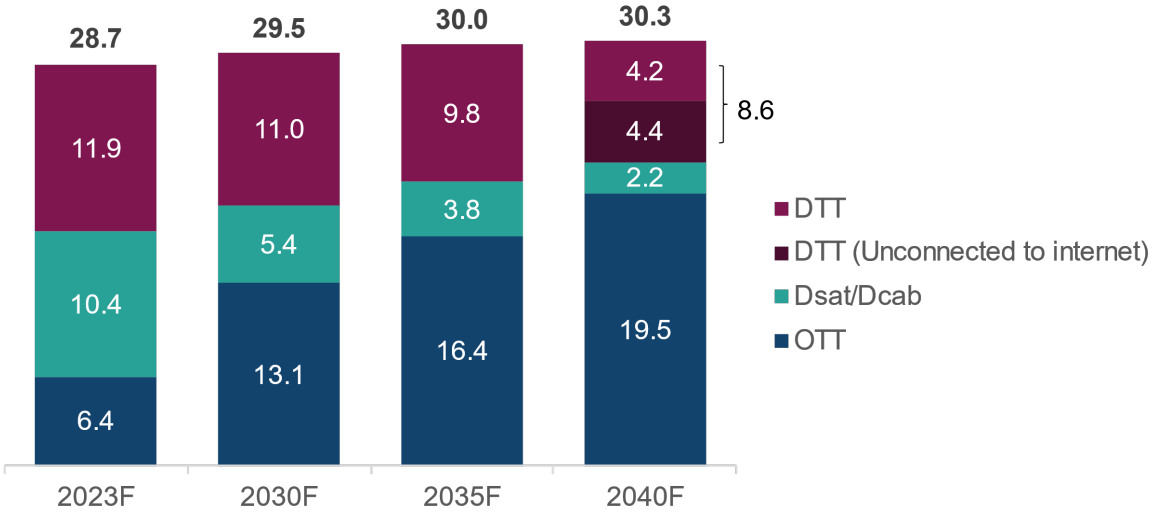
Source: 3 Reasons, MTM analysis

The evolution of secondary sets to 2040

We project that the number of secondary TV sets will grow to just over 30 million by 2040. The majority of these will be 'OTT-only', i.e. connected to the internet without

any broadcast delivery, while c. 8.6 million will be connected to DTT aerials. Of these, about half (c. 4.4 million) will remain unconnected to the internet.

Figure 12: Secondary sets by type of TV signal, 2023F-40F



Source: 3 Reasons, MTM analysis

The evolution of TV viewing to 2040

As a result, viewing will continue to shift toward greater on-demand consumption – though linear viewing will remain more resilient in unconnected TV and hybrid TV homes. The roll-out of superfast broadband contributes to these viewing shifts, and 97% of households in the UK had access to superfast broadband in 2023.[7] By 2040, after the roll-out of superfast broadband and IP-enabled devices is largely completed, most homes will be viewing a mix of linear and on-demand content that best meets their preferences.

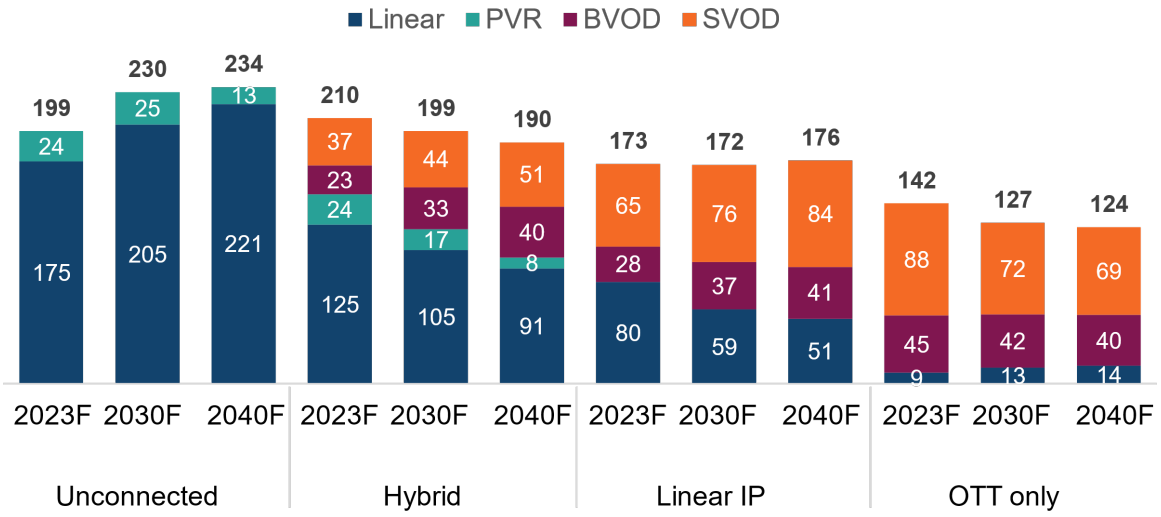
3 Reasons forecasting of viewing is based on assumptions of different viewing behaviour in each type of household, where each user interface (UI) type has a changing viewing profile.

- Unconnected TV: viewing will remain a mix of linear and PVR only, as primary TV sets are not connected to the internet. As the total number of Unconnected TV homes falls, average total viewing in remaining homes will increase, as 93% of this segment is populated by people aged 55+ who, on average, spend more time watching TV per day.[8]
- Hybrid: likely to see a steady reduction in linear and an increase in VOD viewing in line with current trends; however, linear will continue to be a significant proportion of overall viewing.

[7] Ofcom, Connected Nations (2023), 4.
[8] Ofcom, Media Nations (2023), 9.

- Linear IP: Sky & Virgin Media O2[9] IPTV, and selected Freely sets:[10] VOD viewing will continue to increase, while linear viewing will be higher than OTT-only homes. Sky and Virgin are likely to continue to give greater prominence to linear channels because they sell linear Pay TV channel packages - and therefore linear viewing levels are likely to be higher than in other IP-only homes where there is no precedence for linear.
- OTT-only: likely to see continued low levels of linear viewing in favour of VOD. Despite the rise of viewing to FAST channels, this is unlikely to be material in the near term. Multiple FAST channels have been launched on UK services (e.g. ITVX) and other services such as Pluto TV and Freevee have grown their channel portfolios. However, the impact of FAST channels on VOD viewing remains unclear. Linear (simulcast) viewing is projected to increase (at the expense of VOD) as homes with linear TV preferences become OTT-only.

Figure 13: Viewing by user interface and content type, daily individual minutes, 2023F - 2040F



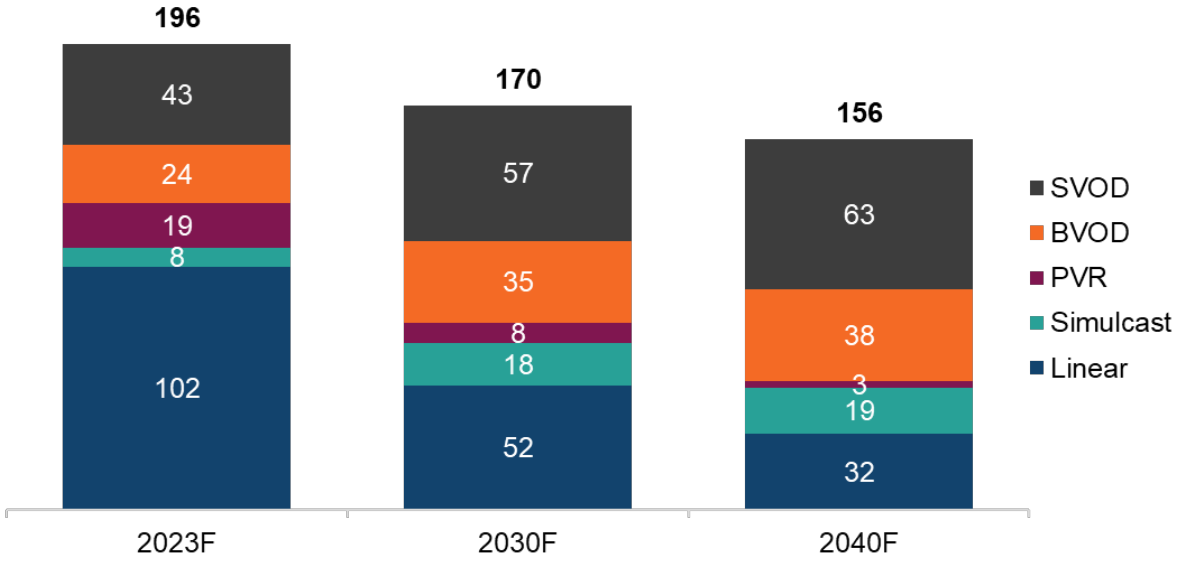
Source: 3 Reasons, MTM analysis

Combining the assumptions for UIs and viewing levels by UI then allows us to model future viewing patterns in terms of total viewing by different types of content. Total viewing is projected to decline from 196 minutes in 2023 to 156 minutes in 2040.

[9] IPTV services provided by Virgin Media O2 (e.g. Stream)

[10] Freely sets which are not plugged into an aerial.

Figure 14: Viewing of content type, average daily minutes per person, 2023F - 2040F



Source: 3 Reasons, MTM analysis

These forecasts mean that while total volume of viewing minutes shifts materially to BVOD and SVOD, the proportion of linear TV viewing (and viewing recorded on PVRs) still remains significant. Overall, by 2040, our viewing projection predicts 65.3% viewing will be via BVOD and SVOD services combined, up from 33.1% in 2023. Conversely, linear (including broadcast and IP-delivered linear) as a percentage of total viewing is forecast to decrease from 56% in 2023 to 33% in 2040. Notably, the volume of linear (and PVR) viewing in Unconnected TV homes is forecast to decline from 12.1% to c. 6.9% of total viewing.

In summary, our forecast suggests that by 2040 the vast majority of audiences will have TVs/devices connected to IP networks which will enable linear-IP and VOD viewing. However, these overall shifts and averages do not reflect the behaviour in a proportion of homes that have low or no appetite for IP currently. We forecast that, in 2040, the Unconnected TV group will amount to c. 1.5 million homes that, without intervention or encouragement, will either be unable or unwilling to connect their TV set to IP networks and will continue to watch linear TV on unconnected DTT or DSat sets. In addition, a proportion of DTT homes which do have IP-connected TV sets will continue to favour linear viewing, some of which is likely to be over broadcast.

The next two Sections, 1.2 and 1.3, will analyse these groups in further detail with a view to understanding the factors that can drive and inhibit the switch away from DTT to IP-enabled TV viewing.

1.2 Key TV audience segments

UK TV audiences can be segmented into distinct groups based on their TV viewing habits and access to TV technology.

Recent research includes analysis done by TRP for Ofcom's 2023 *Media Nations* report,[11] and the 'Ways of Watching' analysis done by Catherine Johnson *et al*. at the University of Leeds as part of the broader Routes to Content project.[12] These segmentations analyse audiences according to their routes to TV viewing and reveal the existence of groups which are significantly heavier users of linear TV than others. They also give insights into their demographics and behaviours which we examine in more detail in Section 1.3.

While these frameworks are useful in mapping out and understanding UK media habits, a full understanding of the groups who are reliant on DTT broadcast and who prefer linear content also requires insight into their access to TV technology. Therefore, in order to enable a robust sizing and modelling of the key groups in focus for this project, we will rely on 3 Reasons' UK TV market model and its segmentation of the TV audience by user interface.

Viewing-based segmentation frameworks

Ofcom's Media Nations Segmentation (TRP)

For its 2023 Media Nations report, Ofcom commissioned TRP to analyse the viewing of 8,500 members of the Barb panel in order to understand patterns of linear vs. VOD viewing and the profiles of different types of viewer.

The analysis yielded five distinct groups, categorised by their volume and type of TV viewing, ranging from 'Linear Heavy' viewers watching over 5 hours of mainly linear TV per day, to 'Linear Medium' and 'Linear Light' viewers, also watching linear TV but with a larger proportion of BVOD and SVOD. The 'Linear Rejectors' group watched significantly less linear TV, even less than the 'Linear Light' group, favouring SVOD, and a small group of 'TV Rejectors' was found to watch very little TV at all. At 30% of TV viewers, the 'Linear Heavy' group stands as the largest segment among UK television audiences.

[11] Ofcom, Media Nations (2023), pp. 17-21 https://www.ofcom.org.uk/__data/assets/pdf_file/0029/265376/media-nations-report-2023.pdf (last accessed November 2024)

[12] Johnson, Catherine, *et al*., *Ways of Watching: Categorising television viewers in an age of streaming* (2023). Available at: https://ahc.leeds.ac.uk/media-industries-cultural-production/dir-record/research-projects/1840/routes-to-content (accessed 3 May 2024).

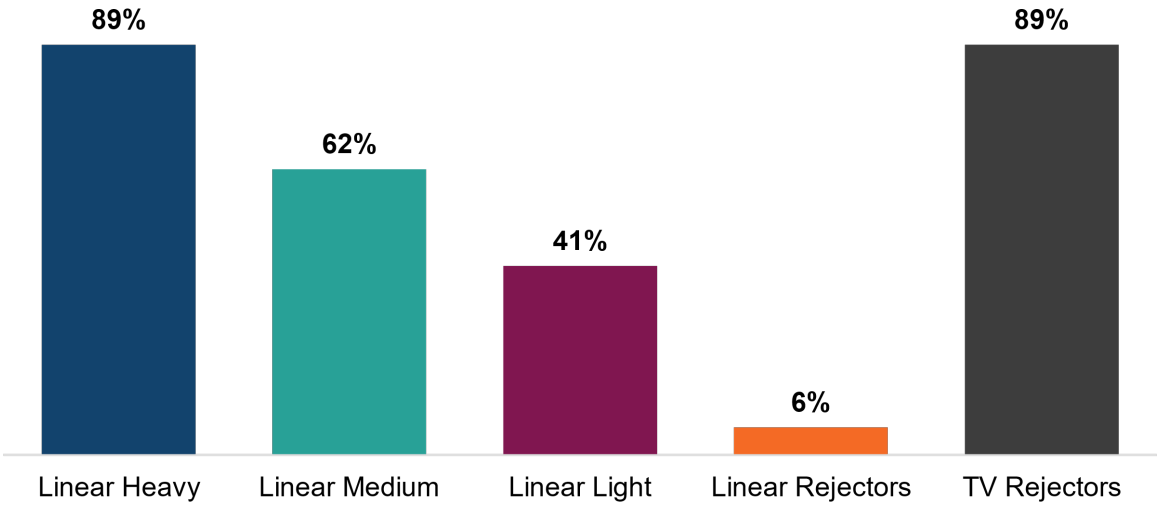
Figure 15: Ofcom TRP viewing segments

Group	Linear Heavy	Linear Medium	Linear Light	Linear Rejectors	TV Rejectors
Viewing	5+ hours of mainly linear TV per day	1.5 to 5 hours of linear/BVOD per day	1.5 hours of linear TV per day, as well as a mix of BVOD / SVOD	Less than 2 hours of linear / BVOD per day	Less than 2 hours of any TV per week
Demos	77% are older viewers (55 or over) 30% are one person households	37% 55+ 38% 35-55 52% are two adult households	29% 16-34 58% are two adult households with children	High proportion of young adults (34% 16-34s) and children (40% 4-15)	High proportion of young adults (42% 16-34s) and children (25% 4-15)
% of total TV viewers	30%	28%	22%	16%	4%

Source: Ofcom/TRP, *Media Nations 2023*

This segmentation is interesting in that it presents a fairly stark picture of the demographic differences among TV viewers, with the 'Linear Heavy' group being significantly older than the others. While the analysis did not specifically examine TV technology access, this group is likely to be heavily reliant on DTT broadcast, in contrast to the other groups (as demonstrated in section C below) – 89% of their viewing is linear, significantly higher than 'Linear Medium' and 'Linear Light' groups.

Figure 16: Ofcom TRP viewing segments, linear viewing %



Source: Ofcom/TRP, *Media Nations* 2023

Routes to Content – Ways of Watching viewer segmentation

The "Ways of Watching" research, carried out by Catherine Johnson (University of Leeds) et al., for the Routes to Content (R2C) project, "examines how and why television viewing habits have changed in the UK since the increased uptake of

streaming services during 2020. It identifies the key factors that shape viewers' use of different TV services – from linear broadcast channels to subscription video-on-demand services (SVOD) – and identifies three new categories of TV viewer."[13]

Unlike TRP's research for Ofcom, this research analysed the frequency of reported usage of different kinds of TV services: free-to-air linear channels, free VOD services, SVOD, free video-sharing platforms, Pay TV services and transaction video-on-demand (renting or purchasing streamed content).

Segmenting viewers according to the underlying patterns of reported individual behaviour within the data, the research discovered that viewer behaviour fell into distinct ways of watching television, clustering into three groups: 'All-Watchers', 'Free-Watchers', and 'Subscribers'.

Figure 17: Ways of Watching viewer segmentation

All-watchers (53%)	Free-watchers (30%)	Subscribers (17%)
Watched the full range of available services, from linear broadcast channels, to VOD, Pay TV and video streaming services.	Primarily watched linear broadcast channels, BVOD services (such as BBC iPlayer) and free video streaming services (such as YouTube).	Mainly watched SVOD services, such as Netflix.

Source: Catherine Johnson et al.: *Ways of Watching*

Similar to the Ofcom segmentation, a distinct group with a disproportionate consumption of free linear TV emerged, the 'Free-Watchers' segment, which was identified as significantly older (an average age of 58) than the other two groups (both at 44). This segment also tended to have lower household income and be more likely to watch TV alone. Again, while the analysis did not analyse viewers' TV access technology in detail, it is likely that this group is more reliant on DTT broadcast than the others.

[13] Johnson, Catherine, et al., *Ways of Watching: Categorising television viewers in an age of streaming* (2023), 1.

Figure 18: Ways of Watching viewer segmentation – detail

Factor	All-Watchers (53%)	Free-Watchers (30%)	Subscribers (17%)
Demographics	• Average age of 44. • Highest household income.	• Average age of 58. • Lowest household income. • More likely white.	• Average age of 44. • Average household income.
Viewing Behaviour	• Highest TV viewing hours. More likely to watch TV with others. Used greatest variety of methods to discover new programmes to watch.	• Below average TV viewing hours. • More likely to watch TV alone. • Used fewest methods to discover new programmes to watch.	• Lowest TV viewing hours. • Most likely to watch TV alone and away from living room. Least likely to discover programmes by chance.
Experience of TV	• More emotionally engaged with TV than the other groups. • Most likely to feel challenged[14] when watching TV.	• Less likely to experience positive emotions when watching TV. • Least likely to feel connected to others and most likely to feel critical about the way the world works when watching TV.	• Less likely to experience positive emotions when watching TV. • Least likely to feel challenged by the content that they watch.
Expectations and Values of TV	• Above average support for public funding of TV. See the primary function of TV as to 'switch off'.	• Above average support for public funding of TV. • See the primary function of TV as to inform / educate.	• Lowest support for public funding of TV.
Genre Preferences	• Watched a wide range of genres.	• Watched a narrower range of genres. • High TV news and factual viewer.	• Watched the narrowest range of genres. • Low TV news and factual viewer.

Source: Catherine Johnson et al.: *Ways of Watching*

Access-based segmentation framework

3 Reasons' user interface-based segmentation

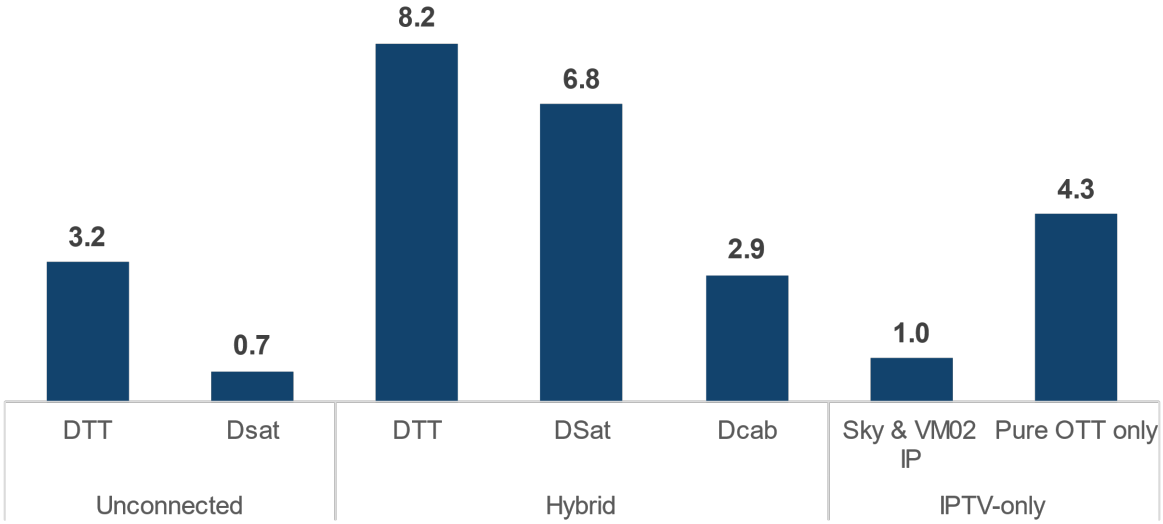
3 Reasons, a media strategy consultancy and part of MTM, manage a comprehensive UK TV market model, tracking and forecasting platform and technology take-up and viewing behaviour. As described in Section 1.1, the model splits the market into four distinct segments based on the type of user interface used to watch TV on the primary TV set in each household:

[14] "Challenged" refers to challenging watchers' beliefs.

- Unconnected TV homes, where the TV set has no connection to IP-delivered video and relies entirely on linear broadcast delivery, mainly from DTT or Freesat.
- Hybrid homes, where the TV set receives linear broadcast programming through a platform like DTT, satellite, or cable, but is also connected to the internet and can receive VOD services and IP-delivered linear channels alongside linear.
- Linear-IP homes, where the TV set receives both linear and on-demand content through a Pay TV platform like Sky or Virgin, but over IP only (i.e. there is no broadcast component).
- OTT-only homes, where the TV set has no broadcast delivery and relies entirely on IP, delivered through a patchwork of VOD and linear services.

Currently there are estimated to be 3.9 million Unconnected TV homes, of which the majority use DTT as their broadcast technology of choice. The Hybrid group accounts for c. 17 million homes, split into those using DTT as their broadcast delivery mechanism and others who use satellite (primarily Sky's Pay TV service). c. 2 million are Linear-IP homes who use Sky or Virgin's IPTV services, while just under 4 million homes are OTT-only homes.

Figure 19: TV households by viewer segmentation, 2023F (millions)



Source: 3 Reasons, MTM analysis

1.3 Unconnected TV and Linear-Heavy groups

We have identified four groups that are most relevant in considering the potential barriers to adopting IP-delivered TV services. These include both those who rely on DTT broadcast and whose TV is not connected to the internet, which total c. 3.9 million homes, and those who use an internet-connected DTT set but continue to heavily favour linear viewing,[15] which we estimate at a further c. 0.7 million homes in 2023.

[15] We define Linear Heavy as those viewers whose TV viewing is 80% linear or greater, as they are the viewers who are most likely to continue relying on broadcast DTT despite having TVs connected

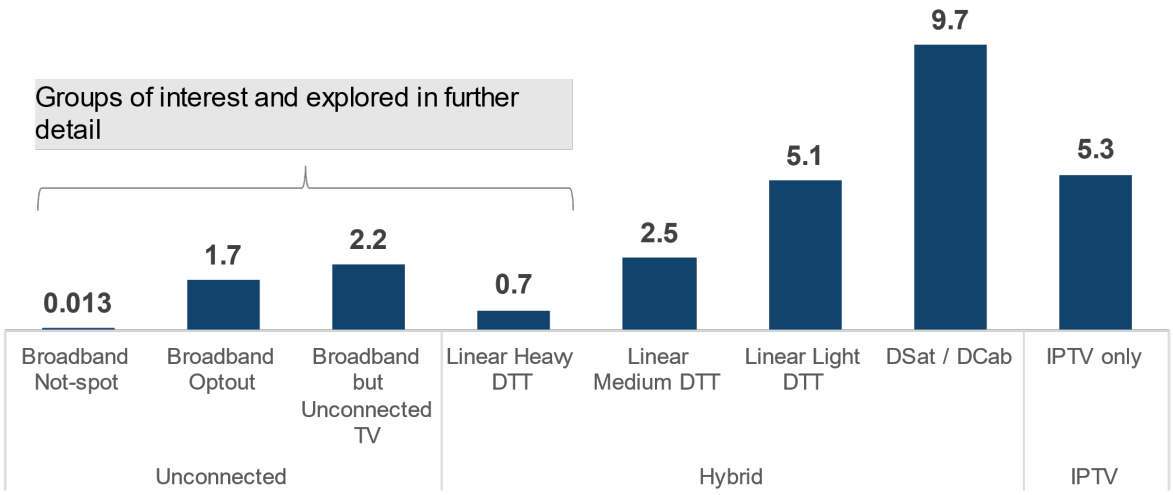
The following section analyses these groups in further detail, combining data from several sources:

- For the Unconnected TV groups, we have used data from 3 Reasons and demographic data from the Barb Establishment Survey.
- For the Linear Heavy group, we have used data from MTM's proprietary online viewing panel, ScreenThink.
- For more detail on our analytical approach, see Appendix A at the end of this report.

On aggregate, these groups have significant demographic commonalities: they are more likely to be older; of lower socioeconomic status; living in single-person homes; living in the North of England or in Scotland, Wales, and Northern Ireland; and to identify as being disabled.

We have also analysed data from the Routes to Content panel, part of the Ways of Watching project described above, which gives valuable further data about attitudes and viewing by different segments. While audience groups in this dataset are not directly comparable to those in the other datasets we use, the analysis still yields useful insights about the attitudes of audiences who rely more heavily on linear broadcast DTT.

Figure 20: Size of unconnected TV and DTT hybrid groups vs. other segments, 2023F (millions)



to the internet. We exclude the Linear Medium (40-80% linear viewing) and Linear Light (40% or less linear viewing) groups from our core analysis as these viewers are already watching substantial amounts of non-linear TV via IP.

Source: 3 Reasons

Figure 21: Key unconnected TV and linear-heavy groups

	1.Broadband Not-spot	2. Broadband Optout	3. Broadband but Unconnected TV	4. DTT Linear Heavy[16]
Description	DTT* homes in areas without any fixed-line broadband coverage or with broadband lines of <2 Mbps	DTT* homes without broadband access for reasons of affordability or choice	DTT* homes that have broadband access, but where the primary TV set is unconnected to the internet[17]	Individuals in DTT homes with a connected set whose viewing is 80%+ linear
Est. m homes	13k	1.7m (1.4m DTT, 0.3m DSat)	2.2m (1.8m DTT, 0.4m DSat)	0.7m
Age	93% 55+	92% 55+	55% 55+	64% 55+
Gender	54% female	55% female	53% female	50% female
SE Group	82% C2DE	79% C2DE	55% C2DE	48% have total HH income <£27k
Avg. HH size	1.2	1.2	1.8	35% live alone
% with disability	42%	41%	14%	*Data unavailable*

*And Freesat Source: 3 Reasons, ScreenThink

These groups overall account for c. 4.5 million, or 17% of TV households in 2023.

Demographic and geographic profile

The unconnected TV and linear heavy groups are clearly demographically and geographically distinct from the wider UK TV audience. Specifically, they are more likely to be significantly older, belong to lower socioeconomic bands, and to live in Scotland, the North-east of England, or the Midlands. They are also more likely to identify as White and to have a disability.

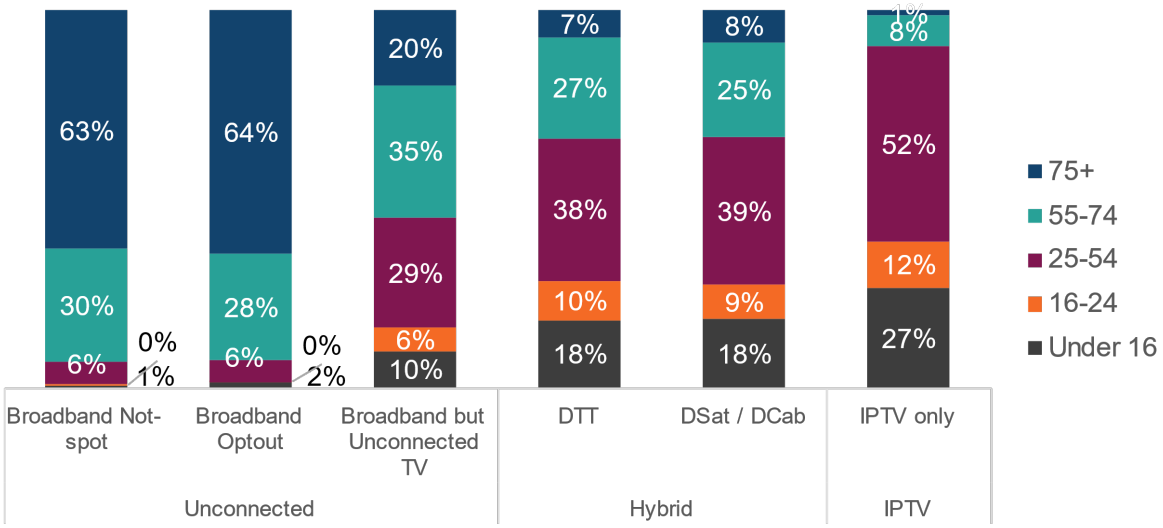
Age

Compared to more connected groups, the Unconnected TV groups are on average significantly older, with over 90% of those without a broadband connection older than 55.

[16] Some data for DTT Linear Heavy group is not available

[17] Based on data from the ScreenThink panel, we estimate that 14% of this group own a smart TV (i.e. connectable to the internet) that is not currently internet-connected. 25% own a streaming device that is not currently used to connect the primary TV set to the internet (and there may be some overlap between these homes and those with connectable TV sets). The remainder of this group owns a non-'smart' primary TV set that is not internet-connectable. While broadband-connected, about 30% of this group has broadband connections of 30Mbps or less, lower than industry consensus for IP streaming.

Figure 22: Age profile of Unconnected TV and DTT Hybrid groups vs. other segments, 2023

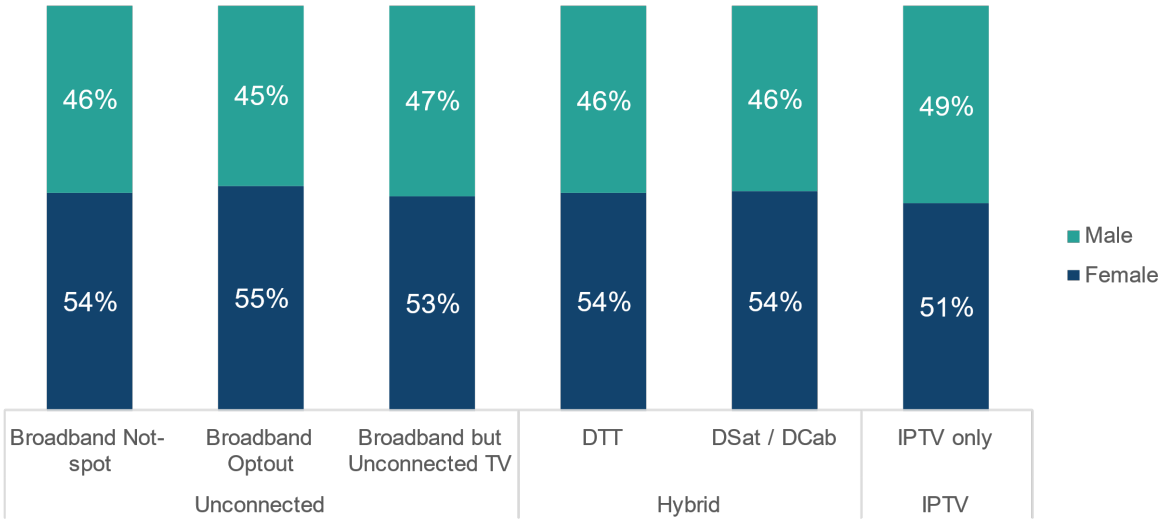


Source: 3 Reasons

Gender

The Unconnected TV and DTT Hybrid groups are somewhat more likely to identify as female than the IPTV only groups, likely at least partly to be driven by the older age profile of these homes.

Figure 23: Gender profile of Unconnected TV and DTT Hybrid groups vs. other segments, 2023

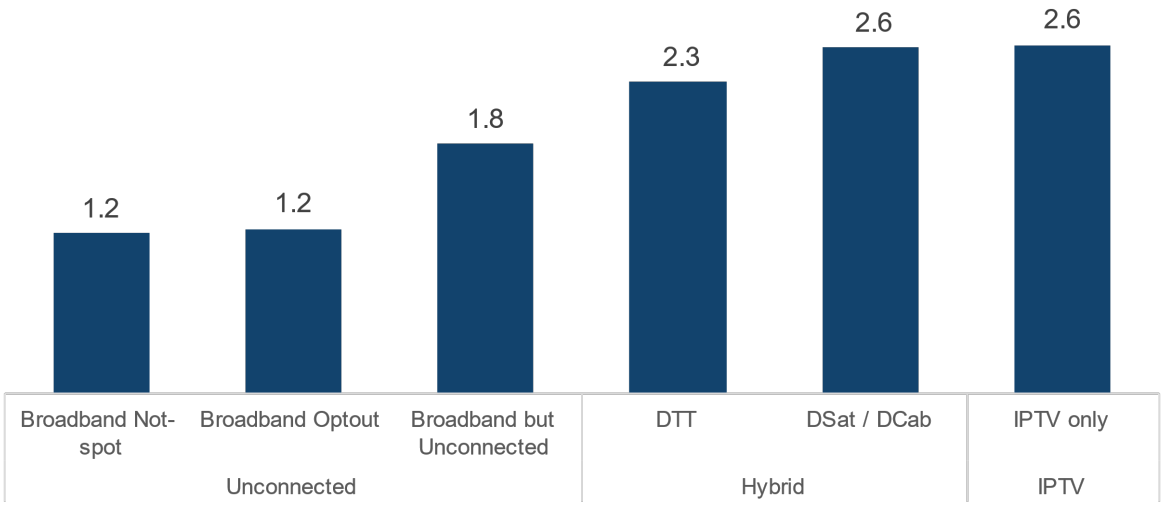


Source: 3 Reasons

Household size and life stage

Similarly, the Unconnected TV and DTT Hybrid groups tend to live in smaller households than the more connected groups, reflecting their more advanced age profile.

Figure 24: Average household size of Unconnected TV and DTT Hybrid groups vs. others, 2023

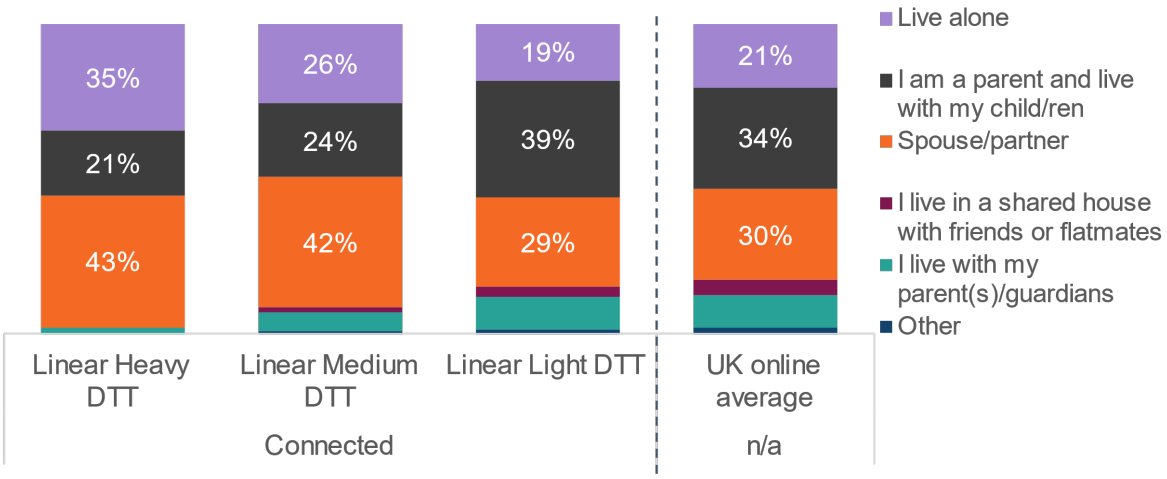


Source: 3 Reasons

Furthermore, ScreenThink data shows that those living in households reliant on DTT are more likely to be single occupancy: 35% of the Linear Heavy segments are people who live alone, significantly higher than the UK online average of 21%.[18]

[18] Unconnected TV group excluded from this view as MTM ScreenThink surveys internet users only.

Figure 25: Connected DTT viewing groups current life-stage, 2023

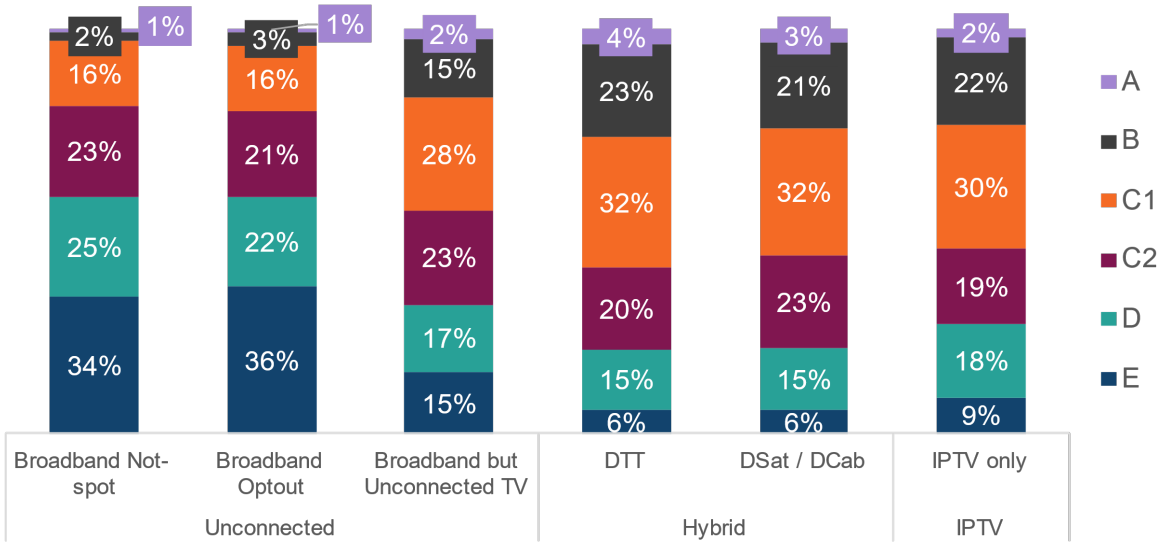


Source: MTM ScreenThink 2022/2023

Socioeconomic status and household income

These groups also tend to disproportionately belong to lower socioeconomic segments. C. 80% of groups with no broadband connection are within the C2DE bands, with the figure at c. 55% for the group with broadband but with unconnected TV sets.

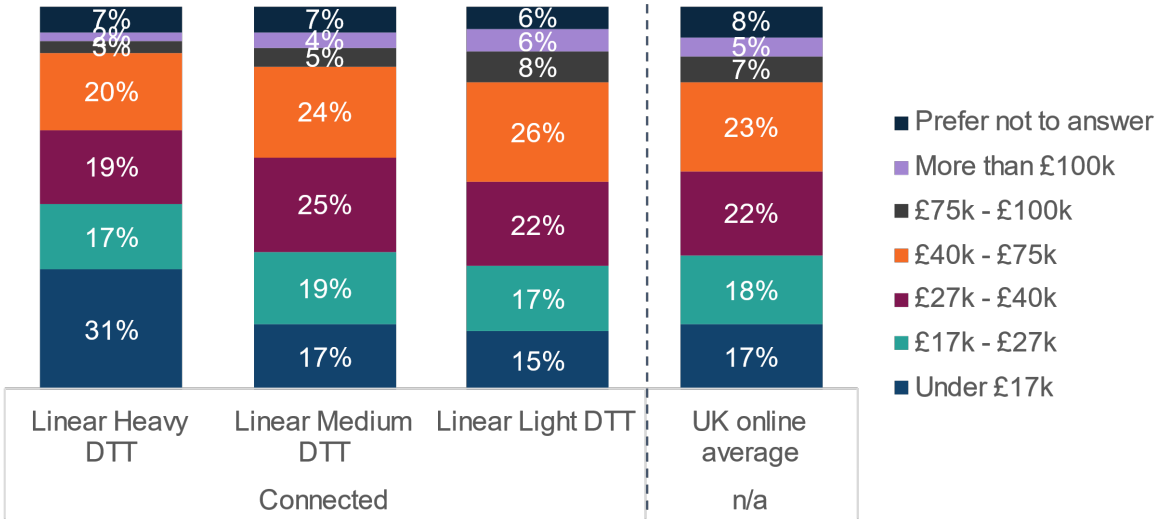
Figure 26: Socioeconomic profile of Unconnected TV and DTT Hybrid groups vs. other segments, 2023



Source: 3 Reasons

Likewise, ScreenThink data shows that the most heavily DTT-reliant viewing segments are overall economically worse off; 31% of Linear Heavy homes have a combined pre-tax household income below £17,000 per annum, compared to a UK average of 17%.

Figure 27: Connected DTT viewing groups household combined pre-tax income, 2023

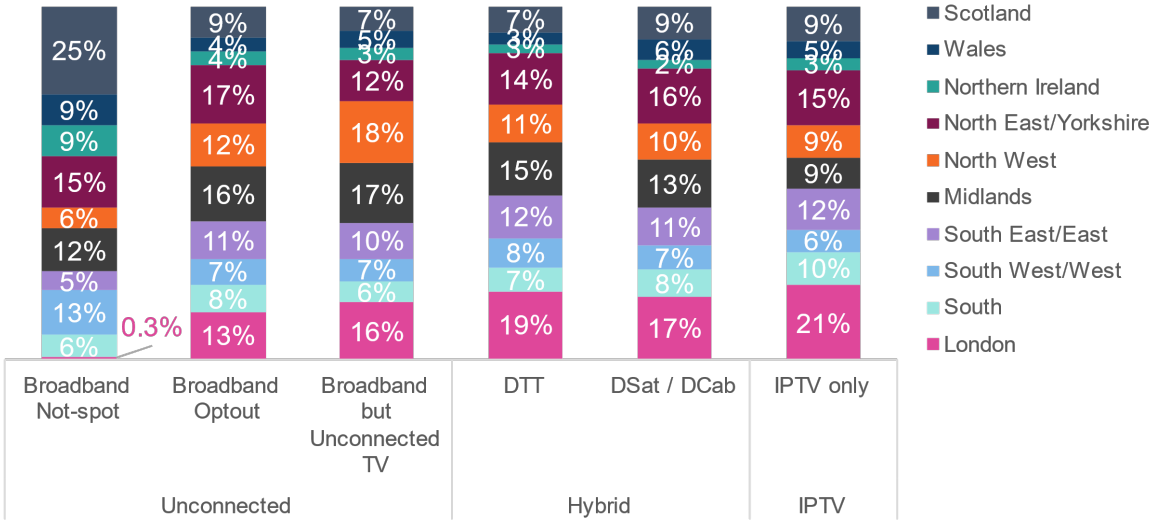


Source: MTM ScreenThink 2022/2023

Geographic distribution

These groups also tend to be disproportionately clustered in Scotland and the North of England than more connected TV viewers.

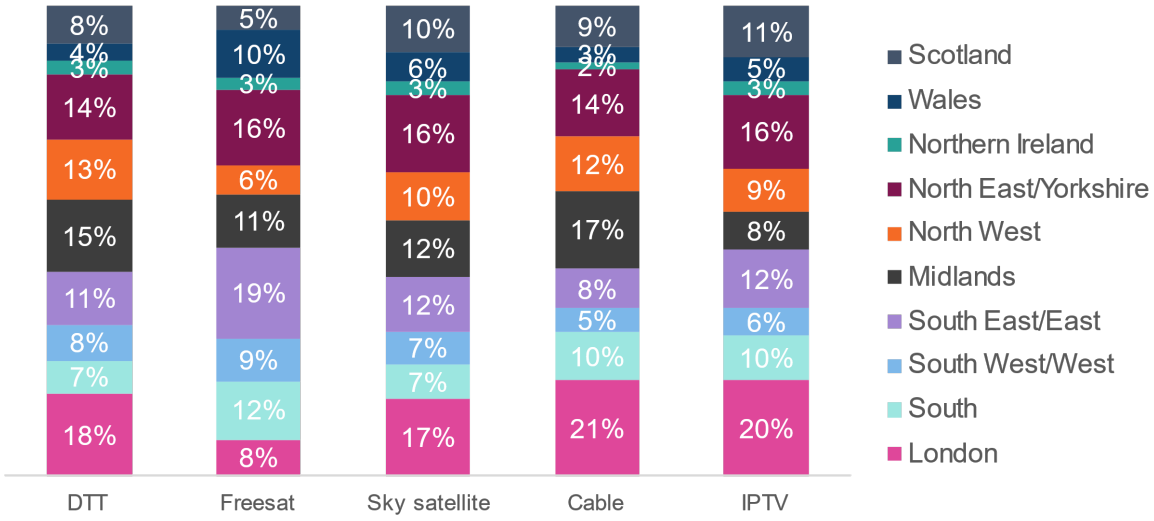
Figure 28: Geographic profile of Unconnected TV and DTT Hybrid groups vs. other segments, 2023



Source: 3 Reasons

Figure 29 shows the regional variation in primary set platform. Households with DTT as their primary set platform are spread across all UK regions, and are most likely to be located in London, the Midlands, the North West, and the North East/Yorkshire.

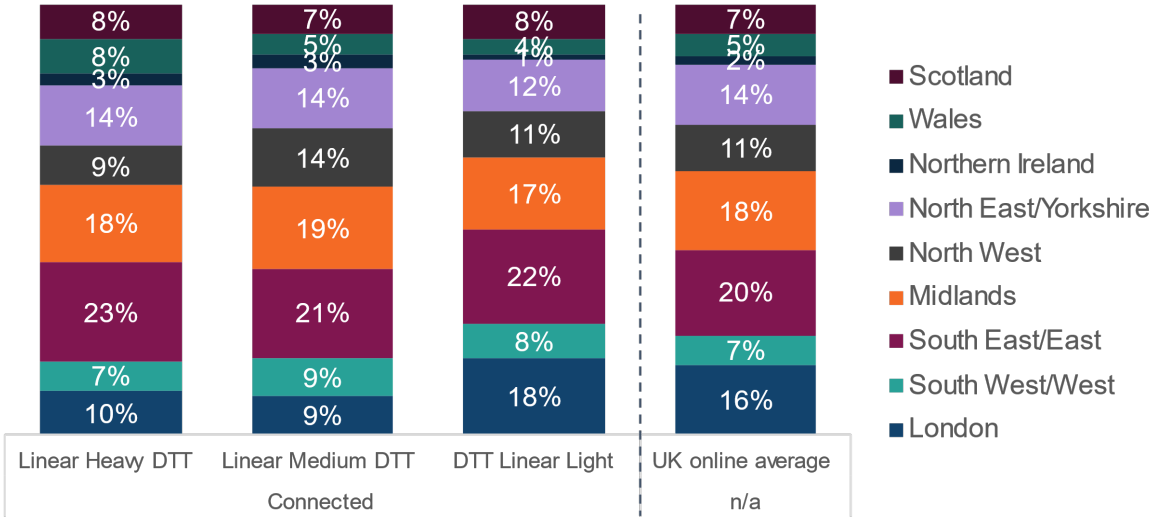
Figure 29: TV households by type of main set and region, 2023



Source: Barb, 3 Reasons

In the ScreenThink analysis, the Linear Heavy groups are also spread across all regions and devolved nations of the UK, and are less likely to be located in London relative to the rest of the UK online population.

Figure 30: Connected DTT viewing groups by region, 2023

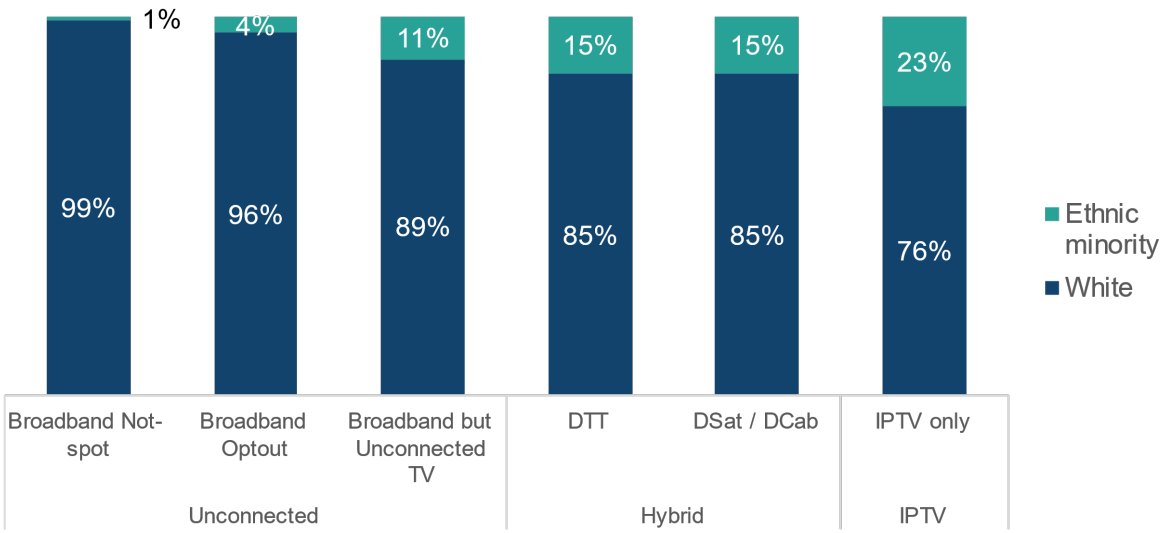


Source: MTM ScreenThink 2022/2023

Ethnicity

Unconnected TV and DTT Hybrid groups are more likely to identify as White than members of other groups.

Figure 31: Ethnic profile of Unconnected TV and DTT Hybrid groups vs. other segments, 2023

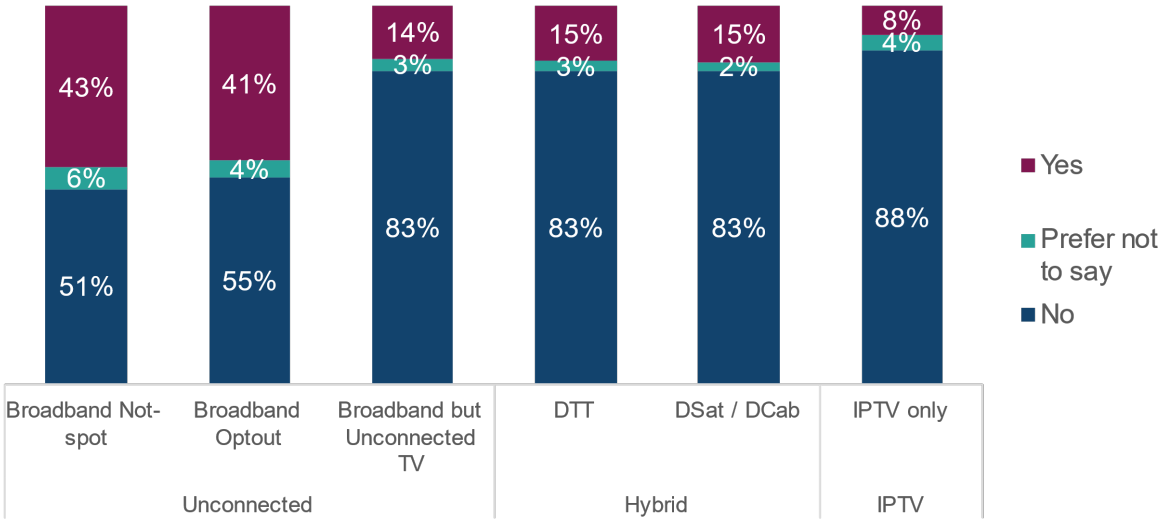


Source: 3 Reasons

Disability

Finally, Unconnected TV and DTT Hybrid groups are more likely to identify as having a long-term disability.

Figure 32: Long-term disability status among Unconnected TV and DTT Hybrid groups vs. other segments, 2023

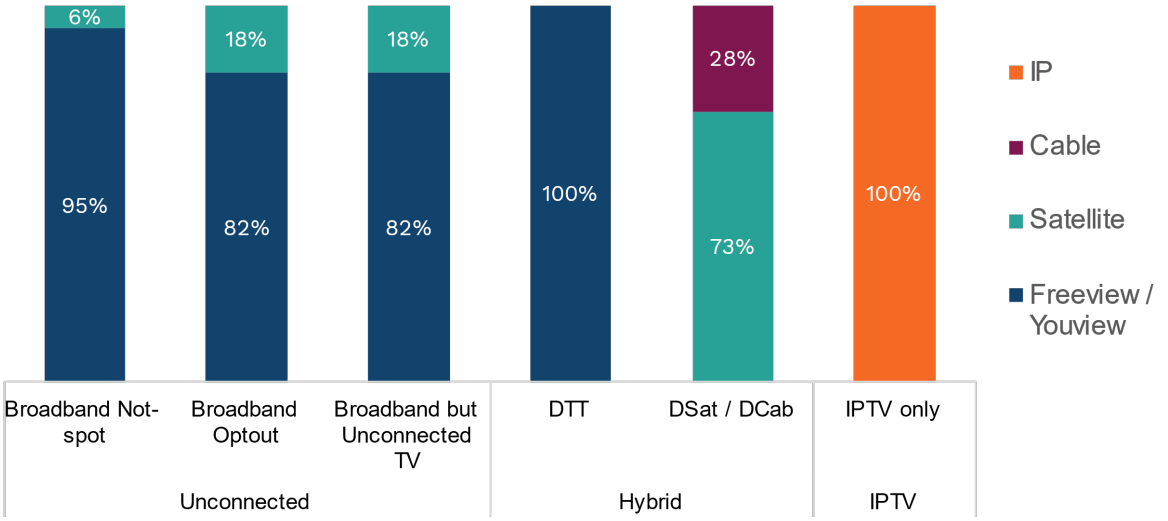


Source: 3 Reasons

Access to technology

By definition, these groups are far more likely to rely on DTT broadcast for the primary TV delivery than other groups.

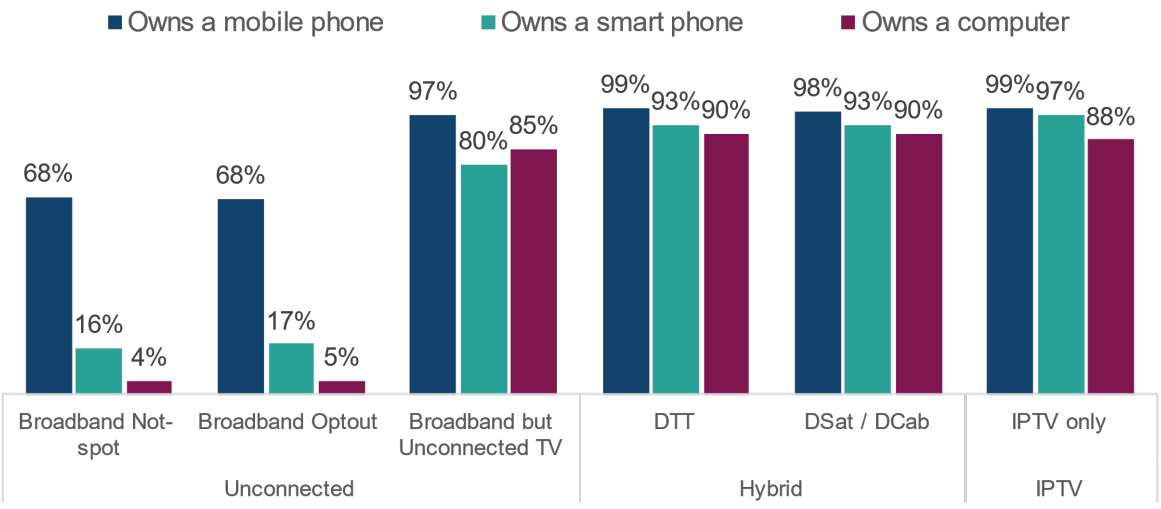
Figure 33: Primary TV platform, Unconnected TV and DTT Hybrid homes, %, 2023F



Source: 3 Reasons

However, in addition they are also less likely to own other communications and entertainment devices, including smartphones and home computers than more connected groups.

Figure 34: Access to key technologies among Unconnected TV and DTT Hybrid groups vs. other segments, 2023



Source: 3 Reasons

Viewing behaviour

The ScreenThink data allows us to understand the connected DTT viewing segments' attitudes towards TV, relative to the rest of the UK online population. With it, we explore three areas:

- IP and linear TV perceptions and usage
- Complexity of IP delivered services

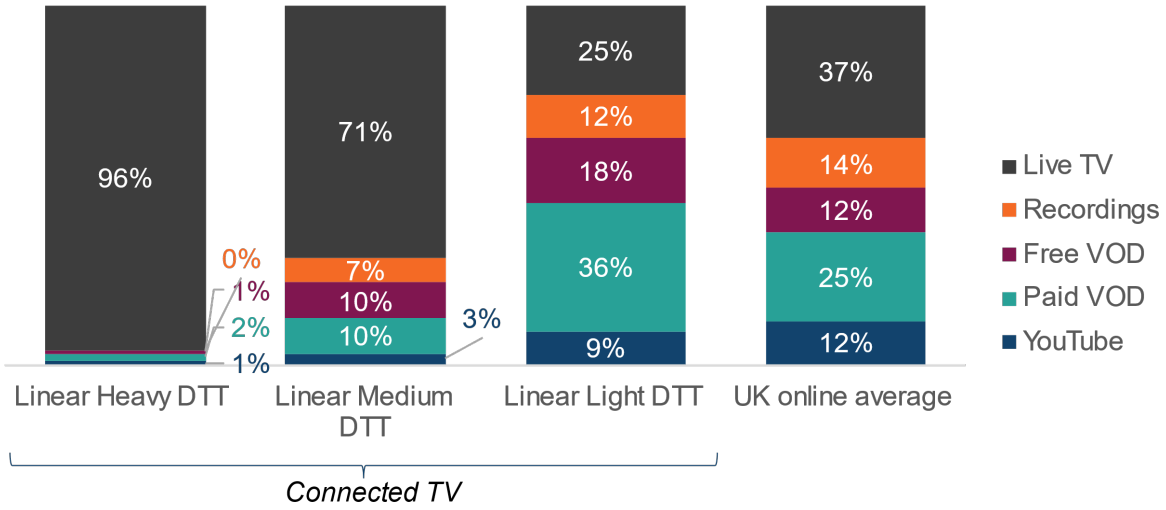
- User attitudes to SVOD service subscriptions

IP and linear TV perceptions and importance

96% of respondents in the Linear Heavy viewing segment state that they turn to live TV as their first destination when looking for something to watch. This is significantly higher than the UK online average of 37%.

In contrast, the Linear Light segment engages with a wider range of services and are most likely to turn to paid VOD services in the first instance.

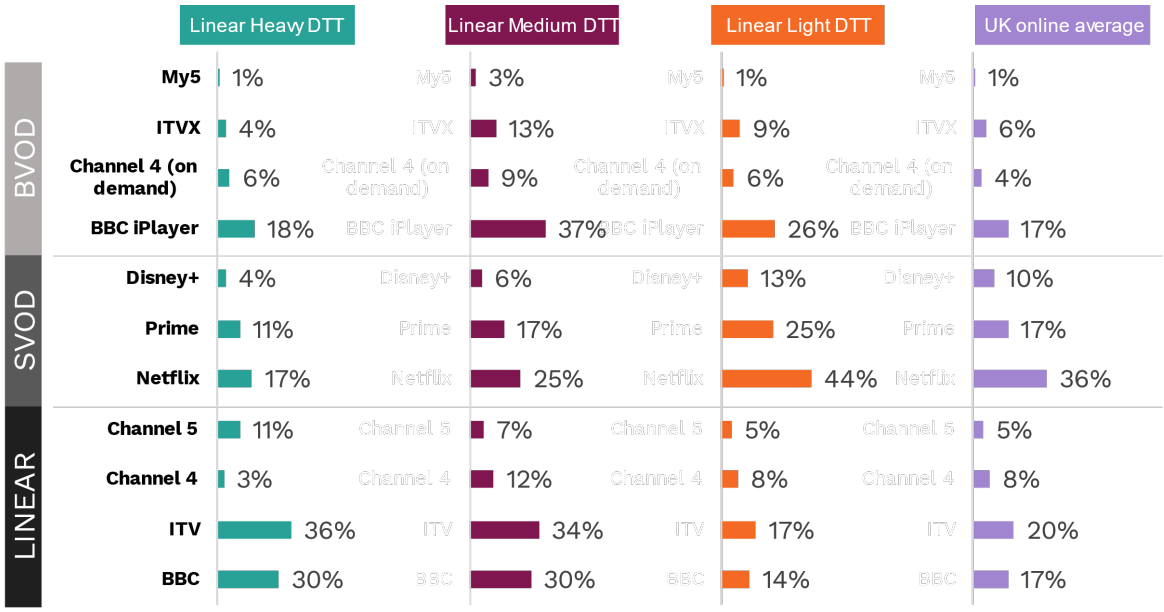
Figure 35: Unconnected TV and Hybrid DTT first destination when looking for something to watch, 2023



Source: MTM ScreenThink 2022/2023

ScreenThink allows us to see which channels, linear, BVOD and SVOD – UK users select in their "top 3 channels or services they could not live without". 36% of the Linear Heavy DTT segment put ITV linear channels in their top 3, whilst 30% do the same for BBC linear channels.

Figure 36: Unconnected TV and Hybrid DTT, top 3 channels they could not live without, 2023

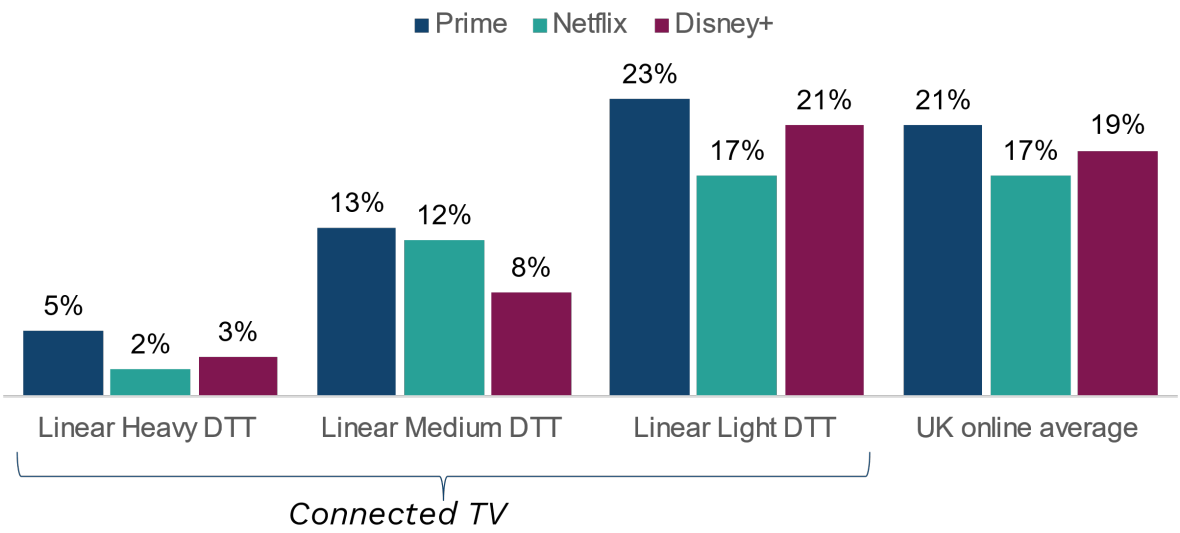


Source: MTM ScreenThink 2022/2023

User attitudes to SVOD service subscriptions

The Unconnected TV and Linear Heavy connected segments are much less likely to be intent on signing up to one of the 'big 3'[19] SVOD service in the next 6 months, suggesting their viewing habits are relatively stable.

Figure 37: Unconnected TV and Hybrid DTT household, likelihood of signing up to SVOD services in the next 6 months, net % likely, 2023



Source: MTM ScreenThink 2022/2023

[19] Netflix, Amazon Prime Video, Disney+

Attitudes to TV – "Routes to Content" panel data

From the research presented above, it is clear that each of these groups is likely to have a different relationship with TV than more IP-connected and IP-reliant groups.

The Routes to Content (R2C) project, funded by the University of Huddersfield and the Screen Industries Growth Network, is a comprehensive look at attitudinal and behavioural factors related to TV consumption, based on reported viewing behaviour. The data is based on a survey consisting of computer-assisted self-interviews of a representative sample of 1,495 people in the UK conducted in May 2021.[20] While the groups studied in the Routes to Content work do not exactly match those defined above, a number of relevant insights can be drawn from the research that illuminates the attitudes of unconnected TV and linear heavy groups.

Analysis of the R2C panel data reveals two groups broadly similar to the Unconnected TV and Linear Heavy groups discussed above. We have identified an R2C 'Unconnected TV' group as those with DTT but no connected TV or TV streaming device (though they may watch video on other devices), while we have identified an R2C 'Linear Heavy' group as those who have a connected TV and watch DTT 'most of the time' but who do not use VOD. While these groups are relatively small in the overall panel (26 and 56 individuals, respectively, of a total sample of 1495), a comparison yields some statistically significant insights.

The data suggests that these groups are more reliant on linear TV (and to a lesser extent BVOD) than other groups, and that they rate it as better value. However, they are more likely to watch TV as a solitary experience with less social interaction, and potentially to have a different emotional connection with it, than other groups.

- Demographically, the Unconnected TV and Linear Heavy groups are on average significantly older than the sample at large, at 57 and 59 years respectively compared to 47 for the total. These groups are also less wealthy than the average, with average incomes of £32k and £28k vs. the total sample average of £41k. They are also more likely to live alone than the average.
- The Unconnected TV and Linear Heavy groups spend more time watching free linear TV services than the whole sample average (229 and 245 minutes per day that that they use the service, vs. a panel average of 207 minutes). In contrast, their consumption of SVOD services is significantly lower, but BVOD usage is relatively indistinguishable from the sample average. In terms of channel preferences, these groups are heavier users of BBC and ITV linear channels than the average.
- They are significantly more likely to *know what they will watch before turning on their TV* or device 'most or all of the time' (77% and 75% respectively vs. an average of 55%).

[20] Johnson, Catherine, et al. *Routes to Content* (2023), University of Leeds: https://ahc.leeds.ac.uk/media-industries-cultural-production/dir-record/research-projects/1840/routes-to-content (last accessed 3rd May 2024)

- They are more likely to rate Free Linear TV and BVOD positively for perceptions of *quality*, *diversity of content* and *value for money* than other types of TV content (Pay TV, SVOD, user-generated content); these ratings are also higher than for the panel average. They are also more likely to agree with the importance of public funding for TV.
- Additional data suggests that these groups are more likely to watch TV as a solitary experience and to have less social interaction around it. They are less likely to 'talk abo*ut TV with othe*rs' (27% and 25% vs. 57%) than the average viewer and are less likely to have '*made social contact'* through an interest in TV. They are also more likely to *watch TV alone* than other groups.
- Emotionally, they are also less likely to feel '*happy'*, '*surprised', or 'comforted'* while watching TV than the average viewer, while members of the Unconnected DTT group are more likely to feel '*critical about the way in which the world works'*. On average, they are more likely to see an important function of TV as *informing and educating.*

1.4 Barriers and enablers of DTT use and IP uptake for Unconnected TV and Linear-Heavy groups

This section outlines the barriers and enablers facing viewers in unconnected TV homes in the shift from broadcast to IP-delivered TV services. These include the cost and affordability of broadband and TV equipment, perceptions of complexity of switching to new equipment and navigating more advanced user interfaces, and satisfaction with the content available on linear broadcast channels. These are particularly important for people in the groups we identified above, who tend to be older, less wealthy, and less digitally confident.

While these represent significant challenges in the shift to IP-delivered TV services, Section 1.5, below, sets out how these barriers are likely to evolve to 2040 and what the impact is likely to be on the unconnected TV audience groups.

Key barriers

Fundamentally, there are four key requirements for accessing IP-delivered TV services.

- A broadband connection to the home. While 10Mbps is considered an acceptable standard for watching 5SD streams,[21] industry consensus is that 30Mbps is a minimum for reliable delivery of video streaming over IP.[22]
- A TV set connected to the internet. This could be either through a connected smart TV with an integrated DTT tuner, through a set-top box (STB), or through a connected device from e.g. Google, Apple, or Amazon.

[21] Enders Analysis, *Leading the UK into Digital* (2022), 12.

[22] Ofcom, *Connected Nations* (2023); House of Lords, *Digital Exclusion* (2023); Enders Analysis, *Leading the UK into Digital* (2022); EY, *TV Distribution After 2034* (2024).

- A user-friendly user interface, enabling access to the range of channels and services available. This can take the shape of an EPG (electronic programme-guide) with a channel schedule matrix, a 'canvas' displaying a range of apps corresponding to VOD and other services, or a hybrid of the two.
- Finally, a range of attractive content is a key requirement, whether linear channels and/or a set of VOD services, enabling an appealing user experience of the service.

Each of these has a corresponding set of potential barriers, falling into several categories:

- Cost and affordability of technology and new services (e.g. broadband, a new TV set or streaming device, or SVOD subscription).
- Complexity of switching to new technology, particularly for consumers with limited digital skills or confidence, or disabilities.
- Complexity of operating IP-enabled – as opposed to linear broadcast – technology and user interfaces; again, digital skills are a critical issue here.
- Satisfaction with existing linear broadcast content and services and, conversely, relative perceived value of IP content.

Figure 38: Potential enablers and barriers of update of IP-enabled TV services

	Broadband →	Connected TV/device →	UI/EPG →	Content
Key requirements / enablers	• Broadband coverage • Speed >30MBps	• IP-enabled TV or device • Device connected to internet	• EPG/canvas/apps etc • Sufficiently usable in enabling access to/discovery of IP-delivered content	• Attractive IP-delivered content selection • Range of channels • Range of VOD content
Key barriers - examples	• Lack of coverage • Slow speed • Poor reliability/downtime vs DTT • High price	• High switching cost/purchase price • Perceived complexity of connecting device	• Perceived complexity of navigating IP-delivered content UI vs linear DTT EPG	• Satisfaction with DTT linear content • Perceived low incremental value of IP-delivered content selection vs linear content

Source: MTM

Among the groups under scrutiny, these barriers are likely to be particularly significant given their demographic composition – many of the barriers correlate with older age, relative poverty, and disability, which often overlap.

- The Broadband Not-spot group is very small compared to the others, and is deprived of decent broadband by a lack of coverage, mainly to more remote areas. Its demographic composition (older and less wealthy) also suggests that acquiring and connecting an IP-enabled TV set may be a further barrier.
- The Broadband Optout group is defined by its lack of broadband access despite living in areas of broadband coverage. Given its demographics (older and less wealthy), this group is most likely to be affected by issues of broadband affordability and by perceptions of broadband irrelevance or complexity. Members of this group are also likely to find challenges in connecting their TV sets to the internet, and in navigating more complex or unfamiliar user interfaces and EPGs.
- The Broadband but Unconnected TV group is defined by having a broadband connection but an unconnected TV set. For this group, which again is somewhat older than the rest of the TV audience, the affordability of new internet-connectable TV sets and/or streaming devices is likely to play a role. The complexity around connecting this equipment and navigating more advanced user interfaces is also likely to be important. Also likely to be significant is the perceived lack of interest in the range of content enabled by an IP connection and a continued satisfaction with linear broadcast content.
- Finally, the DTT Hybrid Linear Heavy group, while having access to internet-connected TV sets, choose primarily to watch broadcast linear TV. For this group, which skews significantly older than the audience at large, the main barriers are likely to be a lack of interest in IP-enabled content, particularly VOD, and also potentially the complexity of navigating IP user interfaces.

While a forensic analysis of the precise importance of the barriers for each group is not possible in the absence of further research, the table below sets out the indicative significance of each barrier for each group, based on the research laid out in the rest of this section.

Figure 39: Indicative relative importance of barriers for IP-delivered TV take-up for key subgroups

Barrier	Issues	Key subgroups			
		Broadband Not-spot	Broadband Optout	Broadband but Unconnected TV	DTT Hybrid Linear Heavy
Broadband	• Coverage • Affordability • Perceived complexity • Perceived lack of necessity • Reliability issues	●	●	○	○

Barrier	Issues	Key subgroups			
		Broadband Not-spot	Broadband Optout	Broadband but Unconnected TV	DTT Hybrid Linear Heavy
Connected TV/device	• Affordability • Perceived complexity				
UI/EPG	• Perceived complexity • Satisfaction with traditional EPGs				
Content/UX	• Satisfaction with linear broadcast content • Perceived low value of IP-delivered content				

Full circle: Important barrier Empty circle: Insignificant barrier Source: MTM

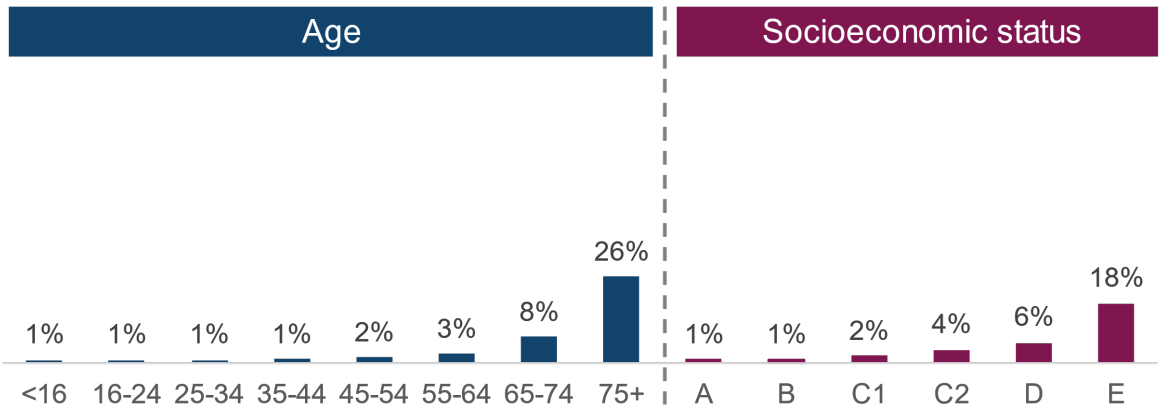
Broadband

Broadband is a key enabler for access to IP-delivered video services. Our broadband modelling, based on 3 Reasons' data and informed by analysis of Barb and Ofcom reporting, estimates 2023 fixed-line broadband penetration at c. 87.7% of all homes, of which c. 93% are superfast (i.e. 30Mbps or above). VOD-capable mobile broadband (i.e. broadband delivered over a mobile network like a 5G home hub, and of sufficient speed to enable video streaming to a TV set) is present in a further 3% of homes, for a total superfast broadband penetration of c. 84.6%.

Some demographics are more likely than others to not have internet access at home: older people (65+), financially vulnerable individuals, single person households, individuals with disabilities, and those not working.[23] While an estimated 4% of people 16-54 have no home internet access, 26% of people 75+ do not. Understanding this segment through a different lens, an estimated 75% of those without internet are aged 65+.[24] Similarly, 6% people in the D, and 18% in the E socioeconomic group are without home internet, compared to 2% of individuals in the ABC1 groups.

[23] House of Lords, *Digital Exclusion* (2023), pp. 10-11; Ofcom, *Digital Exclusion* (2022), pp. 8-9.
[24] BT, *Digital Inclusion: new insights and finding a sustainable way forward* (2023), pp. 42-43.

Figure 40: People without internet access at home, split by age and SE group 2022
%



Source: 3 Reasons/Barb

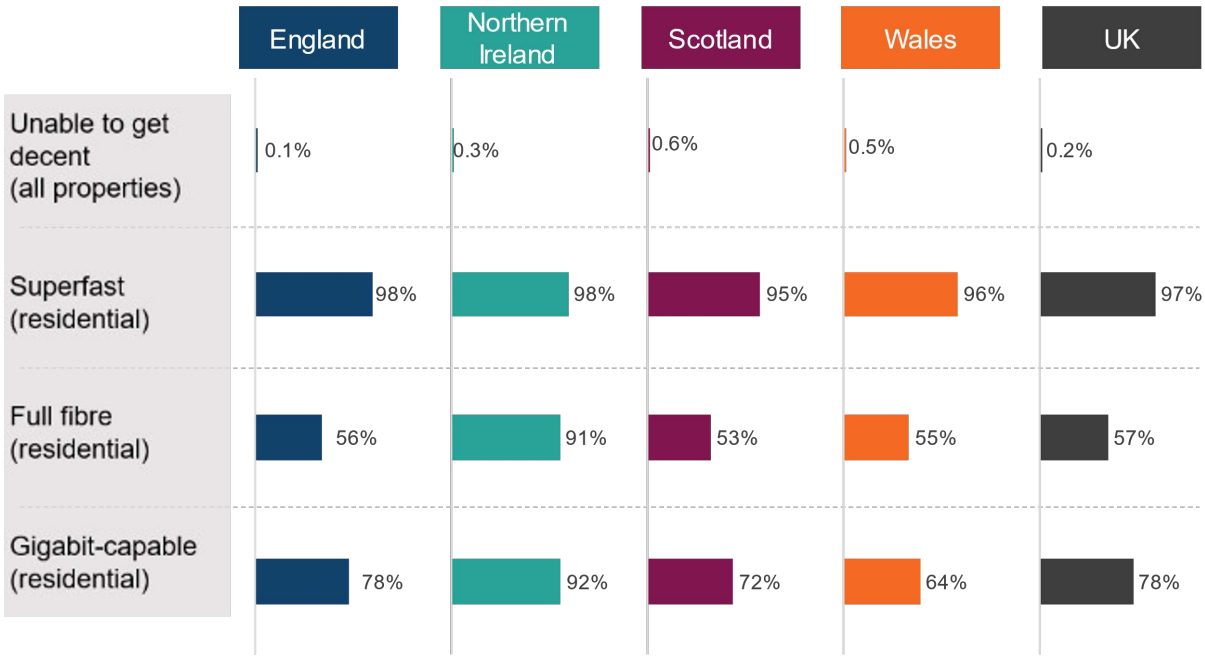
Coverage

While most UK homes are in areas covered by high-speed broadband, there are still gaps in coverage of lines with speeds at or above 30Mbps (required for a robust IP-delivered TV service). Some individuals are unable to access broadband because they live in areas with no or limited broadband coverage, though this is changing rapidly as broadband rollout continues across the UK. While lack of broadband coverage is not a widespread barrier, there are still hundreds of thousands of homes in this category.

- Overall fixed-line broadband coverage (i.e. premises in an area served by any broadband) has increased significantly over recent years, reaching c. 97% across the UK by late 2023 for “superfast” broadband (30 Mbps or above).[25]
- This means that c. 3%, or c. 850,000 households, do not yet have access to fast broadband of sufficient speed to deliver IP-enabled video reliably to a TV.

[25] https://www.ofcom.org.uk/__data/assets/pdf_file/0022/273721/connected-nations-2023-uk.pdf

Figure 41: Broadband coverage at a fixed location across the UK %



Source: Ofcom, Connected Nations (2023)

- Furthermore, 0.2% of households (c. 61,000) do not have access to a "decent broadband connection," defined as connections that provide at least 10Mbps download speed and 1Mbps upload speed, from either fixed or fixed wireless access network.[26] This figure has fallen by approximately 18,000 households from 2022, and Ofcom estimates that the number of premises without access to decent broadband in September 2024 will fall to approximately 50,000, due to take-up of publicly funded schemes.[27]
- Poor broadband accessibility tends to affect those in rural regions more,[28] and broadband coverage is poorer in regions such as Scotland, Northern Ireland, South-west England, and Wales.[29] But broadband accessibility does not only affect those in rural regions, and connectivity issues can be experienced by those in higher density areas, such as basement flats or large houses.[30]

[26] Ofcom, *Connected Nations* (2023), pp. 4, 22.
[27] Ofcom, *Connected Nations* (2023), 22.
[28] Ofcom, *Digital Exclusion* (2022), 18. https://www.ofcom.org.uk/siteassets/resources/documents/research-and-data/media-literacy-research/adults/adults-media-use-and-attitudes-2022/digital-exclusion-review-2022.pdf?v=327651 (last accessed Nov 6th 2024)
[29] EY, *TV Distribution after 2034* (2024), 4; House of Lords, *Digital Exclusion* (2023), 11.
[30] Ofcom, *Digital Exclusion* (2022), 18.

Figure 42: Residential superfast coverage by nation, September 2023

	Total	Urban	Rural
England	98%	99%	89%
Northern Ireland	98%	99%+	93%
Scotland	95%	99%	79%
Wales	96%	99%	86%
UK	97%	99%	88%

Source: Ofcom Connected Nations 2023

Affordability

Broadband is relatively expensive for people in lower socioeconomic groups, and affordability can be a significant barrier. Current average monthly broadband costs in the UK are £26.90,[31] or £322.80 per year. Research published by BT in 2023 found that 1 million individuals eligible for social tariffs live in low-income households that cannot afford any connectivity, even with social tariffs applied.[32]

- Ofcom research in 2022 found that an estimated 100,000 households in the UK cite cost as the reason for not having internet access.[33] Among UK individuals without internet access at home, 23% cited costs specifically related to broadband.[34] The burden of these costs were felt especially by those in the most internet-deprived groups; 31% of individuals in socioeconomic grade DE cited broadband costs as a barrier to their internet access.[35]
- In research conducted for Ofcom in 2023, cost-related issues were among the top reasons cited for why people were not planning on getting internet access at home in the next 12 months: 18% cited broadband setup costs that were too high, 13% cited monthly costs of a broadband subscription, 11% cited the cost of a desktop, tablet, or laptop computer, and 10% the cost of a mobile phone for using the internet.[36]

[31] Max Beckett. *UK broadband statistics 2024* (2024) Uswitch. https://www.uswitch.com/broadband/studies/broadband-statistics/ (last accessed 13th August 2024)
[32] BT, *Digital Inclusion: new insights and finding a sustainable way forward* (2023), 10. https://newsroom.bt.com/download/48887a73-c09a-47fd-81a7-4a10330d830b/3952-btgroup-costoflivingevidence-a4-digitalv5.pdf (last accessed Nov 6th 2024)
[33] Ofcom, *Digital Exclusion* (2022), 5.
[34] Ofcom, *Online Nations* (2023), 15. https://www.ofcom.org.uk/siteassets/resources/documents/research-and-data/online-research/online-nation/2023/online-nation-2023-report.pdf?v=368355 (last accessed Nov 6th 2024)
[35] Ofcom, *Online Nations* (2023), 15.
[36] Ofcom, *Communications Market Report* (2023), interactive data. https://www.ofcom.org.uk/phones-and-broadband/service-quality/communications-market-report-2023-interactive-data/ (last accessed Nov 6th 2024)

- In their 2023 Digital Inclusion report, Enders Analysis and BT found that an estimated 1-4% of all UK households were digitally excluded or at risk of digital exclusion because of cost reasons.[37] Enders Analysis found that a maximum of about 1% of all UK households do not have internet access due to cost reasons.[38]
- Broadband affordability is also an ongoing issue for some current subscribers; people in an estimated 2.4 million UK homes with fixed broadband stated difficulty with affording their fixed broadband service.[39] These households are at risk of modifying or cancelling their broadband service in the future.[40] Additionally, an estimated 1 million individuals in the UK have had to cut back or cancel current internet packages in 2023 because of affordability issues.[41]
- As of January 2023, 6% of households (around 1.4 million households +/- 400,000) with fixed broadband found it difficult to afford the service.[42] Households that received benefits (11%) and households that were categorised as "potentially financially vulnerable" (12%) were most likely to experience affordability issues with their fixed broadband.[43]
- As of 2023, broadband social tariffs are available to an estimated 4.3 million UK households but have currently only been taken up by 220,000 homes. Savings from social tariffs available on the market in 2023 ranged from 12% to 29% versus the cheapest commercially available tariff, depending on the broadband provider.[44] Though the availability of social tariffs for broadband has improved over the past 18 months, a majority of households eligible for social tariffs are unaware or do not use these programmes.[45] 42% of eligible customers also believe that cheaper broadband packages provide less reliable and lower quality broadband, presenting a key barrier for social tariff take up.[46] Additionally, the limited choices for bundled TV services within social tariff packages presents another barrier for eligible consumers.[47] For homes without any broadband service, additional barriers to taking up social tariffs include perceptions that broadband is an unnecessary entertainment service, reluctance to hand over bank details, and issues with English as a non-native language.[48]

[37] BT, *Digital Inclusion: new insights and finding a sustainable way forward* (2023), 40.
[38] BT, *Digital Inclusion: new insights and finding a sustainable way forward* (2023), 41.
[39] Ofcom, *Online Nations* (2023), 15; Ofcom, *Technology Tracker* (2023).
[40] Ofcom, *Online Nations* (2023), 15.
[41] House of Lords, *Digital Exclusion* (2023), 6.
[42] Ofcom, *Affordability of Communication Services: April 2023 Update* (2023), 4.
[43] Ofcom, *Affordability of Communication Services: April 2023 Update* (2023), 8.
[44] BT, *Digital Inclusion: new insights and finding a sustainable way forward* (2023), 23-24.
[45] Ofcom, *Affordability of Communication Services: April 2023 Update* (2023), 4, 10.
[46] BT, *Digital Inclusion: new insights and finding a sustainable way forward* (2023), 26.
[47] BT, *Digital Inclusion: new insights and finding a sustainable way forward* (2023), 49.
[48] BT, *Digital Inclusion: new insights and finding a sustainable way forward* (2023), 28

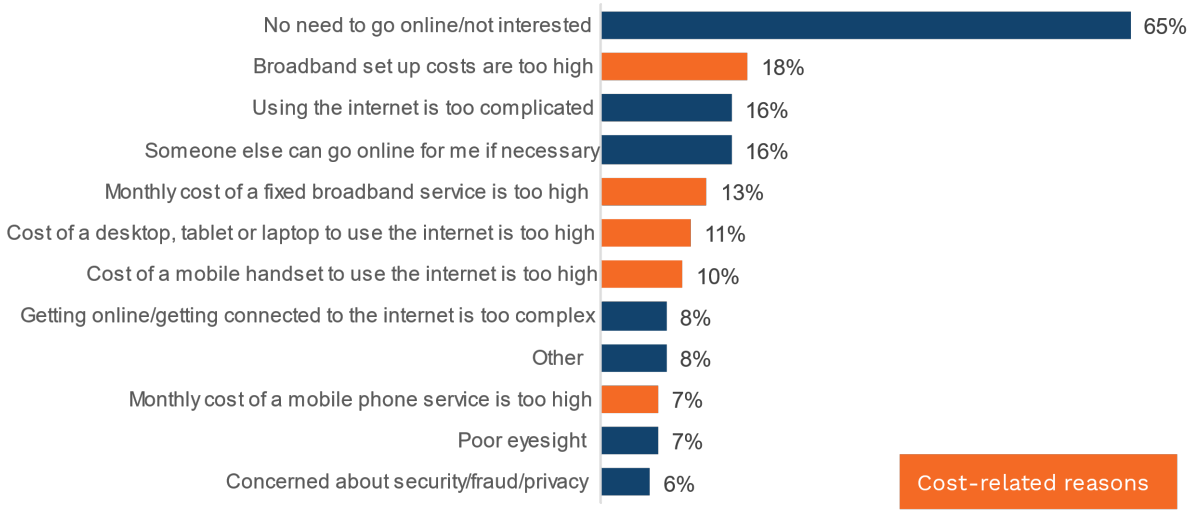
- However, some households (19% of UK households with family income of less than £20,000) are already paying under £20 per month for broadband, meeting Ofcom's 'social tariff' price standards without the official 'social tariff' label.[49]

Lack of interest, perceived complexity, lack of skills, and disability

A number of other reasons have also been cited for individuals not using the internet, or broadband, at home, including a lack of interest, excessive complexity, and lack of skills. Echoing findings in other research, such users are disproportionately likely to be older.

- A lack of interest in or need for the internet was cited as the top reason (45% of respondents) for not planning to get internet access at home in a 2023 Ofcom survey. 16% also responded that 'someone else can go online for me if necessary'.[50] Similarly, in another survey, 65% of people without internet access at home cited a lack of interest or need as their reason for not taking up any broadband connection.[51]

Figure 43: Reasons for not getting internet access at home in the next 12 months, %, 2023 [52]



Source: Ofcom Technology Tracker Survey 2023

- Perceptions of complexity of setting up or using broadband were also cited, with 16% stating that 'Using the internet is too complicated'.[53]

[49] BT, *Digital Inclusion: new insights and finding a sustainable way forward* (2023), 25, 49.
[50] Ofcom, Communications Market Report (2023), interactive data.
[51] Ofcom, *Online Nations* (2023), 15.
[52] Ofcom Technology Tracker (2023) QE16: Which of these are reasons why you are unlikely to get internet access at home in the next 12 months? All respondents aged 16+. Answers with lowest percentages of agreement from respondents are excluded from chart: *Broadband is too slow where I live, Concerned about harmful/offensive content, Don't have broadband where I live, Don't know.*
[53] Ofcom, Communications Market Report (2023), interactive data.

- Other reasons cited (by less than 10% of respondents each) include disability (including poor eyesight) and concerns about fraud and privacy and harmful or offensive content.[54]
- Research done for the 2023 Lloyd's Consumer Digital Index indicated that older audiences are more likely to be "offline" individuals because of personal choice, affordability, and limited access to services and devices.[55] A report commissioned by BT and AbilityNet supported these findings, noting that 90% of those not online were aged 55+.[56]
- These findings are also supported by research commissioned by Silver Voices, which found that some audiences felt they lacked the digital skills to access online services and television. 77% of individuals surveyed thought the internet was 'too late to learn' and 68% found it 'difficult to learn'. 45% of individuals with a disability reported difficulty in learning the right skills for the internet.[57]
- Among individuals with internet access, 8% reported a lack of confidence in using the internet.[58] For individuals without internet access at home, 26% cited complications with getting online or using the internet as their barrier to access.[59] These complications were the second most cited barrier, behind a lack of interest or need in going online.[60]
- The Lloyds Consumer Digital Index suggests individuals with disabilities are twice as likely to lack the basic digital skills needed to navigate life online.[61]
- Findings from BT's and AbilityNet's Digital Inclusion report also identify disabled individuals as being more likely to be offline.[62] Research demonstrates that individuals with disabilities are more impacted by the digital divide. ONS data

[54] Ofcom, Communications Market Report (2023), interactive data.
[55] Lloyds, 2023 *Consumer Digital Index* (2023), 17. https://www.lloydsbank.com/assets/media/pdfs/banking_with_us/whats-happening/231122-lloyds-consumer-digital-index-2023-report.pdf (last accessed Nov 6th 2024)
[56] BT, *Digital Inclusion: new insights and finding a sustainable way forward* (2023), 31.
[57] Silver Voices, *Safeguarding Universality: the Future of Broadcast TV and Radio* (2022), 25-26. https://drive.google.com/file/d/13AuyjLc9ivb8Pb9wPjeZmGMtqsNoeqkK/view (last accessed Nov 6th 2024)
[58] Ofcom, *Digital Exclusion: a review of Ofcom's research on digital exclusion* (2022), 7.
[59] Ofcom, *Adults' Media Use and Attitudes 2023: interactive report* (2023). https://www.ofcom.org.uk/research-and-data/media-literacy-research/adults/adults-media-use-and-attitudes/adults-media-use-and-attitudes-2023-interactive-report (last accessed Nov 6th 2024)
[60] Ofcom, *Adults' Media Use and Attitudes 2023: interactive report* (2023). [https://www.ofcom.org.uk/research-and-data/media-literacy-research/adults/adults-media-use-and-attitudes/adults-media-use-and-attitudes-2023-interactive-report]
[61] Lloyds, *2022 Consumer Digital Index* (2022), 40. https://www.lloydsbank.com/assets/media/pdfs/banking_with_us/whats-happening/221103-lloyds-consumer-digital-index-2022-report.pdf (last accessed Nov 6th 2024)
[62] BT, *Digital Inclusion: new insights and finding a sustainable way forward* (2023), pp. 31-32.

from 2019 indicates that 56% of adults who did not use the internet were disabled.[63]

Broadband reliability issues

Broadband has a greater number of points of failure in its delivery chain than DTT, and also less end-to-end management. As a result, it is prone to sporadic delivery issues. It may also result in delivery latency (lag) when watching live events via IP networks. As a result, some customers may perceive broadband and IP-enabled delivery of video as less reliable than a DTT signal through an aerial.

- Broadband is more likely to suffer outages than broadcast TV. According to Ofcom, the proportion of broadband subscribers experiencing at least one daily disconnection of at least 30 seconds in March 2023 was c. 6% for customers with 63-67 Mbps Fibre-to-the-Cabinet (FTTC) connections, 2% for 264 Mbps cable connections, and c. 5% for 145-160 Mbps Full Fibre connections.[64] In contrast, Arqiva claims to have delivered 99.9% service availability for its DTT customers in the last 5 years.[65]
- Additionally, broadband connectivity issues may affect those in rural areas more than urban areas. During the peak-time period between 8-10pm, there was a 26% difference between the average rural download speed (56.0 Mbit/s) and the average urban download speed (70.3 Mbit/s).[66]
- Likewise, streaming quality can diminish when multiple viewers are watching using the same connection. [67]
- In a report on the future of TV commissioned by Arqiva, EY noted that IP streaming services can face unique challenges due to network constraints, resulting in lower quality streaming, streaming issues, and problems with real-time live broadcast latency.[68]
- Regarding consumer perceptions, research in this area is limited, but in a study carried out for Silver Voices in 2023, of the 33% of respondents who believed

[63] ONS, *Exploring the UK's Digital Divide* (2019), 14. https://www.ons.gov.uk/peoplepopulationandcommunity/householdcharacteristics/homeinternetandsocialmediausage/articles/exploringtheuksdigitaldivide/2019-03-04 (last accessed Nov 6th 2024)
[64] Ofcom, *UK Home Broadband Performance* (2023), 17. https://www.ofcom.org.uk/siteassets/resources/documents/research-and-data/broadband-research/broadband-speeds/home-broadband-performance-september-2023/march-23-home-broadband-performance.pdf?v=330131 (last accessed Nov 6th 2024).
[65] Ernst & Young, *TV distribution after 2034* (2024), 31. https://www.broadcast2040plus.org/_files/ugd/4e1def_238637d098d54a9e8dcd9da12055d1ee.pdf (last accessed Nov 6th 2024)
[66] Ofcom, *UK Home Broadband Performance* (2023), 3.
[67] Ofcom, *UK Home Broadband Performance* (2023), 15.
[68] EY, *TV Distribution after 2034* (2024), 30.

picture quality was better on broadcast services than online, 69% cited better signal quality & reliability as a reason.[69]

Connected TVs/devices

As outlined in Section 1.1 above, there are segments of the UK TV audience who have broadband at home but who have not connected this to an internet-capable TV or other device. As a result, they are unable to watch IP-delivered video on their TV and remain reliant on broadcast delivery.

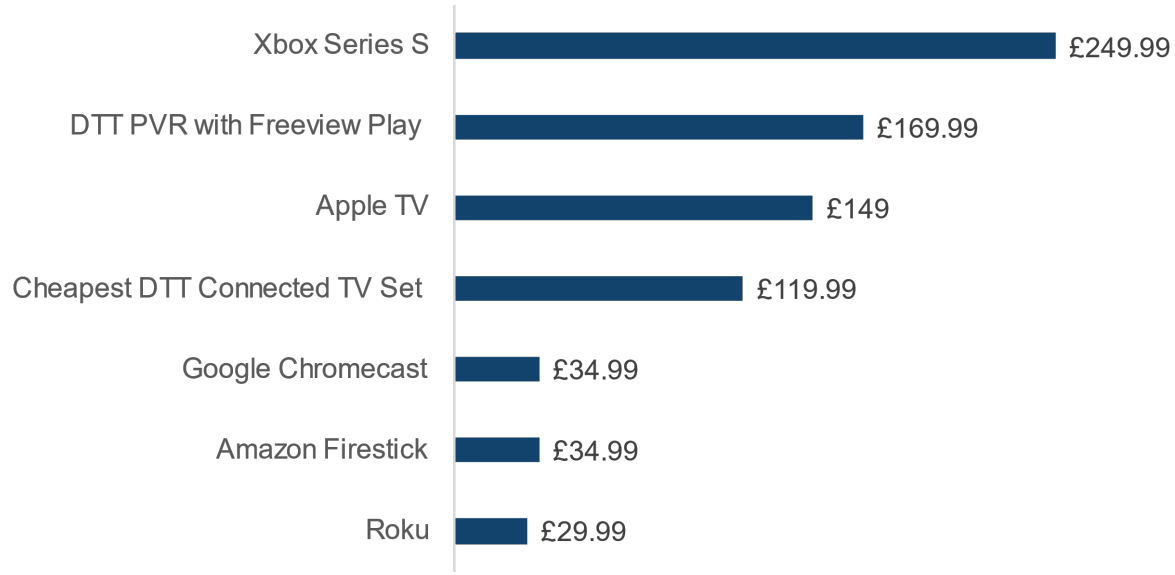
Overall, the Broadband but Unconnected TV group amounts to c. 2.2 million TV homes, the majority of which have Freeview (DTT) primary sets that are not connected to the internet. Based on data from the ScreenThink panel, we estimate that 14% of this group own a smart TV (i.e. connectable to the internet) that is not currently internet connected. 25% own a streaming device that is not currently used to connect the primary TV set to the internet (and there may be some overlap between these homes and those with connectable TV sets). The remainder of this group owns a non-'smart' primary TV set that is not internet connectable. Potential reasons for this may include affordability or the perceived complexity of new TV technology.

Affordability issues

As we have discussed above, a lower propensity to use IP-delivered TV content broadly correlates with age and lower socioeconomic status. It is reasonable to assume that some individuals who do not connect their TV sets to allow IP video delivery do so for cost reasons. While costs of the technology required to watch IP-delivered video over a DTT TV set have been falling in recent years, they can still be significant, particularly relative to the buying power of groups with limited incomes.

[69] Silver Voices, *Safeguarding Universality*. (2023), 14.

Figure 44: Purchase price of TV IP connectivity technology, Q1 2024



Source: MTM market research[70]

Perceptions of complexity and lack of skills

Some groups also see connecting TVs or devices to internet as relatively complex**.**

- 10% of adults surveyed by Ipsos for Arqiva in 2022 reported that they would be unable to set up some sort of CTV or connected device.[71]
- While digital skills in the UK have increased gradually over the years, some individuals still face barriers in taking up new technologies and learning new digital skills. Additionally, the shift of essential products and services online during the pandemic may have worsened the digital divide for those who already lacked digital skills.[72] According to the House of Lord's Digital Exclusion 2023 report, around 2.4 million adults lack the skills to complete a basic online task, such as connecting to Wi-Fi.[73]

[70] Cheapest DTT Connected TV Set: Bush 24 Inch Smart HD Ready LED HDR Freeview, accessed from [https://www.argos.co.uk/product/2255138?clickPR=plp:2:143]; DTT PVR with Freeview Play: Manhattan T4•R Freeview TV Recorder, launching for sale in early 2024, accessed from [https://manhattan-tv.com/freeview/manhattan-t4r-tv-recorder]; Amazon Firestick Lite, accessed from [https://www.amazon.co.uk/fire-tv-stick-lite-with-alexa-voice-remote-lite/dp/B091G31KSJ]; Chromecast HD version, accessed from [https://store.google.com/gb/product/chromecast_google_tv_compare?hl=en-GB]; Roku Express, accessed from [https://www.roku.com/en-gb/products/roku-express]; Apple TV 4K, accessed from [https://www.apple.com/uk/shop/buy-tv/apple-tv-4k/128gb]; Xbox Series S, accessed from [https://www.xbox.com/en-GB/consoles/xbox-series-s].

[71] Arqiva, *The Importance of Digital Terrestrial Television and Broadcast Radio* (2022), 15. https://www.arqiva.com/Importance_of_Broadcast.pdf (last accessed Nov 6th 2024)

[72] Ofcom, *Digital Exclusion: a review of Ofcom's research on digital exclusion among adults in the UK* (2022), 17.

[73] House of Lords, *Digital Exclusion* (2023), 9.

- Lloyds' 2023 Consumer Digital Index found that 16% of UK adults lack a "Foundation Level" of Essential Digital Skills for both life and work.[74] The Foundation Level is defined around the ability to perform online tasks—ranging from turning on a device and entering login information to setting up a Wi-Fi network, independently without help.[75] The findings show regional and demographic patterns for these essential digital skills across the UK, revealing a higher lack of digital skills in the Midlands, North East, and Wales, individuals from C2DE households, older individuals, and individuals living with a disability/impairment.[76]
- Digital 'poverty' more generally, a term which takes into account a lack of internet connection, lack of digital skills and inability to get online more than once per week, demonstrates similar demographic trends.[77] Digital poverty is more likely to affect older adults, women, and individuals living in DE households.[78] Additionally, Northern Ireland and Wales demonstrate a significant gap in digital skills compared to the rest of the UK.[79]

User Interfaces and Electronic Programme Guides

Television user interfaces (UIs) have grown increasingly complex in recent years, with new options for advanced search, user recommendations, on-demand content and more. Additionally, new device shortcuts, such as remote controls with buttons for live and on-demand content, provide new routes for television viewing.[80] This shift away from simpler, schedule-based electronic programme guides (EPGs) towards more comprehensive UIs and device shortcuts has created more potential barriers within a user's TV viewing journey.[81]

Increasing diversity of user interfaces

There are a now a variety of increasingly complex home screens and navigational starting points for a TV viewer, depending on their TV set, the manufacturer, VOD subscriptions and more.

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[74] Lloyds, *Essential Digital Skills Interactive Data Tables.* https://www.lloydsbank.com/banking-with-us/whats-happening/consumer-digital-index/essential-digital-skills.html (last accessed Nov 6th 2024)
[75] For the full list of Foundation Level Skills, see Lloyds, *Consumer Digital Index* (2023), Appendix, pp. 81-82.
[76] Ibid pp. 54-55; *Essential Digital Skills Interactive Data Tables.*
[77] Deloitte, *Digital Poverty in the UK: a socio-economic assessment of the implications of digital poverty in the UK* (2023). https://digitalpovertyalliance.org/wp-content/uploads/2023/09/Deloitte-Digital-Poverty_FinalReport_29092023.pdf (last accessed Nov 6th 2024)
[78] Ibid 5.
[79] Ibid 5.
[80] Ofcom, *EPG Prominence: A report on the discoverability of PSB and local TV services* (2020), 10; Mediatique, *Connected TV Gateways: review of market dynamics* (2020), 30. https://www.ofcom.org.uk/siteassets/resources/documents/consultations/category-2-6-weeks/201462-epg-code-competition-rules-review/connected-gateways.pdf?v=325194 (last accessed Nov 6th 2024)
[81] Ibid pp. 10-11.

- Smart TVs and connected TV devices present a series of apps on the homepage in different orders depending on the manufacturer. Smart TV remotes complicate the viewing journey by providing shortcut buttons to VOD platforms such as Netflix or Disney+. Pay TV platforms, such as Sky or Virgin, also provide a different navigational starting point with their own programme guides. Additionally, various VOD platforms (both BVOD and SVOD) provide different homepages for viewers, offering recommendations and platform search capabilities.[82]

- This complexity is greatest on more advanced, connected and VOD-enabled TV sets and interfaces, where access to a linear schedule through a traditional EPG sits alongside more complex, app-based interfaces to on-demand services. TV sets used solely for linear viewing over DTT broadcast delivery mechanisms tend to have much simpler EPG interfaces.

Fragmentation of audience usage of user interfaces

Recent research shows that, confronted with a range of choices of how to access TV content, audiences are using different approaches based on their preferences. This is pronounced for audiences who watch mainly linear vs. on-demand content, with the former tending to favour traditional linear EPGs.

- Ofcom's 2020 report on EPG prominence indicated that the EPG was the primary method for viewers to find and select their television programmes.[83] However, this is likely to be changing and fragmenting, given the increasing use on VOD content in the intervening years.

- Catherine Johnson *et al.* have conducted research into the viewing habits of individuals throughout the UK, drawing conclusions about different "routes to content".[84] Despite the rise of streaming services and IP viewing options, the linear environment still shapes television content discovery for many audiences in the UK. In research carried out in 2021, *'Watching the channel I usually watch'* remained the second most frequently used route to content (30% of respondents). [85] Johnson *et al.'s* qualitative study in 2019 revealed four primary 'routes to content' for viewers to find and watch TV:[86]

    - Some audiences relied on the EPG first for finding television content. This EPG default viewing was more associated with linear television.

[82] Mediatique, *Connected TV Gateways: review of market dynamics* (2020), 16-30.
[83] Ofcom, *EPG Prominence: A report on the discoverability of PSB and local TV services* (2020), 20.
[84] Johnson et al., *An audience studies' contribution to the discoverability and prominence debate: Seeking UK TV audiences' 'routes to content'* (2023); Johnson et al., *The Impact of Video on Demand TV Viewing in the UK: Routes to Content after COVID-19, Interim Report* (2022).
[85] Johnson et al., *The Impact of Video on Demand TV Viewing in the UK: Routes to Content after COVID-19, Interim Report* (2022), 20, 23. https://screen-network.org.uk/wp-content/uploads/2022/06/Routes-to-content-june-22.pdf (last accessed Nov 6th 2024)
[86] Johnson et al, *Routes to Content: How people decide what TV to watch* (2020)

    - A second audience type ('3-Digit default') found content first by going straight to their preferred channels, again watching more linear television than other audiences.
    - Other audiences relied heavily on the home pages, UI, and search features of their smart TV or connected device, typically choosing on-demand television content. The study found that this audience was composed mostly of younger participants. The individuals who relied on on-demand services or devices tended to rely on the services' algorithms for finding content to watch.
    - A final audience segment defaulted to the recordings on their set top box at the start of their TV viewing journey.

- Past research conducted by MTM found similar results in terms of the importance of the traditional linear EPG. Many users rely on the TV guide at the start of their viewing journey, especially heavy linear audiences who watch a fairly limited set of channels—typically terrestrial—and have habitual journeys to specific content. These 'mainstream' users rely on the familiar and structured layout of the TV Guide to find their desired TV content.

Perceived complexity of user interfaces

This growing diversity of UIs means that some audiences are finding the discovery and access to content increasingly challenging, particularly on more complex interfaces that go beyond simple linear EPGs.

- Johnson *et al.*'s research found a range of different technological literacies among participants. In particular, older female participants (35+) lacked some of the digital skills needed to operate television devices, especially smart TVs and connected devices, and to navigate online TV services.[87]
- A study commissioned by Silver Voices found that older viewers found channel navigation to be easier for broadcast television than for online viewing.[88] Almost half of older participants (48%) aged 65 to 74 noted the issue of channel navigation online.[89]
- Industry interviewees echoed this, noting that many people, especially older viewers and viewers with certain disabilities, find navigating OTT UIs too complex and difficult, as they are used to switching on the TV and accessing e.g., BBC One. Compared to traditional broadcast television with a relatively simple EPG and functionality, IP-delivered services can be siloed within different apps or curated within walled gardens.[90] This was also cited as a reason why linear

[87] Johnson et al., *An audience studies' contribution to the discoverability and prominence debate: Seeking UK TV audiences' 'routes to content'*(2023), 12.
[88] Silver Voices, *Safeguarding Universality: the Future of Broadcast TV and Radio* (2023), 14.
[89] Silver Voices, *Safeguarding Universality: the Future of Broadcast TV and Radio* (2023), 14.
[90] DTG, Chatham House roundtable notes, February 2024

viewing drops off in OTT-only homes, due to the difficulty of switching between apps and a linear EPG.[91]

Content

A range of attractive and appealing programming is the final requirement for a successful television offer, and a crucial enabler of switch from broadcast-led to IP-delivered content consumption. While many audiences already engage with on-demand video (whether subscription or free), others are satisfied with the linear channels available over broadcast television and see little need for switching to IP technology from a content perspective. Indeed, some of these audiences find the range of VOD and other IP content overwhelming or irrelevant and fail to see value in the incremental choice on offer compared to e.g. DTT linear broadcast channels over Freeview. In the words of one industry executive, 'since there is no free-to-air IP offering which acts in the same way as Freeview yet, [some Freeview viewers] have no motivation to get online at the moment.'[92]

Linear viewing habits

As we have demonstrated above in Section 1.3, significant segments of the audience continue to rely wholly or mostly on linear TV over broadcast. These audiences tend to be primarily older and in lower socioeconomic groups. While many are in the 'Unconnected TV' groups, others have connected TVs but continue to watch mainly linear television over broadcast. Recent MTM consumer research sheds some light on this.

- A wealth of research by MTM observes a group of TV 'satisficers' who are more willing to settle on content deemed 'good enough' for their needs. These individuals are driven by easy viewing decisions, and so are heavier viewers of linear for the ease in routine driven by the live schedule.
- Similarly, MTM also see an older skewing audience (often aged 55+), who prefer free and informative TV content, and typically rely on linear television for their viewing. These viewers tend to feel overwhelmed by the amount of choice available and so choose linear TV as the more reliable and simpler viewing option.
- A third group of viewers emerges who are more interested in immersive content (especially comedies and entertainment) and new and 'trendy' content (esp. dramas and documentaries). These viewers tend to be younger (e.g. 16-34) and rely more heavily on BVOD and SVOD services, rather than linear TV.
- EY's *TV Distribution After 2034* report, commissioned by Arqiva, demonstrated similar demographic patterns for content consumption in the UK. Adults aged 75+ preferred to watch live TV content, making up about 80% of their total viewing.

[91] Industry interview, February 2024
[92] Industry interview, February 2024

However, younger adults aged 16-34 consumed a larger variety of content, including SVOD/AVOD, video sharing platforms, live TV, and other TV services.[93]

- Additionally, Silver Voices' 2023 Report on the Future of Broadcast TV and Radio found associations for viewers between viewing platforms and preferred television content.[94] Some surveyed participants stated that they preferred broadcast TV to online viewing for watching national or local TV news, large state events (e.g. the Coronation), and live sporting events.[95]

Overwhelming content choices

Given the variety of available content across different providers and platforms, some audiences feel overwhelmed by choice, especially for streaming services. 54% of individuals surveyed for Ofcom's 2023 Communications Market Report felt overwhelmed by the amount of content available on VOD services, and this number rose to 57% of individuals 65+.[96]

Affordability

Affordability issues also influence choice of TV viewing, with some audiences finding paid TV services and SVOD subscriptions too expensive.

- Ofcom's 2023 Pricing Trends report demonstrates that households that paid for Pay TV and/or SVOD services were more likely than other households to report struggling with affordability.[97] Additionally, Pay TV and SVOD services had the highest levels of cancellation of any communications service, including broadband and mobile plans.[98]

- Participants in the 2019 study by Johnson et al. expressed difficulties in choosing different combinations of television services in order to access content. For example, some viewers had to make choices between Pay TV and SVOD services based on content and affordability.[99]

- An Ipsos report commissioned by Arqiva on the importance of DTT and broadcast radio had similar findings. 13% of surveyed participants noted that they could not afford Pay TV services, and more than half of the individuals who rely only on Freeview claimed that they would not pay for any pay TV service.[100]

[93] EY, *TV Distribution after 2034* (2024), 24.
[94] EY, *TV Distribution after 2034* (2024), 24.
[95] Silver Voices, *Safeguarding Universality: the Future of broadcast TV and radio service* (2023), 13.
[96] Ofcom, *Communications Market Report 2023: Interactive data.* [https://www.ofcom.org.uk/research-and-data/multi-sector-research/cmr/2023/interactive]
[97] Ofcom, *Pricing Trends for Communication Services in the UK* (2023), 45.
[98] Ofcom, *Pricing Trends for Communication Services in the UK* (2023), 45.
[99] Johnson et al., *Routes to Content: How people decide what TV to watch* (2020), 9.
[100] Arqiva, *The Importance of Digital Terrestrial Television and Broadcast Radio* (2022), 14.

1.5 Likely evolution of DTT use and IP uptake among Unconnected TV and Linear-Heavy groups to 2040

While the barriers described above are likely to decline in importance for most audiences by 2040, with enablers evolving to underpin greater uptake, some will remain significant, resulting in a 'rump' of IP rejectors. Several key dynamics are likely to drive greater take-up of IP-enabled services to 2040:

- The coverage and take-up of broadband with speed sufficient to enable IP-delivered video will grow significantly. This will be underpinned by competition among broadband providers, the Government's Gigabit rollout plans, and the changing age profile of broadband users who are likely to increasingly regard broadband as a basic utility.
- The use of connected TVs and devices is likely to grow and these will be increasingly connected to the internet. Real-terms prices may decrease somewhat, and complexity of connecting them is likely to fall, in line with growing digital skills and confidence in the population at large.
- TV user interfaces and EPGs are likely to become somewhat less complex to use. Some manufacturers are likely to focus on improved usability, and Freely and other platforms are likely to design their user interfaces to make navigation easier. At the same time, improving digital skills are likely to further lower barriers for some user.
- Content on IP-delivered TV platforms like Freely is likely to increasingly include a familiar range of linear channels from public service broadcasters, further lowering the barrier for audiences who prefer a linear experience.

In parallel, a significant age cohort effect is likely to play out over the next 16 years, where today's younger viewers age into the audience segments currently occupied by older audiences. These younger viewers have different attitudes to the internet, television, and on-demand content than today's older viewers, meaning that older cohorts in 2040 are likely to have significantly different profiles to those of today. Economic deprivation and affordability will still represent significant barriers for some audiences, but it is our view that this cohort effect will materially impact the take-up of broadband, connected TVs and IP-delivered services.

We conclude that while the vast majority UK homes will use IP-delivered TV services by 2040 through internet-connected sets and devices, a small but significant minority of c. 1.5 million homes, will remain wholly reliant on DTT broadcast, either because they do not have broadband access or because, despite having broadband, they have yet to connect their TV set to the internet. A further group will use internet-connected Freeview or YouView sets (a 'hybrid' platform) via DTT broadcast delivery mechanisms to watch TV, but a minority of these viewers ('linear heavy') will still strongly favour linear viewing and therefore potentially be more reliant on DTT broadcast. In addition, we project that c. 4.4 million secondary DTT TV sets will remain unconnected in 2040, presenting a further challenge.

Likely evolution of key enablers and barriers

Broadband

Broadband access is likely to become cheaper, faster, and more widespread. By 2040, MTM projects that superfast broadband coverage will reach at least 99.65%, and take-up will reach 97.5%.[101]

This will be driven by a reduction in the barriers identified above – increased coverage, affordability, perceived complexity, and perceived need.

- In terms of coverage, the Government's Gigabit project aims to make gigabit-capable broadband available to 99% of the country by 2030. Further infill is likely by 2040. Ofcom estimates that already by 2026, only c. 25,000 premises will remain unable to receive 'decent' broadband (>10Mbps).[102]
- Real terms reduction in high-speed broadband price is likely over the coming years.
    - Prices for standalone fixed broadband fell in 2023, with the exception of the price for superfast connections (30-99 Mbit/s) which rose by 1%.[103]
    - BT Openreach's Equinox 2 discounted broadband price scheme will be available to providers from 1st April 2024.[104] The Equinox 2 reductions provide discounts of up to 42% for rental charges and 75% for connection charges in comparison to Openreach's previously standard price list.[105] This scheme would lead to price reductions for broadband providers, which will likely trickle down to individual consumers.
    - The gigabit-capable network market is likely to remain fiercely competitive during the period of fibre-to-the-premises (FTTP) network construction, maintaining downward pressure on FTTP broadband prices. There is a large number of smaller FTTP providers which is expected to undergo consolidation, creating a small number of well-resourced competitors able to offer alternatives to Openreach's incumbent network at scale.
    - Likewise, further effort from government is likely to increase the take-up of broadband social tariffs, which is currently low relative to the number of homes that are eligible.
- Changing age cohorts will have different attitudes towards broadband access and technological skills. While people above retirement age currently are by far the

[101] Includes both fixed line and mobile connections.
[102] Ofcom, *Connected Nations* (2023), p. 28.
[103] Ofcom, *Pricing Trends for Communication Services in the UK* (2023), 17-18. Ofcom's data is based on UK's largest providers: BT, EE, Plusnet, TalkTalk, Sky, Virgin Media, and Vodafone.
[104] OpenReach, *Ultrafast Full Fibre Broadband (FTTP) pricing for service providers* (2024). https://www.openreach.com/content/dam/openreach/openreach-dam-files/documents/Equinox-pricing-model-for-Full-Fibre-Broadband-from-April-24-online.pdf (last accessed Nov 6th 2024)
[105] Ofcom, *Annexes: Openreach proposed FTTP offer starting 1 April 2023* (2023), 5.

most likely to be without broadband access, many people of retirement age in 2040 will be those who are in their 50s in 2024, whose attitudes to broadband are significantly more positive, and with far higher usage rates. Currently, 96% of people between 45 and 54 claim to use the internet at home, versus 69% of people 65+.[106] It is unlikely that a significant proportion of those younger users would cease wanting to access the internet in their later years.

- There is likely to be an increase in the salience/importance of broadband as a utility, and a growing awareness of the additional benefits of IPTV delivery. It is highly likely that underlying perceptions of the importance of and need for broadband will shift significantly and that people in general will be more aware of how it can improve their TV experience.

Connected TVs/devices

Overall, it is likely that some of the barriers that prevent viewers from connecting TV sets to broadband that enables IP delivery of video services will decrease somewhat by 2040.

- Smart (IP-connectable) TV sets will increasingly become the norm in the market, meaning that all new TV sets will be enabled for IP connectivity. 3 Reasons projects that by 2025, all new TVs sold in the UK will be IP-enabled.
- Prices of TVs and IP-enabled connected devices are likely to continue falling in real terms, in line with historic trends. While a new TV set will remain a significant investment, affordability is likely to increase somewhat as prices continue to fall.
- However, while the average replacement cycle for a primary set in the UK is c. 7 years, some TV homes may take significantly longer to replace their sets. Industry interviewees noted that while many will upgrade, some audiences are perfectly satisfied with their sets and will not see a reason to buy new sets.[107]
- 3 Reasons projects that by 2030, 26 million UK TV homes, or 94%, will have a smart TV as a primary set, and we project that this number will rise to 29 million, or 99%, by 2040. (This does not include the proliferation of non-TV connected devices, which is likely to be significant.)
- In addition, the technical complexity of connecting smart TVs or other devices to the internet is likely to continue to fall somewhat, as manufacturers seek to make the connection process as easy as possible.
- Simultaneously, it is also likely that, on average, the level of digital skills in the population will increase over the next 16 years, in line with historic trends, leading to greater confidence in managing tasks like connecting smart TVs.
- Finally, broadcast aerials (both terrestrial and satellite) are in many cases already decades old (particularly terrestrial) and are likely to degrade steadily and fail,

[106] Ofcom, *Adults' media Use and Attitudes Report* (2023), 5

[107] Industry interview, February 2024

leaving the customer with a choice whether to replace at significant expense (the aerial industry is contracting and becoming significantly less competitive) or opt to go all-IP.

User interface/electronic programme guide

Overall, TV user interfaces (UIs) are likely to continue to change, with a diversity of available models depending on the manufacturer and service provider. While it is likely that there will be some continued simplification of user interfaces in a consumer-centric fashion, and that usability will increase with technological innovation, UI design choices are likely to be influenced to some extent by the commercial and strategic priorities of the manufacturer or provider.

- For example, Freely is likely to present a user experience that builds on a familiar linear EPG while enabling a greater range of IP-delivered linear and VOD content.[108] Industry interviewees noted that Freely is likely to make it significantly easier to consume linear services over IP.[109]
- These developments will be underpinned by technologies that facilitate service discovery and access to programme metadata in a standardised format. This can be used by devices to present programme choices to viewers in a simplified/ consolidated way.[110] In general, some industry participants noted that TV UIs are likely to become more standardised and simple, in line with the evolution of smartphone interfaces.[111]
- Conversely, other industry players like smart TV manufacturers may choose to give prominence to non-linear services to the extent possible within overall prominence regulations, depending on their own commercial arrangements, as they may regard linear audiences as having lower value.[112]
- At the same time, the implementation of PSB prominence provisions in the new UK Media Bill, requiring prominence for designated PSB players and content as well as securing the accessibility of their services to people with disabilities, will be subject to Ofcom consultation in 2025[113] and is also likely to impact the development of UIs.
- Finally, technological advancements in accessibility and discoverability are likely to expand the ease of use of many user interfaces, driven by developments including voice navigation and increased personalisation. Artificial intelligence (AI) will also have a significant impact on functionality, including ease of

[108] Industry interview, February 2024
[109] Industry interview, February 2024
[110] DTG, Chatham House roundtable notes, February 2024
[111] Industry interview, March 2024.
[112] Industry interview, February 2024
[113] Ofcom, *Media Bill: Ofcom's roadmap to regulation* (2024)

discovery and curation; and improved accessibility from on-demand translation, audio description and signing.[114]

Content

As discussed above, some audiences have a strong preference for watching linear content, particularly many of those who are reliant on DTT broadcast services. This often has psychological dimensions, i.e. those who 'satisfice' and don't see the need for additional services and those who feel overwhelmed by on-demand choice. As with many of the other barriers we have discussed, older viewers are overrepresented in these groups. For them, there is little incentive to switch to IP-enabled delivery that is not perceived as offering any incremental value. However, as new IP-delivered platforms increasingly make linear channels available alongside a range of VOD services, it is likely that some of this reluctance will decline.

- While additional content services (linear or VOD) on IP-connected platforms appear unlikely to sway these audiences into switching to IP-enabled delivery, there is likely to be an increasing shift toward replicating the familiar linear channel experience through IP-delivered services.
- Freely will provide a range of PSB linear channels on a hybrid platform with both broadcast- and IP-enabled delivery through a traditional EPG interface, offering those who prefer to watch these channels an experience that is essentially identical (albeit with some additional functionality), and serve as a 'bridge between the old world and the new'.[115] Over time, the Freely lineup aims to replicate the Freeview lineup and may include IP-only channels not currently available on Freeview.[116]
- Similarly, while public service broadcasters have withheld some channels and services from IP platforms historically, they are increasingly making their full range of services available on new platforms.
- They also see Freely and IP-delivery in general as an opportunity to offer traditional linear-heavy audiences a wider range of services and functionality (in addition to their BVOD players). This could include pause/rewind/restart functions, additional content such as live breaking news stories and events, increased accessibility and improved picture quality.[117]
- Future IP-delivered television services will also include virtual reality (VR) and highly immersive experiences[118], which will further enhance their attractiveness relative to broadcast-delivered TV for some audiences.

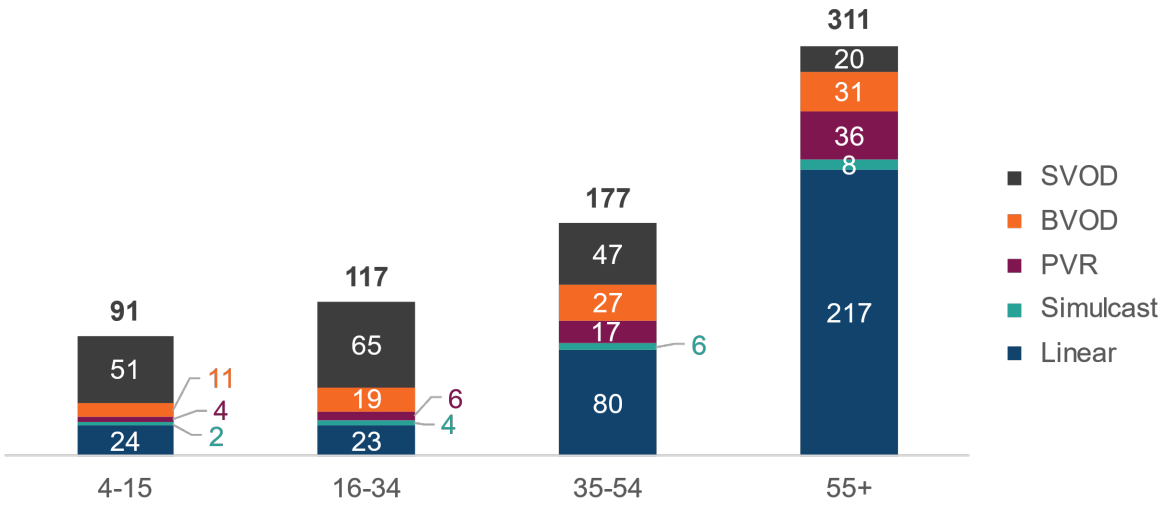
[114] DTG, Chatham House roundtable notes, February 2024
[115] Industry interview, February 2024
[116] Industry interview, February 2024
[117] Industry interview, February 2024
[118] DTG, Chatham House roundtable, 2024

- Over time, some industry executives believe that audiences to non-IP platforms will become curious about the additional functionality available on IP services like Freely, which may drive faster adoption.[119]

Age cohort profiles and audience preferences

Fundamentally, the ageing of TV audiences over the next 16 years is likely to bring about a significant shift in the attitudes and behaviours of older viewers. Simply put, younger viewers are significantly more likely to watch on-demand content as opposed to linear. This gap is pronounced even in the difference between today's 55+-year olds and 35-54 year olds.

Figure 45: Type of viewing by age group, avg. daily minutes, 2023F

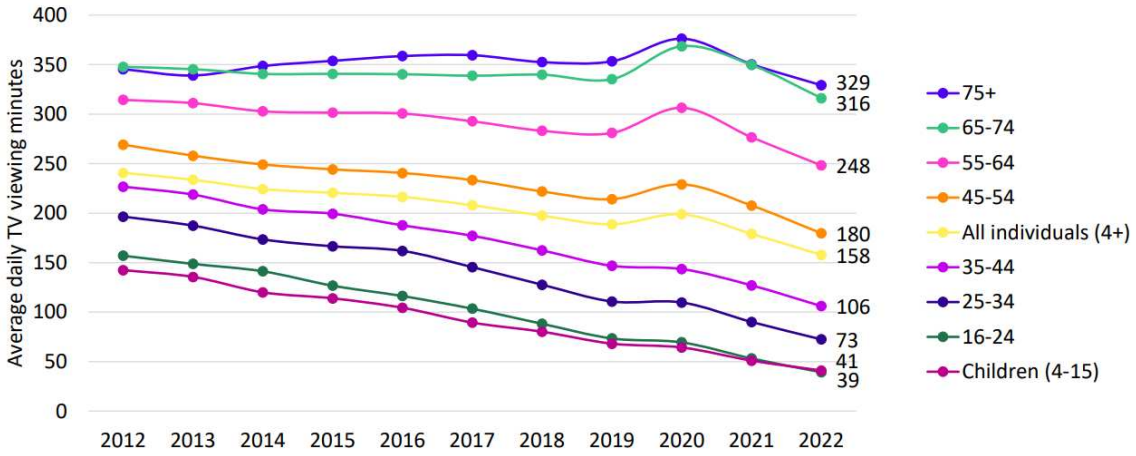


Source: 3 Reasons

Average daily viewing minutes of linear TV have declined for all age cohorts. This trend is expected to continue, as individuals from all generations continue to access more content from VOD services.

[119] Industry interview, February 2024

Figure 46: Average daily minutes of broadcast TV viewing by age group: 2012-2022



Source: Screenshot taken from Ofcom Media Nations: UK, 2023[120]. Accessed 14/03/2024.

Likely evolution of unconnected and low-connected groups to 2040

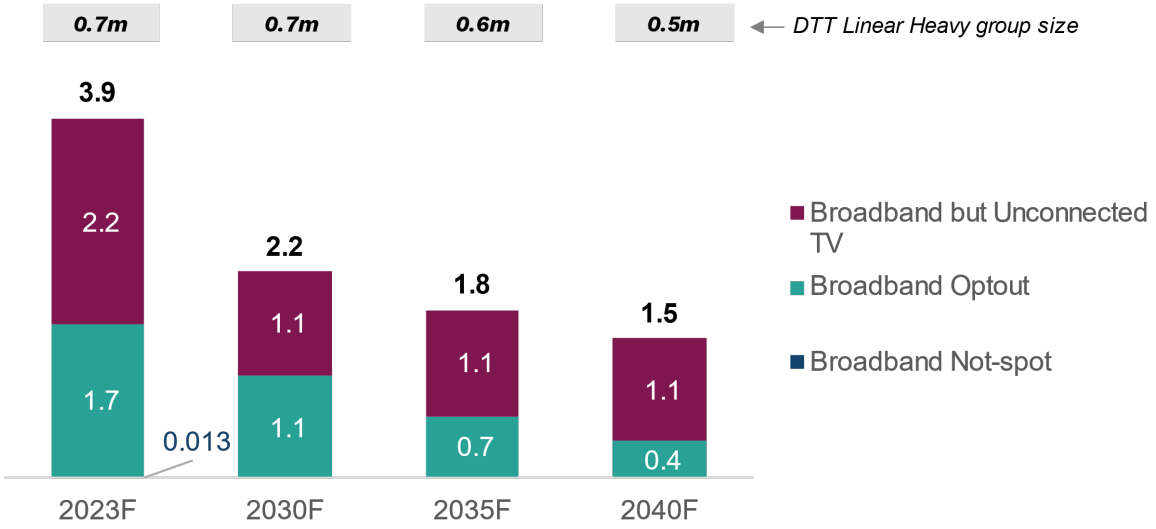
In light of these trends, we have analysed the likely impact on the un- and low-connected groups that we identified in Section 1.3.

- In summary, we forecast that homes in the Unconnected TV groups will decline in size from about 3.9 million in 2023 to c. 1.5 million in 2040.
- The Broadband Optout group, homes which choose not to take broadband, will decline from 1.5 million to 0.4 million.
- The Broadband but Unconnected TV group will decline from 1.8 million to 1.1 million.
- The Broadband Not-spot group, outside decent broadband coverage, will be fully covered by 2030 and decline to zero.
- In addition, we estimate that the DTT Hybrid Linear Heavy group, or viewers whose share of linear viewing is greater than 80%, will decline from an equivalent of 0.7 million homes in 2023 to c. 0.5 million homes in 2040.

For more detail on the assumptions and methodology used, see Appendix B.

[120] Ofcom, Media Nations (2023)

Figure 47: Unconnected TV households, 2023F-2040F (millions)



Source: 3 Reasons, MTM

Group 1: Broadband Not-spot

The Broadband Not-spot group, comprising homes in areas that are not currently covered by broadband of greater than 2 Mbps, numbers c. 13,000 homes in 2023. Its primary barrier to accessing IP-delivered services is lack of broadband coverage.

Given the projected evolution of broadband coverage across the UK and considering the goals of planned network upgrade projects, which are focused on the areas with the poorest connections (such as Project Gigabit[121]), we estimate that this group will be reduced to zero by 2030.

Group 2: Broadband Optout

This group currently numbers an estimated 1.7 million homes and is defined by its reliance on DTT broadcast as its primary TV delivery and by its lack of broadband access, either via fixed line connection or a mobile connection which is insufficient to stream VOD.

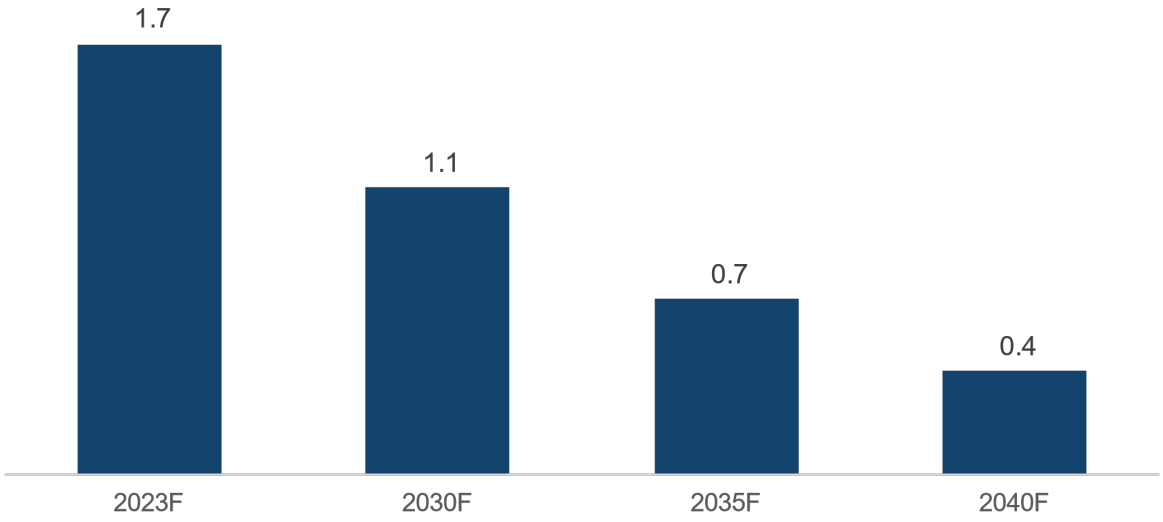
We forecast that this group will substantially reduce in size by 2040 for several reasons:

- Broadband price reductions in real terms and further take-up of broadband social tariffs.
- Changing expectations of broadband given age cohort mix which is trending toward individuals for whom broadband plays a more central role.
- Growing awareness of benefits of broadband's role in IPTV delivery.

We estimate that by 2040 this group will be reduced to c. 0.4 million homes.

[121] UK Government. *Project Gigabit* (2022) https://www.gov.uk/guidance/project-gigabit-uk-gigabit-programme (last accessed Nov 6th 2024)

Figure 48: Broadband Optout households, 2023F-40F (millions)



Source: 3 Reasons

Group 3: Broadband but Unconnected TV set

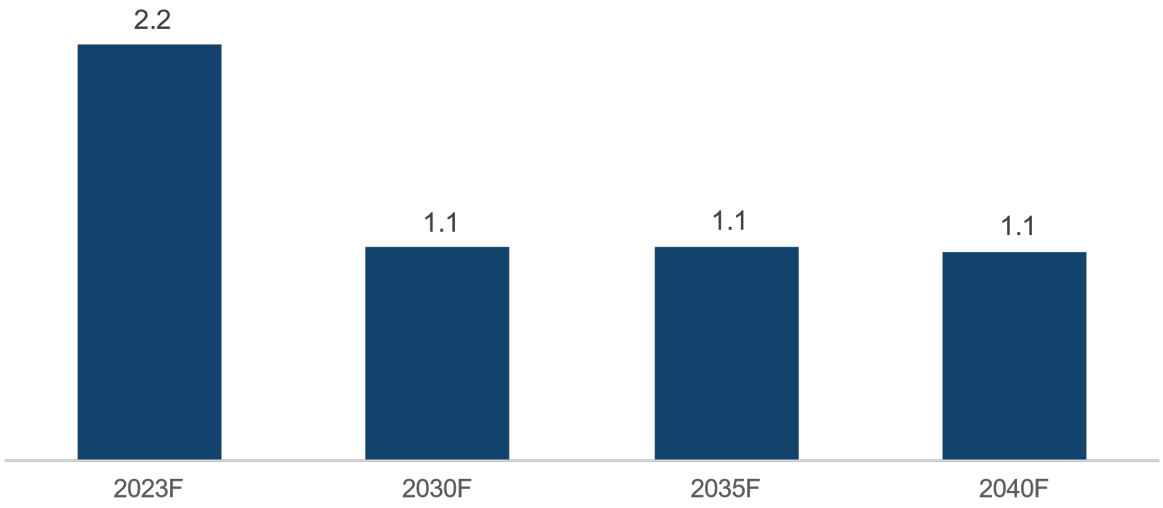
This group currently numbers an estimated 2.2 million homes and is defined as homes with a broadband connection, but an unconnected primary TV set.

We estimate that this group will substantially reduce by 2040:

- More consumers will purchase smart TV sets to upgrade previously unconnectable TV sets; by 2025 all new TV sets sold will be connectable and we project that by 2040 99% of primary sets in UK TV homes will be connectable.
- At the same time, more homes in this group will connect previously unconnected but smart TV sets to the internet. This will be driven by changing age cohort preferences for IP-delivered TV as this group ages, and by members of this group who “digitally upskill” and learn how to set up and use connectable TV sets.

We estimate that by 2040 this group will be reduced to 1.1 million homes. We also project that a proportion of these homes (c. 30%, or c. 0.35 million) will rely on a mobile broadband connection that may offer speeds of less than 30Mbps, which may make IP video streaming more challenging (although advances in video compression and streaming technology may make this less of an issue by 2040).

Figure 49: Broadband but Unconnected TV households, 2023F-40F (millions)



Source: 3 Reasons

Group 4: Linear Heavy DTT Hybrid homes

The DTT Hybrid group currently numbers an estimated 8.2 million homes and is defined as homes with a DTT primary set connected to the internet. Of these, we estimate the 'Linear Heavy' subgroup, DTT hybrid homes whose viewing is 80% or more linear, to number c. 0.7 million.

We project that the DTT Hybrid group will decline to 5.9 million homes by 2040:

- The growth of Freely and other platforms like EE TV are likely to shift some homes into the Linear-IP category, as these homes will not connect their Freely set to a DTT aerial but use only its IP connectivity to watch TV.[122]
- Some other Hybrid homes are likely to transition to 'OTT-only' homes as demographic shifts favour greater uptake of IP-delivered services.

Within the Hybrid DTT group, we project that the volume of Linear Heavy homes will decline somewhat to c. 0.5 million by 2040:

- The overall size of the Hybrid DTT group will decline as described above.
- Age cohort preferences are likely to drive linear viewing somewhat lower.
- But conversely, greater accessibility of high-quality IP-delivered linear channels over platforms like Freely are likely to boost linear viewing somewhat.

It is important to note that these homes will, by definition, have the option of watching linear TV over DTT broadcast or linear-IP delivered channels (for example via Freely), but we do not project the mix of that viewing.

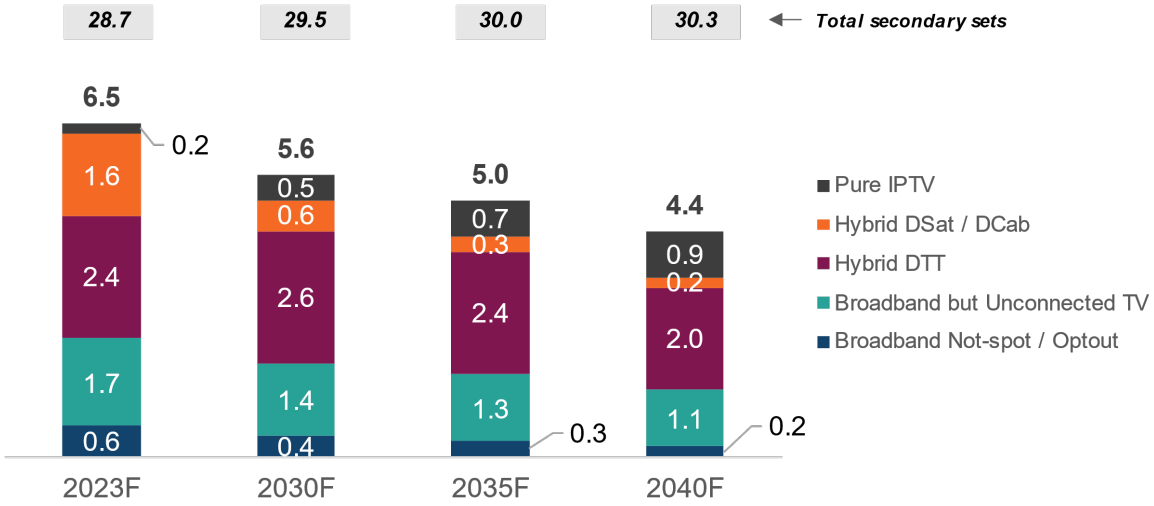
[122] This is speculative and subject to Freely specifications.

Secondary TV sets

In addition to the shift in primary set delivery, secondary sets will also be affected by changing delivery methods.

Our forecast projects that the total number of secondary sets will continue to increase slowly to approximately 30.3 million in 2040, at which point there will still exist 4.4 million unconnected DTT secondary sets. These are projected to be spread across each of the groups explored in this report, but 2 million (or 46%) of unconnected DTT sets will be in Hybrid DTT homes.

Figure 50: Unconnected DTT secondary sets, homes split by type of main set, 2023F-40F (millions)



Source: 3 Reasons

Implications

These groups present different challenges in terms of enabling a potential shift from DTT to IP-delivered TV.

- For the group without broadband access (Broadband Optout), affordability is likely to be a significant barrier, potentially coupled with perceptions of complexity and, for some, an ongoing lack of interest in the internet.
- For those with broadband but unconnected TV sets, barriers are likely to include the affordability of new internet-connectable TVs and devices, and the perceived complexity of connecting the device.
- For both of these groups, lack of digital skills is likely to be a factor. High satisfaction with existing and familiar linear channels delivered over DTT broadcast, relative to the content delivered over IP, is also likely to play a role in terms of disincentivising a switch.
- For the 'linear heavy' viewers who watch TV on 'hybrid' DTT sets, barriers are much less significant as they will already have access to IP-delivered TV services

on their sets; the challenge is more a behavioural one, i.e. a potential lingering affinity for broadcast vs. linear IP streaming, for reasons of habit or perceptions of greater reliability.

- For unconnected secondary sets, while most will be owned by households that already have an internet connection, they may face a particular challenge in terms of in-home Wi-Fi networks. These are often optimised to favour areas of the home like the living room (site of the primary set) and secondary sets in places like kitchens or lofts may be more difficult to connect satisfactorily, even in homes with otherwise fast broadband lines.

While we make no recommendations for policy interventions in this section, we believe that further research is warranted. Specifically, targeted qualitative research into the unconnected groups of TV viewers, to understand their barriers, motivations and preferences in more detail, and to understand what specific policy remedies may be most effective, should be a priority for the next stage.

A specific area of focus would include understanding the evolving behaviour of viewers in hybrid homes, and the choices/preferences they exhibit when faced with a mixed platform like Freely, in particular as they navigate between watching linear TV over a DTT broadcast stream or over IP streaming.

2 Technology

This section examines the technological developments related to digital terrestrial television (DTT) and internet-delivered (IPTV) television. First, we examine the efficient use of spectrum that could affect the quality and coverage of DTT services. We then focus on IPTV technology to identify the technological barriers and enablers to IPTV uptake and assess if the UK's digital infrastructure is sufficient to enable widespread viewing of IPTV.

Firstly, we provide information about the expected evolution of DTT technology and the technical features enabling the improvement of spectrum efficiency. DVB-T2, the second-generation terrestrial transmission standard for DTT, includes new or improved features related to modulation parameters, error correction and bandwidth use, each delivering gains in capacity and robustness. DVB-T2 can offer an average improvement of 30-50% in spectral efficiency compared to its predecessor, DVB-T, but the overall increase in capacity varies from country to country. Replacing first-generation MPEG2 encoding with High Efficiency Video Coding (HEVC) or newer encoding results in a larger, additional improvement in spectral efficiency. A likely shift to higher resolution content might consume some of the spectrum gains. There are other options to improve the spectrum efficiency, such as using Single Frequency Networks (SFNs). However, migrating to an SFN-based network would require replanning the entire network. Further research including a cost-benefit analysis needs to be carried out to compare options.

Secondly, we reviewed technical barriers and enablers to IPTV uptake. IPTV technology is mature, and it is now relatively easy for content providers to launch services and for most users to consume them. Core network capacity is growing rapidly, and rollout and uptake of superfast and ultrafast access network connections will continue. However, IPTV delivery's biggest technological challenge is the lack of control that service provider has over the access network and in-home network.

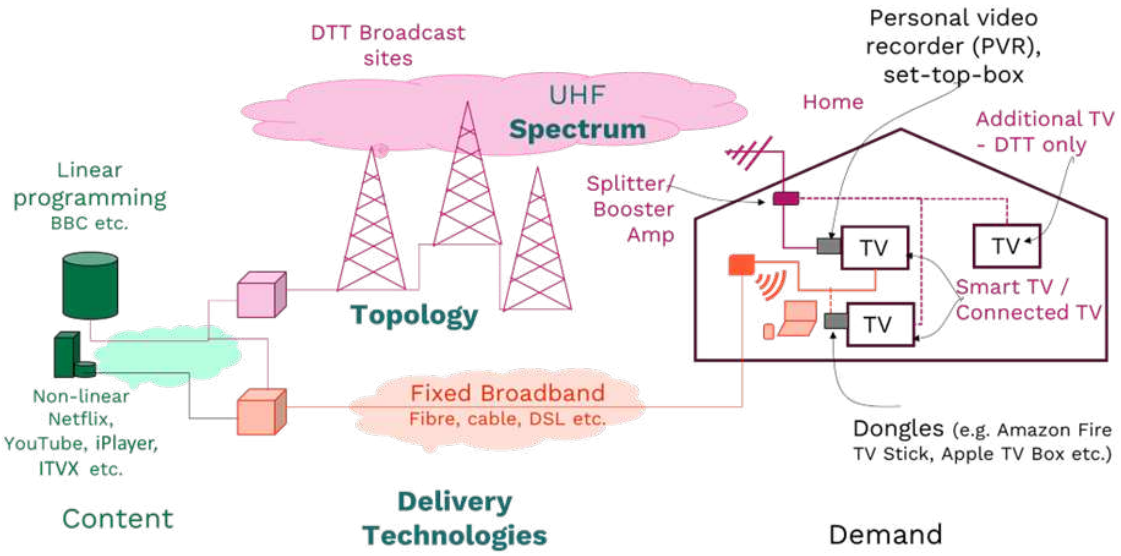
Thirdly, we assessed the UK digital infrastructure's ability to enable widespread IPTV viewing. The two key issues facing the UK are access network availability and uptake, and in-home networking (e.g. Wi-Fi). The challenge of providing superfast/ultrafast broadband to hard-to-reach premises has been thoroughly analysed, and is relatively well understood, though no solution has been agreed upon and committed to yet. The challenge of in-home networking is less well understood, with little evidence on real-world user experience, and could lead to a high degree of variability of user experience depending on each household's technology and local environment. Other issues to be considered are how to ensure access to IPTV services on TV sets, through services such as Freely, and how to develop a better understanding of the reliability of IPTV services in an environment where there is far less control over the end-to-end distribution of content than in the DTT environment. The exponential nature of the growth of network capacity means that we do not see peak traffic in the core network as a significant risk – even in an extreme scenario, network operators should be capable of delivering IPTV traffic through the core network reliably.

2.1 Use of spectrum that could affect the quality and coverage of DTT services

2.1.1 Introduction to DTT broadcasting and terminology

Figure 51 captures this study's relevant dimensions, parameters and terminology.

Figure 51: Illustration of end-to-end TV delivery platforms



The demand for broadcast services[123] presented in the audience analysis section is served by various broadcasting networks today. The shape of these broadcasting networks is characterised by three key areas:

Delivery technologies: Over-the-air technologies such as DTT and satellite TV broadcasting deliver TV content to users. Delivery technologies have differing abilities to serve different types of demand and impact spectrum efficiency. The current digital terrestrial television network is based on digital technology, DVB-T. Whilst DTT and IPTV are the main focus of this research, we have also considered the impact of cable and satellites. Today, each technology predominantly serves a different type of demand, but there is an overlap and the boundaries are blurring. The evolution and penetration of technology could cause their suitability for different user groups to change significantly in the future (e.g., DTT users could be served using IPTV).

- Ultra-high frequency (UHF) spectrum: The spectrum within the frequency range of 300 to 3,000 MHz is known as the UHF spectrum. The ability to use the spectrum efficiently and how the spectrum is reused varies according to the network and to technology advancements. DTT occupies the UHF spectrum from

[123] In the International Telecommunication Union (ITU), the broadcasting service is defined as a radiocommunication service in which the transmissions are intended for direct reception by the general public. This service may include sound transmissions, television transmissions or other types of transmission.

470 – 694 MHz[124]. The lower propagation losses of the UHF spectrum help signal travel further compared to higher frequency bands, i.e. above 1 GHz, resulting in a larger coverage area. Therefore, the UHF spectrum is also in demand from other wireless communication systems.

- There is a growing demand for this spectrum from the mobile sector to extend its coverage in rural areas. For instance, the 800 MHz band (790 – 862 MHz) and the 700 MHz band (694-790 MHz), previously allocated to broadcast TV, were allocated to mobile service at the World Radio Conference 2012 (WRC-12) and WRC-15, respectively. Existing mobile network operators use these spectrum bands for 4G and 5G mobile services. The regulators also try to achieve some policy objectives through these licences. For instance, one of the 800 MHz licences carries an obligation to deliver indoor 2 Mbps data services to 98% of the population, and all operators have delivered similar coverage levels over time. On 27 April 2021, Ofcom awarded the 700 MHz band (694-790 MHz band) to mobile services in the UK, aligning with Europe and the rest of International Telecommunication Union (ITU) Region 1.[125]
- The UHF spectrum is also used by programme-making and special events (PMSE) applications such as wireless microphones, on a short-term, temporarily licensed basis.
- In the past, Ofcom has also allowed the 470-694 MHz band to be used for White Space Devices[126] (WSD) under a database-driven, licence-exempt regime.[127] White space devices will share the frequency band with the existing uses, such as DTT and PMSE, without causing harmful interference to these existing users. However, according to the latest information available from Ofcom, the TV WSD authorisation framework is no longer available in the UK.[128]

DTT network topology characterises the network's shape in terms of the distribution and the size of the transmission/cell sites. Today's broadcast network topology is based on a legacy system and method of consumption to suit viewers who watch TV in a linear fashion. Broadcast networks deliver programmes and content in a highly efficient way where the same content is delivered to many viewers simultaneously using a single channel. The DTT network consists of high-power high tower sites (HPHT) built at the most suitable locations to serve up to 98.5% of the population through fixed outdoor antennas. In many locations, it is also possible to receive DTT

[124] The band edge may differ from region to region. 470-694 MHz refers to the ITU region 1, which includes Europe, Africa and the Middle East.
[125] ITU Region 1 comprises Europe, Africa, Middle East and Russia.
[126] A common approach is to use a managed database that holds information on the location of DTT and PMSE users and whitespace devices. This information allows whitespace devices to access the spectrum not used by the existing spectrum users in some geographic regions and at different times.
[127] "TV white spaces, A consultation on white space device requirements", Ofcom, 22 November 2012 http://stakeholders.ofcom.org.uk/binaries/consultations/whitespaces/summary/condoc.pdf (last accessed Nov 6th 2024)
[128] Ofcom. *Radiocommunications licences*, https://www.ofcom.org.uk/manage-your-licence/radiocommunication-licences (last accessed Nov 6th 2024)

signals using an indoor antenna, such as a loop antenna on top of the TV set. Some HPHT masts that are used for broadcasting DTT are used for other services such as broadcast analogue and Digital Audio Broadcasting (DAB) radio signals. ‘This interdependence means that when changes happen to one platform, there are knock-on implications for the other. For example, any reduction in demand for masts from the TV sector could potentially shift more costs to radio providers.’[129]

The quality and/or coverage of DTT services heavily depends on the above characteristics of the networks. When the shape of demand is significantly mismatched to capacity, the potential for inefficiencies results, impacting the quality and/or coverage of the DTT services.

2.1.2 The role of spectrum and factors affecting coverage and quality

Quality and coverage are highly interdependent. The coverage area of a broadcasting station is defined as the region where the desired field strength of the broadcast signal is equivalent to or surpasses the operational field strength specified for a precise reception condition. The ITU report on characteristics of DTT broadcasting systems[130] provides some quality of service (QoS) requirements. Many administrations require terrestrial television broadcasting services to cover a high percentage of the population/households (e.g. in the UK, it is 98.5% of the population without a subscription[131]) or geographic regions (e.g. the entire country). This can be achieved by statutory requirements or by commercial agreements 'with all reception in the area defined by this coverage requirement essentially stipulated for continuous use to a specified time availability, within the hours of transmission’.

Within the broadcast service area, interference effects may reduce the signal quality below that needed to meet the coverage requirement of the broadcasting service. Examples of the way interference may affect TV reception are from ‘continental interference’ in summer, when signals from adjacent countries are stronger than usual due to atmospheric conditions, or by 4G mobile signals on adjacent frequencies interfering with existing TV receivers and their reception of broadcast services. A reduced ability to meet the coverage requirement effectively translates to a loss of access to broadcast receiving stations at the specified time availability. 'Broadcast service planning methods are based on meeting a prescribed coverage requirement'. In particular, 'the broadcast service delivery to the target population within the broadcast service area has been based on the expectation of signal quality with minimum interruption'.[132]

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[129] Ofcom consultation on *Future of TV Distribution*, (2023), https://www.ofcom.org.uk/__data/assets/pdf_file/0038/269777/Call-for-Evidence-Future-of-TV-Distribution.pdf (last accessed Nov 6th 2024)

[130] ITU Report ITU-R BT.2383-1. (2016) *Characteristics of digital terrestrial television broadcasting systems in the frequency band 470-862 MHz for frequency sharing/interference analysis* https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-BT.2383-1-2016-PDF-E.pdf (last accessed Nov 6th 2024)

[131] Ofcom consultation on Future of TV Distribution, (2023)

[132] Refer Recommendations ITU-R BT.500 and ITU-R BT.1735

DTT networks are usually designed to have a high-reliability requirement e.g. availability of 99.999% per year.[133] The requirement for other services such as broadband is usually lower i.e. 99.9%.[134] In TV broadcasting, several TV channels are usually multiplexed into a single 8 MHz channel before broadcasting. For multiplex services licensed under the Broadcasting Act 1996, service providers are required to observe the Ofcom Television Technical Performance Code,[135] which states that standards of reliability (measured in terms of service availability to viewers) must be maintained to levels as high as reasonably practicable. According to this code, the minimum standard of availability is 99.8% for viewers served by reference transmitters and 99.0% for other transmitters.

Like several other radiocommunication services, interference assessment for DTT broadcasting services is based on an interfering signal exceeding an annual 1% time-limit based upon a methodology that includes Recommendation ITU-R P.1546. Meeting this requirement required careful planning of parameters associated with technology, spectrum and topology, as given below:

1. Technology: DVB technology trends (i.e. coding and modulation techniques), transmitter and receiver characteristics including user devices.
2. Spectrum: spectrum band and the bandwidth.
3. Topology: Location of the broadcast towers, transmission power, antennas used, the height of the tower.

2.1.3 DVB technology trends and techniques to improve spectrum efficiency

This section provides an overview of the existing DTT broadcast technologies and their adoption in Europe.

Currently, there are four major standards of DTT in the world approved by the ITU[131]:

1. Advanced Television Systems Committee of the (ATSC)[136] used in North America, South Korea and parts of Central America.
2. Digital Video Broadcasting-Terrestrial (DVB-T)[137] used in Europe and elsewhere.

[133] Kenelm Deen. 2018. Arqiva https://www.arqiva.com/news-views/views/the-evolution-of-a-traditional-broadcast-infrastructure-provider (last accessed Nov 6th 2024)
[134] Report on Future benefits of broadband networks, https://nic.org.uk/app/uploads/Benefits-analysis.pdf (last accessed Nov 6th 2024)
[135] Ofcom Television Technical Performance Code, May 2023, https://www.ofcom.org.uk/__data/assets/pdf_file/0023/58910/tv_tech_platform_code.pdf (last accessed Nov 6th 2024)
[136] ATSC standards webpage, https://www.atsc.org/documents/atsc-1-0-standards/#:~:text=%E2%80%9CATSC%201.0%E2%80%9D%20is%20the%20designation,television%20and%20broadcast%20surround%20sound. (last accessed Nov 6th 2024)
[137] DVB project webpage, https://dvb.org/about/ (last accessed Nov 6th 2024)

3. Integrated Service Digital Broadcasting-Terrestrial (ISDB-T)[138] used in Japan.

4. Digital Television/Terrestrial Multimedia Broadcasting (DTMB)[139] used in China.

These standards have differences in their technical features and evolutions. However, there is relatively little difference in performance among like-for-like current state-of-the-art systems of DVB-T2, ISDB-T, ATSC and DTMB standards.

Europe has adopted the DVB-T standard, which was developed through the Digital Video Broadcasting Project (DVB). It is an industry-led consortium of 'broadcasters, manufacturers, network operators, software developers, regulatory bodies, content owners and others committed to designing global standards for delivering digital television and data services'.[140] The consortium came together in 1993 to provide global standardisation, interoperability and future-proof specifications. This research focuses on the digital terrestrial television broadcasting standards of DVB, which are most widely adopted in Europe, including in the UK. The initial version of the standard, DVB-T, evolved to a more advanced version known as DVB-T2, although both are used in the UK. DVB-T2, offers significant benefits (e.g. more capacity, spectral efficiency and robustness) compared to DVB-T standard[141] and includes many new techniques not previously used in the DVB family of standards. Many options and combinations of different parameters (e.g. support for additional bandwidth options, modulation/Forward Error Correction (FEC) rates, multiple carriers, and multiple guard intervals) have been deliberately retained to provide flexibility for the service providers. As a result of the advancements introduced in DVB-T2, the potential capacity gain that has been achieved in the UK is nearly 50% compared to DVB-T.

However, typical deployments use a small subset of the possible combinations.

Modernisation of the MPEG2 audio and video encoding technology, used for DVB-T services, to newer technologies (MPEG4 / H264 and HEVC) results in more efficient use of spectrum in terrestrial networks.[142] Figure 52 shows that the modern codecs provide higher compression efficiency. This modernisation provides more capacity, allowing standard definition (SD) channels to be replaced with high definition (HD)

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[138] ISDB-T. https://www.telecomabc.com/i/isdb-t.html (last accessed Nov 6th 2024)

[139] Documentation of DTMB standard http://www.dtnel.org/en/promotion/introduction/report/ (last accessed Nov 6th 2024)

[140] ETSI TS 102 831 V1.2.1 (2012-08) *Digital Video Broadcasting (DVB);Implementation guidelines for a second generation digital terrestrial television broadcasting system (DVB-T2),* https://www.etsi.org/deliver/etsi_ts/102800_102899/102831/01.02.01_60/ts_102831v010201p.pdf (last accessed Nov 6th 2024)

[141] ETSI EN 300 744: *Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television.* https://www.etsi.org/deliver/etsi_en/300700_300799/300744/01.06.01_40/en_300744v010601o.pdf (last accessed Nov 6th 2024)

[142] BrightlinkAV (2024) https://brightlinkav.com/blogs/news/mpeg-4-h-264-a-comprehensive-guide-to-the-widely-adopted-video-compression-standard (last accessed Nov 6th 2024)

versions and some Ultra High Definition (UHD) channels without significantly increasing the capacity requirements.

Figure 52: Resolution, and typical raw and compressed bit rates for video content.[143]

Resolution	Pixels (Horizontal x Vertical)	Typical raw bit rate	Typical average compressed bit rate	Compression ratio (compressed bitrate/raw bitrate)
SD	720 x 576	622 Mbps	2.9 Mbps (MPEG2)	214
HD	1920 x 1080	3.1 Gbps	4.9 Mbps (MPEG4)	633
UHD-4K	3840 x 2160	12.4 Gbps	22.5 Mbps (HEVC)	551
UHD-8K	7680 x 4320	49.8 Gbps	40.0 Mbps (HEVC)	1245

Source: Ofcom

2.1.3.1 DTT network implementation in single-frequency networks (SFN) and multi-frequency networks (MFN)

The UK DTT network is primarily a multi-frequency network (MFN), with frequencies reused at large spatial intervals between transmitters to avoid interference. Some DTT networks internationally use SFNs where the same signal is transmitted from multiple transmitter sites on the same frequency across the network. In the UK, the MFN is the network infrastructure directly inherited from the analogue era. However, SFNs are used within some UK regional networks. Since analogue TV signals had low robustness to interference, using the same frequency in two adjacent cells was impossible, to avoid interference in overlapping areas between adjacent transmitters. DVB-T and DVB-T2 are designed to be much more robust to interference, allowing SFN implementation. The main drawback of MFNs is their lower spectral efficiency: all the frequencies within one cell are unusable in adjacent cells, and many “holes” in the frequency plan must be managed, making the use of the frequency resource sub-optimal. SFNs can use the same frequency between adjacent cells, making them much more spectrally efficient.

SFNs allow a much more efficient use of the scarce spectrum resource. By migrating from MFNs to SFNs, significant gains in spectral efficiency might be expected for certain scenarios. Due to its improved robustness to multipath propagation, DVB-T2 drastically relaxes the constraints on SFN implementation. Moreover, by permitting longer guard intervals, DVB-T2 allows for much larger-cell SFN network architectures than its predecessor.

Unlike many other countries, Italy uses SFN networks for TV broadcasting, which greatly increases the number of channels carried. There were many unlicensed analogue TV channels operating in Italy, requiring SFNs to accommodate these channels after switch over to all digital broadcasting. The UK network also uses

[143] Technology Futures Spotlight on the technologies shaping communications for the future, January 2021, https://www.ofcom.org.uk/__data/assets/pdf_file/0011/211115/report-emerging-technologies.pdf (last accessed Nov 6th 2024)

medium-power SFNs in a small number of cases where one master transmission site is synchronised with its in-fill transmitters. Despite having many debates, the UK has no plans to migrate to the widespread use of SFNs. It requires reallocating spectrum in different localities. In the UK, there are many regional broadcasters. There is a good case for migrating to SFNs on regional basis for more efficient use of spectrum for regional channels, and to national SFNs for non-regional channels. However, there are significant costs and operational demands associated with this migration.

2.1.3.2 Status of the UK DTT network and migration considerations to DVB-T2

The current DTT network in the UK includes six multiplexes of TV content, including three for public service broadcasting and three for commercial broadcasters.

The European Broadcasting Union (EBU) report on frequency and network planning aspects of DVB-T2[144] mentioned three main factors that determined the UK mode for DVB-T2:

1. Maintenance of public service broadcasters' (PSB) coverage requirement (i.e. by 98.5% of the UK population) based on DVB-T after the Digital Switch Over (DSO).
2. Re-use of existing broadcast infrastructure for practicality and to reduce implementation costs (a commercial requirement of the T2 specification). This requirement implies using the same Effective Radiated Power (ERP)[145] and antenna patterns as proposed for the upgraded DVB-T2 multiplex.
3. Maximum capacity.

At the time of the Digital Switch Over and the start of HD transmissions, the UK made two important decisions on how it was carried out. One of them was not changing the downlead (the connection from the TV antenna to the TV receiver) requirements at home to minimise the changes at the receiving end. This means users were only required to change their TV receiver to one capable of receiving digital signals or HD channels. The second was to retain existing transmitter sites, so that roof-top aerials did not need to be repointed to a different transmitter site.

Despite the significant capacity and spectrum efficiency gains made possible by migrating to DVB-T2, in the UK, many broadcasters still use DVB-T, which was introduced in the 1990s together with MPEG2 video encoding. Some broadcasters have migrated to DVB-T2 for their HD channels, but their SD channels continue to be carried on multiplexes using DVB-T and MPEG2.

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[144] EBU. *Frequency and network planning aspect of DVB-T2, EBU Status report, Version 4.1.2*, January 2020, https://tech.ebu.ch/docs/tech/tech3348.pdf (last accessed Nov 6th 2024)

[145] The effective radiated power (ERP) of an antenna in a specific direction is the power that will need to be supplied to a reference antenna to produce the same power this antenna is producing in this direction, https://www.sciencedirect.com/topics/computer-science/effective-radiated-power (last accessed Nov 6th 2024)

Most EU countries have migrated or have plans to migrate to all DVB-T2 broadcasts. The UK is therefore lagging, compared to most other European countries (as is discussed further in the International Comparisons section below) and has yet to make plans to replace the remaining DVB-T / MPEG2 services with much more efficient technologies. By adopting DVB-T2 and HEVC together, efficiency gains of 100% or more can be achieved. There are strong technical and economic arguments for a full migration, should there be the political and regulatory will to migrate to DVB-T2.

Certainty about the DTT platform is likely to be necessary to maintain DTT delivery efficiency, which is important for maintaining investment and confidence in its future. For this reason, the UK Government has put in place legislation to enable Freeview licence extensions until 2034, subject to a break clause in 2030[147] Ofcom maintains that there is a need for DTT to continue until at least 2030 and probably beyond, in the UK. The policy paper Up Next - the government's vision for the broadcasting sector - [146] in April 2022, mentioned that the government will ask Ofcom to continue to track changes to DTT viewing and to undertake an early review of market changes that may affect the future of content distribution before the end of 2025. In the same paper, the government stated that they will consult on options and take actions to make changes to the local TV licensing regime to enable the extension of the local TV multiplex licences until 2034, subject to the same conditions that apply to the national DTT multiplexes.

Ofcom recently published its Early Market Report to the Government on the Future of TV Distribution, highlighting the broad directions of travel that could sustain the universal TV provision. [147] Ofcom has identified three broad approaches to the future of DTT for industry and Government to consider:

1. Investment in a more efficient DTT service
2. Reduce DTT down to a core service (known as a 'nightlight')
3. Move towards DTT switch-off over the 2030s.

Ofcom also mentioned that a clear and timely vision is required to ensure the support of audiences and give investors certainty. Further, 'options that rely on replanning the DTT broadcast frequencies or a complex initiative to roll out and increase broadband take-up would take 8-10 years to plan and execute. With many multiplex licences expiring in 2034 and some sooner, the need for certainty about the future approach to DTT by 2026 is increasingly pressing, in line with the Government's current planned work'.

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[146] The Policy paper published by the Government on Up next - the government's vision for the broadcasting sector, Updated 29 April 2022, https://www.gov.uk/government/publications/up-next-the-governments-vision-for-the-broadcasting-sector/up-next-the-governments-vision-for-the-broadcasting-sector (last accessed Nov 6th 2024)

[147] Ofcom. *Future of TV Distribution, Early market report to Government*, 2024, https://www.ofcom.org.uk/__data/assets/pdf_file/0024/285018/Future-of-TV-Distribution-Report-to-Government.pdf (last accessed Nov 6th 2024)

Changes to how TV is delivered are relevant to several of Ofcom's statutory duties, including maintaining broadcast standards to protect audiences, regulation ,[148] managing the optimal use of radio-spectrum, and promoting the availability of high quality, resilient broadband networks. In the consultation, Ofcom sought views from stakeholders on the 'financial health and prospects of free-to-view platforms to deliver TV to audiences'. It also explores whether, 'through commercial pressures or policy preference, a managed move of free-to-view TV to internet distribution is likely or desirable and what such a move would require of industry, the Government, and regulatory support'.

2.1.3.3 Other options that could improve the spectrum efficiency

A new system concept for DTT, known as WiB (wideband broadcasting) technology, was proposed in a 2016 paper.[149] The paper proposed that the entire UHF spectrum be allocated to TV broadcasting as a single multiplex and operating as a single frequency network, allowing a reduction in transmission power (of up to 90%) and a significant (37-60%) increase in capacity. According to this proposal, the interference from adjacent transmitters operating on the same frequency while transmitting different information is mitigated by a robust transmission mode, directional discrimination of the receiving antenna and interference cancellation methods. This approach provides a higher spectrum utilisation for the same coverage as the current DTT network. The paper also outlines further possible developments of WiB, e.g. doubling the capacity via cross-polar Multiple In Multiple Out (MIMO), backward-compatible with existing receiving antennas, and adding a second, WiB-mobile, Layer Division Multiplexing (LDM) layer within the same spectrum, either as mobile broadcast or as mobile broadband. Implementing WiB requires a complete reengineering of the DTT network, resulting in a significant cost. The commercial review of the WiB Study Mission has concluded that there is insufficient market interest in WiB for it to be taken further at the time of the review.[150]

Currently, DTT mainly uses horizontal polarisation.[151] Technically, it is possible to use both horizontal and vertical polarisation modes for TV reception, increasing the spectrum efficiency, but it is at the expense of complexity. For instance, it requires two downleads from the antenna to the TV receiver. Consequently, if the signal is transmitted using both polarisation techniques to improve spectrum efficiency, all

[148] The PSBs are the BBC, the Channel 3 services, Channel 4, Channel 5, and S4C.

[149] WiB – *a new system concept for digital terrestrial television (DTT)* E. Stare1, J.J. Giménez2,, P. Klenner3, published in *The Best of IET and IBC* 2016-2017, https://www.theiet.org/media/9531/the-best-of-iet-and-ibc-2016.pdf (last accessed Nov 6th 2024)

[150] DVB. *Commercial Review of WiB CM-WiB Study Mission Report*, June 2018, https://dvb.org/wp-content/uploads/2020/01/201809_dvb_wib_reports.pdf (last accessed Nov 6th 2024)

[151] The direction of the electric field vector specifies the polarization of the antenna. In horizontal polarization, the electric field vector of an electromagnetic (EM) wave is parallel to the earth. In vertical polarization, the electric field vector of an EM wave is perpendicular to the earth. For a communication link to work effectively, both transmitting and receiving antennas should be in the same polarization.

households would require an additional downlead from the antenna, resulting in increased costs at the user end.

The following table provides a view of feature combinations currently used or feasible with each DTT delivery technology.

Figure 53: Realistic combinations of technology features

DTT delivery Technology	Features					
	MPEG2	MPEG4	HEVC	Regional SFN	National SFN	Comments
DVB-T	**X**	x		x		Used for SD in the UK
DVB-T2		**X**	x	x	x	Used for HD in the UK
WiB			x	x	x	Not economically viable

Key:

X = currently used in the UK; x = feasible to use

2.2 Technological barriers and enablers to IPTV uptake

2.2.1 Introduction: Getting IP video to the TV set

2.2.1.1 IPTV technical background

During the early days of broadband, most internet connections were not fast enough to support a “stream” of video, meaning most video was downloaded to be watched when fully (or partially) delivered. As broadband speeds increased, and video compression improved, it became possible to support “live” streams of Over the Top (OTT) video over the open internet. However, due to high contention ratios,[152] where multiple customers share a limited amount of bandwidth leading to lower delivered bandwidth at peak times, internet service providers (ISPs) were unable to support reliably a large number of customers streaming video at the same time.

As a more reliable alternative to OTT video, some ISPs introduced multicast IPTV services. These required the deployment of special equipment within the ISPs’ network and a dedicated Set-top Box (STB) within the customer’s home but allowed many customers simultaneously to receive live streams of video.

During the 2000s and early 2010s, the launches of OTT streaming services such as BBC iPlayer and Netflix drove rapid growth of OTT IP video delivery. The growth of

[152] The contention ratio is the ratio of total available bandwidth to the maximum theoretical demand for bandwidth – e.g. if 100 households have a 4Mbit/s connection, and the ISP provides a total of 20Mbit/s across those households, the contention ratio is 20:1 (400Mbit/s ÷ 20Mbit/s); in other words, only 5 of the 100 households can use their full bandwidth at the same time.

these services was supported by two key developments: 1) the deployment and use of content delivery networks (CDNs), and 2) the increasing standardisation of OTT video delivery.[153]

CDNs moved the source of video content closer to the customer and reduced the volume of traffic flowing through the core parts of ISPs' networks, increasing reliability.

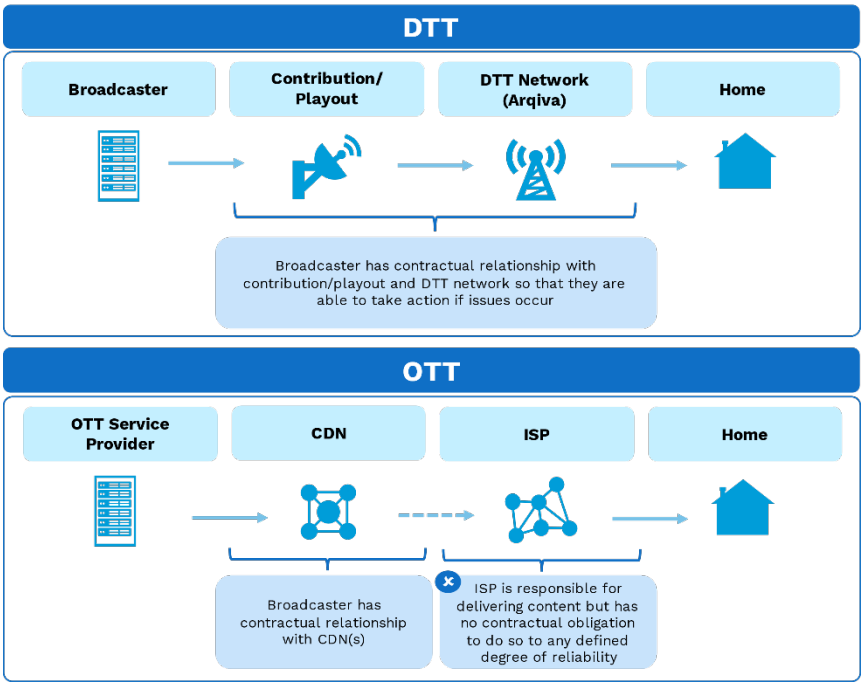
Standardisation meant that it became easier for any device to support any service, making it simpler for customers to access the service of their choice on the screen of their choice.

In 2024, the IPTV ecosystem can now be described as mature, with high penetration of services, and standardised approaches to service delivery.

2.2.1.2 Service provider control

One of the key differences between a traditional broadcast service and OTT IPTV service is the level of control that the service provider has over the end-to-end distribution of service content, as shown in Figure 54 below.

Figure 54: Diagram of distribution comparing broadcast to OTT



Source: Cartesian

OTT service providers generally control, either directly or contractually:

- The OTT backend platform (the software responsible for controlling the service's content and how it is made available to its customers, including

[153] Cloudfare, *What is a content delivery network (CDN)? | How do CDNs work?,* https://www.cloudflare.com/en-gb/learning/cdn/what-is-a-cdn/ (accessed 6th Nov 2024)

functions such as content curation, search/recommendations, and subscription management).

- The service client/frontend (the website and/or applications that the service's customers use to access content).
- The delivery of content to the CDN (the content delivery network used to position the source of content as close to the user as possible) and the operation of the CDN (we explain CDN usage in more detail in later sections).

All other parts of OTT distribution are typically outside the control of the service provider. This includes:

- The distribution of content through ISPs' core networks from the CDN to the user.
- The suitability and reliability of a customer's broadband connection (the ISP's access network).
- Distribution of IP content to the end device in the home (home networking), including Wi-Fi performance.

For an IPTV service using multicast distribution (as described later in this section), the service provider also has control over the core network, but not over the access and home network.

This lack of control in key parts of the distribution chain has significant implications for the quality and reliability of IPTV delivery, acting as a potential barrier to the delivery of IPTV. Effectively, the IPTV service provider is at the mercy of the "best efforts" of a variety of ISPs to deliver its content from the CDN to the home. Hence, performance of the core and access networks are dependent on commercial decisions as well as technical ones. To a certain extent this also applies to Wi-Fi and home networking, where the ISP can help the customer to improve Wi-Fi performance by providing better equipment and optimally configuring that equipment, but even here, environmental factors (such as size/construction of home and population density) place Wi-Fi performance outside the control of the ISP.

The technical enablers and barriers to performance in each of these areas are detailed in this section and we have highlighted where commercial considerations should be taken into account.

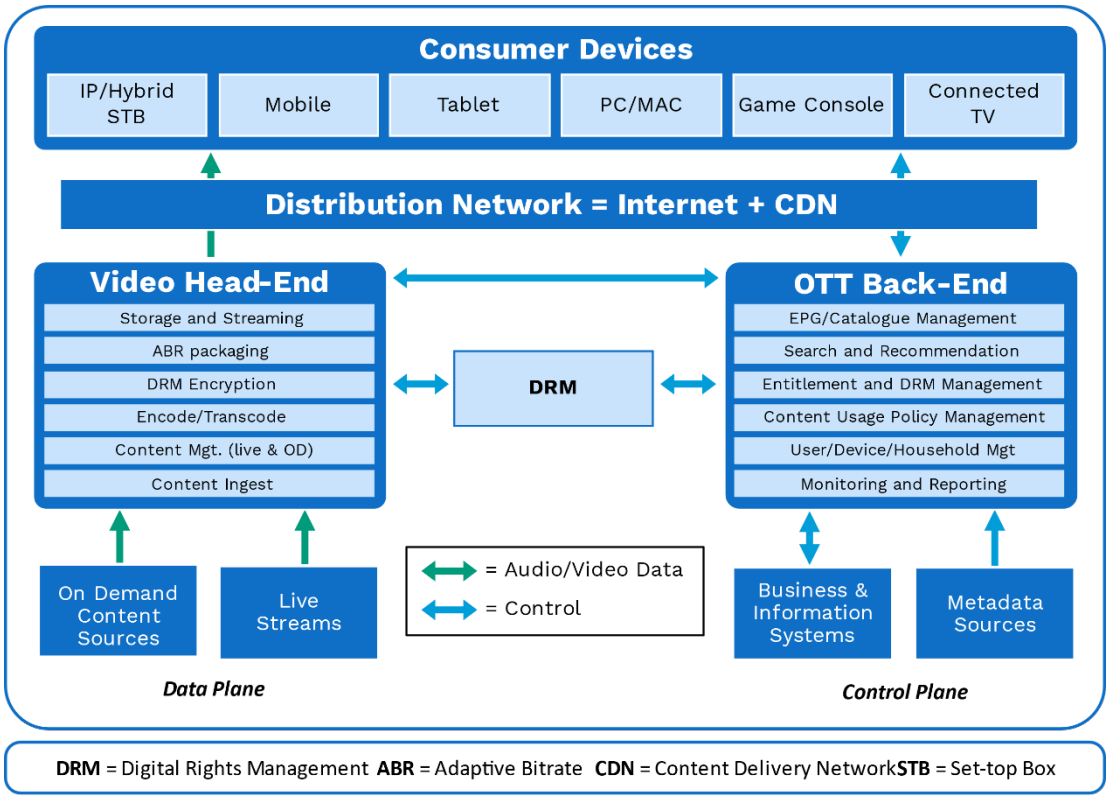
2.2.2 Technical barriers and enablers to IPTV uptake

2.2.2.1 Platform

The technical development of IPTV platforms has acted as an enabler of the uptake of IPTV services.

Early OTT service providers often built entire platforms from scratch, at great expense, covering all or most of the key components, from video processing to search and recommendations, as shown in Figure 55.

Figure 55: Typical OTT platform components



Source: Cartesian

New platforms can now be launched more easily and at a much lower cost due to several factors:

1) The availability of many end-to-end white label OTT platforms, providing "ready-to-go" platforms, albeit with a varying ability to customise the platform.[154]

2) The availability of many mature off-the-shelf components covering each of the requirements of an OTT platform (as shown in Figure 55).

3) The growth of cloud computing, which can simplify the deployment and scalability of components.[155]

When considering the operation of an IPTV service at scale, the growth of cloud computing is particularly important. If configured appropriately, cloud computing enables rapid, on-demand expansion of capacity for a service at times of unusually high demand.

[154] Ventuno, *Whitelabel OTT Platform*, https://blog.ventunotech.com/glossary/whitelabel-ott/ (accessed Nov 6th 2024)
[155] S. Susnjara, I. Smalley, *What is cloud computing*?, *IBM,* https://www.ibm.com/topics/cloud-computing (accessed Nov 6th 2024)

2.2.2.2 *Service*

The traditional broadcast TV ecosystem is reliant on service operators that aggregate content from multiple content providers. These include Pay TV platforms, such as satellite and cable providers (e.g. Sky or Virgin in the UK), and consortia responsible for running free TV platforms such as DTT or Free Satellite (e.g. Freeview or Freesat in the UK).

In the OTT world, it is easier for content providers to make their content available to consumers without the need for an aggregator, through D2C (Direct to Consumer) models. Their services can be accessed through a dedicated website and bespoke applications which run on a range of devices. Most major OTT services follow this model, including those from the UK PSBs and commercial SVOD services.

Some aggregation of these services is performed by Pay TV operators and TV/device manufacturers, although the nature of this aggregation is not standardised, including:

- How content from different providers is presented.
- How content from different providers is discovered (through search and recommendation).
- How content is played back once selected (e.g. by launching a dedicated application, or by playing back within the aggregator's application).

Discovery of content, in particular, is usually a fragmented experience, acting as a potential barrier to IPTV uptake. For instance, TV manufacturers run operating systems (such as LG's WebOS and Samsung's Tizen) that provide access to applications from most content providers, but do not provide universal search and recommendation of all content across those providers. To do so, they would need specific agreements with all content providers to make metadata available – even then, usage data from within the application is unlikely to be shared with the manufacturer, meaning that personalised recommendations are not possible in the aggregated environment.

Our Audience Analysis sections suggests that a more uniform user experience that is not limited to Pay TV services would be an enabler to more widespread uptake of IPTV.

Requirements for such a technical initiative include:

- Standardisation and centralisation of content metadata enabling the platform to perform content discovery across multiple providers.
- Widespread presence of the aggregated service software on devices available to the UK public (either through applications on smart TVs or devices that can be connected to TVs).

The second of these requirements (widespread device presence) faces the barrier of the range of operating systems used by TV manufacturers. Using existing standards

where possible, rather than creating a fully bespoke application, can help solve this problem.

In section 2.3, we discuss initiatives in the UK that are targeting this challenge, including the proposed Freely TV service from Everyone TV.

Any proposed service, such as Freely, also faces the barrier of availability on secondary TV sets in the home. There are two key requirements that are enablers allowing services to be made available to these sets:

- Good home networking connectivity (covered in subsequent sections of this report).
- The availability of IPTV devices that can be plugged into legacy TV sets.

2.2.2.3 Compression/Bitrates

The ability of IP video to be delivered through the core, access and in-home networks has historically been heavily influenced by the bitrate of the content being delivered.

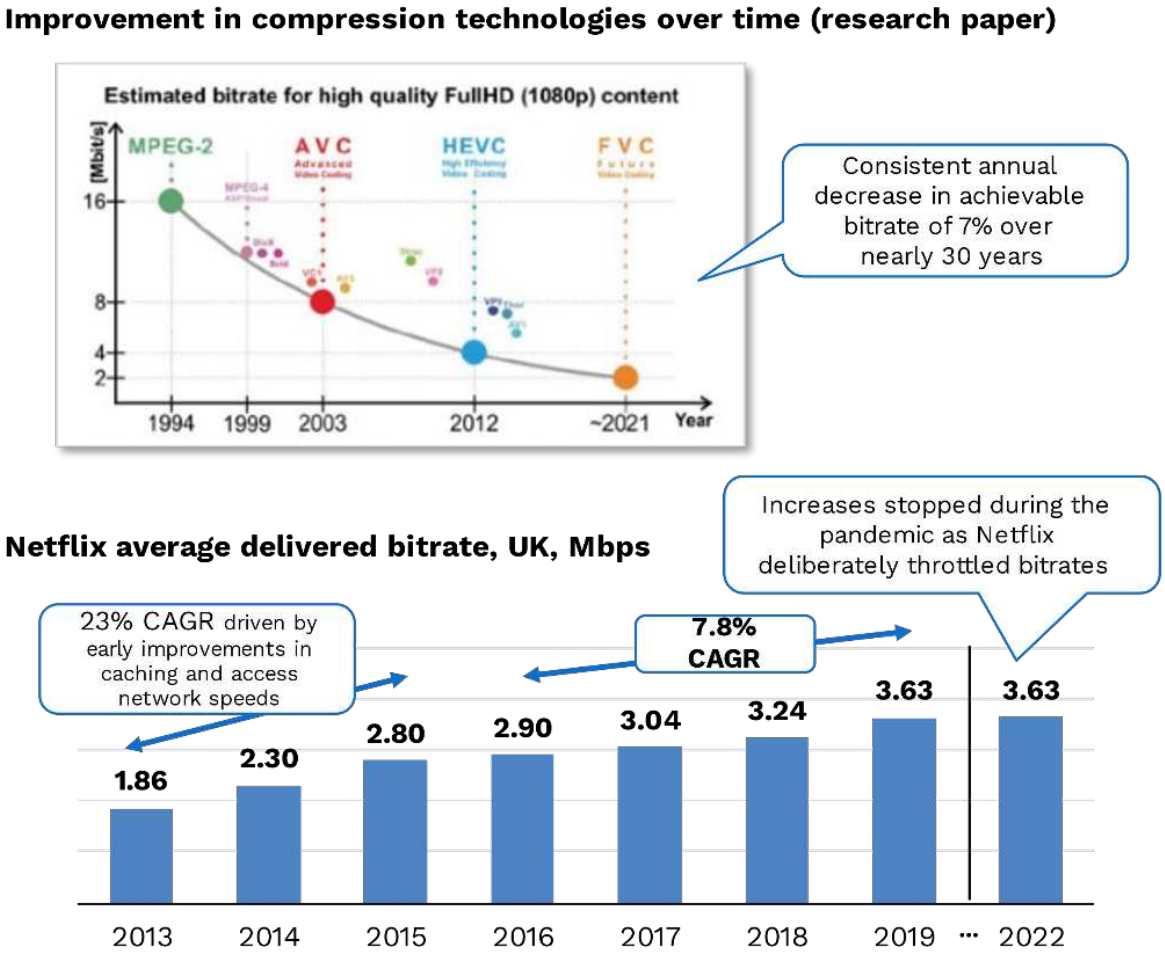
Historically, bitrate changes have been driven by a combination of: 1) improvements in access networks enabling delivery of higher bitrate streams; 2) improvements in compression enabling delivery of lower bitrates at a given quality; 3) increases in requested quality/resolution due to the rollout of HD/4K/HDR technologies.

The combination of these factors has led to a steady increase in delivered bitrate over time, although the rate of increase has slowed in recent years, and indeed halted during the Covid pandemic, as service providers throttled bitrates.[156] We have also seen reports that demand for 4K quality is beginning to saturate.[157]

Figure 56 below shows the combined impacts of these drivers on Netflix's delivered bitrate. Note that the reported Netflix delivered bitrates are per stream, not per subscriber, so they include the effect of an increasing share of streams being delivered in 4K/HDR, but not the effect of subscribers using multiple streams in parallel.

[156] BBC News, '*Netflix to cut streaming quality in Europe for 30 days,*' https://www.bbc.co.uk/news/technology-51968302 2020, (accessed Nov 6th 2024)
[157] D. Rayburn, '*Rate of Video Traffic Growth Declining Across CDNs and ISPs As OTT Services Optimize Encoding Bitrates, See Little Demand for 4K Quality*,' *Streaming Media Blog* (24th August 2022), https://www.streamingmediablog.com/2022/08/traffic-growth-cdn.html (accessed Nov 6th 2024)

Figure 56: Increase in video bitrates



Source: "20 Years of Progress in Video Compression – from MPEG-1 to MPEG-H HEVC": Karkowski, Grajek et al; Netflix; Cartesian

When considering the impact of bitrates on quality and reliability of service it is critical to take into account that all modern OTT services use Adaptive Bitrate (ABR)[158] streaming which enables the service to dynamically change the bitrate of the delivered content depending on the quality of the user's connection and the capabilities of the user's device.

This means that congestion at any point in the delivery process (see next sections) does not necessarily lead to outright failure of the stream but may simply lead to a decrease in delivered bitrate – the resultant change in quality for the user could range from imperceptible to significant picture degradation, depending on the level of congestion.

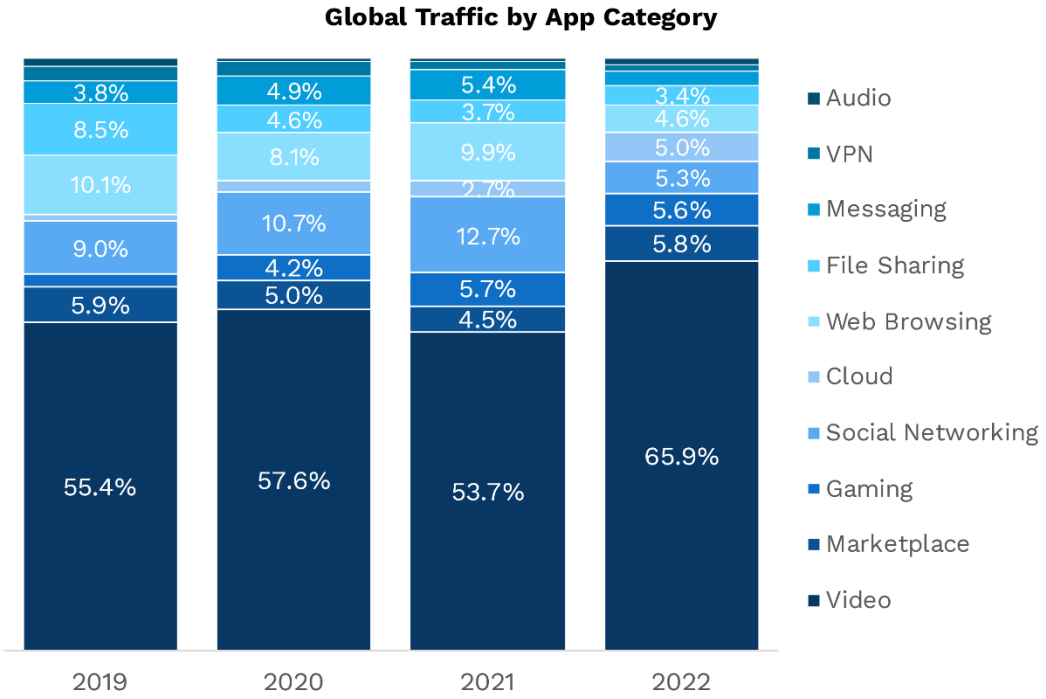
[158] AWS Whitepaper - *Amazon CloudFront for Media*, AWS, p.3, https://docs.aws.amazon.com/pdfs/whitepapers/latest/amazon-cloudfront-media/amazon-cloudfront-media.pdf#streaming-techniques-for-media (accessed Nov 6th 2024)

2.2.2.4 Load on the core network

One potential barrier to IPTV performance is congestion in the core network. OTT video delivery has been the main driver of overall IP traffic in recent years. The application and network intelligence company Sandvine measure internet traffic and, in their most recent global internet phenomena report, have stated that in the first half of 2022, video accounted for 65.93% of total data volume over the Internet, a 12 percentage point increase over the same period a year earlier.[159]

Sandvine data for global traffic by application category is shown in Figure 57.

Figure 57: Video/non-video traffic growth



Source: Sandvine, Cartesian

Telecoms operators have had continuously to increase the capacity of their networks to enable them to meet this demand.

To understand the impact on performance, we need to understand the impact of IP video traffic on peak traffic volumes. Telecoms network operators typically plan the capacity of their core networks such that average peak traffic does not exceed a certain percentage threshold of available capacity (e.g. 80%). This provides some headroom for unusual traffic peaks.

[159] Sandvine, *'The Global Internet Phenomena Report January 2023,'* pp 10-14, https://www.sandvine.com/hubfs/Sandvine_Redesign_2019/Downloads/2023/reports/Sandvine%20GIPR%202023.pdf?hsCtaTracking=3cbc04da-fd44-481b-ad03-811d23b7b2c5%7C131df09f-dbdd-41a0-9dce-aac8879403ff ; "Video" includes TV, video, and streaming download (last accessed Nov 6th 2024)

A TalkTalk press release[160] from 2023 revealed its peak traffic growth from 2020 to 2023, and its forecast growth until 2027. While the Covid-19 pandemic caused previously un-seen levels of daytime internet traffic, TalkTalk's peak traffic has increased year on year since, growing from peak traffic of 7.64Tbps in 2020 to 10.25Tbps in early 2023, a growth rate of around 10% per annum. The ISP predicts that peak traffic will reach 17.94Tbps in 2027, equivalent to a growth rate from 2023-2027 of 13% per annum.

Additionally, network operators need to plan for suitable redundancy. This often means that networks are designed such that if a connection fails, backup connections will not themselves exceed the peak traffic threshold.

Network operators typically forecast growth of peak traffic on their networks and plan ahead as appropriate, enabling them to ensure that the lead times for the installation of new capacity do not lead to traffic exceeding thresholds.

However, it is critical to note that the capacity and associated reliability of telecoms networks is a commercial and operational decision, dependent on the operator's desire to ensure a certain quality of service for its customers, which could act as a potential barrier to IPTV performance.

Any given OTT service will rely on the distribution of its content by a wide variety of network operators, each with its own operational and commercial objectives.

There are several important enablers for ensuring sufficient capacity in the core network. These can be split into two categories:

1) Increasing network capacity at a higher rate than the growth of IPTV peak traffic (network capacity expansion).

2) Decreasing the IPTV traffic load on the core network (CDNs and multicast).

2.2.2.5 Network capacity expansion

Increases in network capacity are driven by demand (peak traffic) and supply (the ability to install higher capacity for lower costs).

The performance and price of network components generally follows Moore's Law – i.e. the capacity of a network component available at a given price grows at an exponential rate, at around 40% per year, or roughly doubling every 2 years.

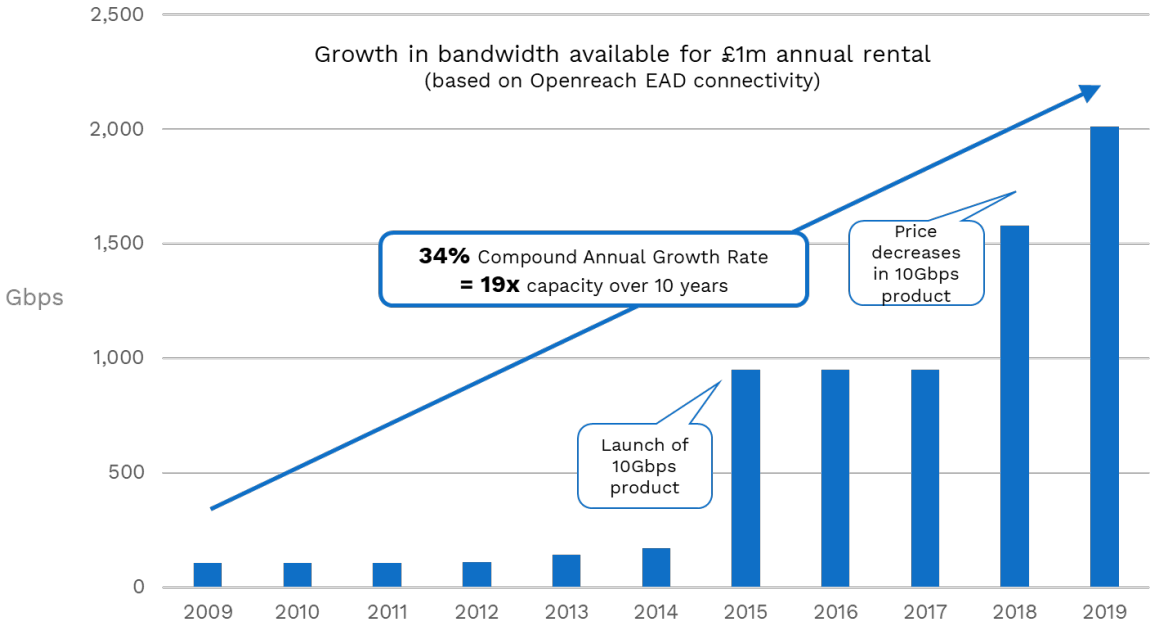
Ofcom's "Technology Futures" report supports this trend, with research showing the consistently exponential growth of fibre capacity over time, although commercial systems lag behind research systems. Ofcom says that this trend is set to continue, with new technologies such as space division multiplexing, hollow core, and

[160] Talk Talk Group, *'2023 peak internet traffic forecast to rise by a fifth as post-pandemic demand continues to grow due to streaming and gaming updates*,' (2023) https://www.talktalkgroup.com/newsroom/2023-peak-internet-traffic-forecast-to-rise-by-a-fifth-as-post-pandemic-demand-continues-to-grow-due-to-streaming-and-gaming-updates (last accessed Nov 6th 2024).

improved optical fibre amplifiers allowing more complex networks and increased capacity, acting as an IPTV enabler. Ofcom, however, does mention some physical barriers, with an argument that, despite technological developments, the cost of installation is more resistant to productivity improvements than digital elements.[161]

Cartesian has performed an analysis of Openreach pricing to understand the impact on costs for telcos over time (see Figure 58 below). Over a ten-year period, the capacity of Openreach EAD[162] connectivity purchasable for £1 million increased by nineteen times, or 34% per annum, demonstrating the exponential gains in capacity to cost ratio, a key enabler for capacity growth.

Figure 58: Growth in bandwidth affordability 2009-2019



Source: Openreach, Cartesian analysis

Additionally, new optics technologies enable the process of upgrading capacity to be easier and cheaper.

For example, Optical Wavelength products provide multiple connections over a single optic fibre, meaning that operators can purchase additional capacity without needing to make new physical connections.[163]

[161] Ofcom 'Technology Futures Spotlight on the technologies shaping communications for the future,' (2021), https://www.ofcom.org.uk/siteassets/resources/documents/consultations/category-2-6-weeks/198737-emerging-technologies/associated-documents/report-emerging-technologies.pdf?v=325824 (last accessed Nov 6th 2024)

[162] EAD = an Openreach Ethernet product operating over fibre optic cables.

[163] A. Zola, *'Definition, Dense wavelength-division multiplexing (DWDM),' Tech Target*, https://www.techtarget.com/searchnetworking/definition/dense-wavelength-division-multiplexing-DWDM (last accessed Nov 6th 2024)

2.2.2.6 Content Delivery Networks (CDNs)

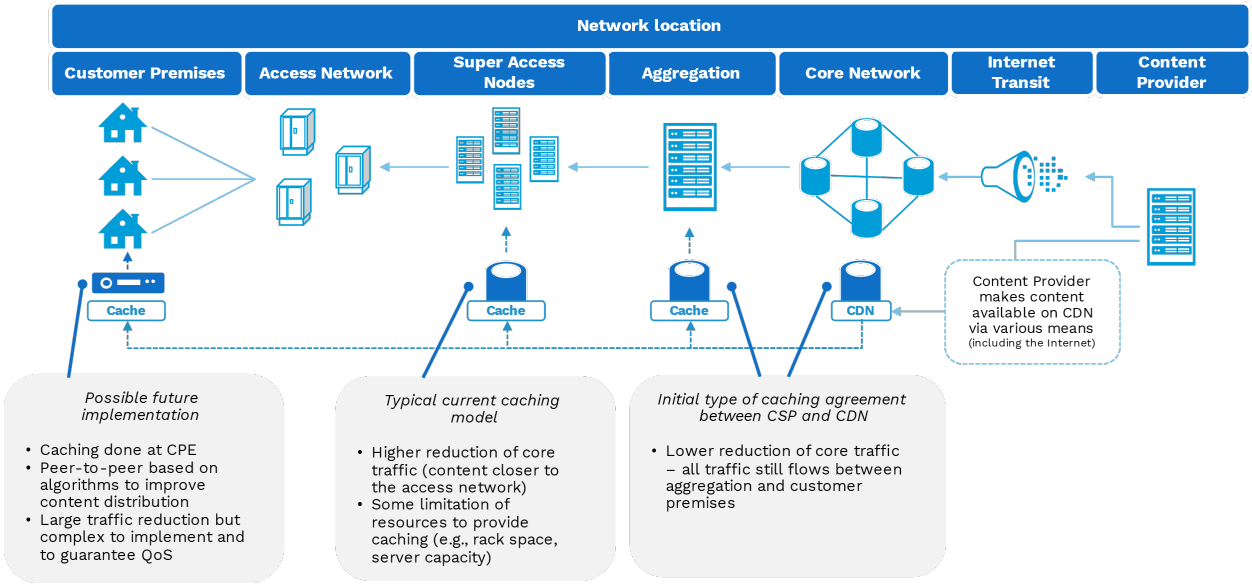
CDNs are IPTV enablers, moving the source of content closer (in network terms) to the end user. A CDN is a set of content caches that are distributed at various points in telecoms operators' networks.

For OTT IPTV service providers, CDNs increase the quality of their service by reducing reliance on third-party network operators and reducing the length of the connection between user and content source.

For operators, CDNs reduce the volume of traffic in their core networks (depending on the location of CDN caches).

As shown in Figure 59, the closer that the cache is placed to the customer premises, the larger the decrease in core network traffic and increase in quality.

Figure 59: Typical CDN topologies and associated impact



Source: Cartesian

CDNs are generally divided into two types:

1) Self-built CDNs
2) Commercial CDNs

Self-built CDNs are built by the providers of the OTT (or other content) services. Typically, these are restricted to large global players due to the investment required (for example, Netflix, Google, Meta and Amazon all operate global self-built CDNs).

Operating a self-built CDN provides a high level of control over quality of service.

Commercial CDNs are operated by a wide range of suppliers, each with a network of caches that can be used as a service by OTT service providers. Often multiple CDNs are used by a single service provider, using Multi CDN services. This can provide

additional quality by automatically choosing the optimum CDN provider and cache location for a given user and providing redundancy in the event of an outage.

Many broadcasters use a combination of self-built CDNs (e.g. to meet their base load of demand) and commercial CDNs to meet a share of the total, including peaks in demand.

2.2.2.6.1 Scalability of CDNs

One potential barrier to the impact of CDNs is scalability and the difficulties that can occur if too many people try to access CDNs.

The BBC discusses how it distributes live TV over the internet in an R&D article[164] on its website. BBC iPlayer uses CDNs to 'provide a tree of web caches that pull content from the BBC's origin servers and serve it closer to end consumers,' allowing it to simultaneously serve a large number of viewers. However, Ultra High Definition TV creates issues due to the high bitrates required, which consume large amounts of capacity in CDNs. For this reason, the BBC placed limits on the UHD audience for their 2018 World Cup and Wimbledon Centre Court HD streams. In the article, the BBC acknowledged that, while CDNs can effectively distribute pre-recorded content on demand, they believe a different method would be required for popular live content 'in a future where all live television is distributed over IP networks,' and they proceed to discuss a hypothetical hybrid CDN/multicast (see next section) distribution model.

Recent years have seen CDN providers develop solutions enabling them to deal with unpredictable demand. For example, the use of multi-CDN architecture to ensure redundancy.[165] In a post on its website,[166] CDN provider Edgio discusses techniques such as partial cache sharing, cache fill wait time and hot filing, which it uses to maintain optimum service when delivering live events and to cope with sudden surges of demand to its CDN caches.

2.2.2.7 Multicast

Multicast is a technology which acts as an enabler of IPTV by reducing traffic in the core network when multiple users view the same piece of content simultaneously.[167] It can also deliver a consistent quality of video content at all times, including during peak demand.

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[164] BBC Research and Development '*Dynamic Adaptive Streaming over IP Multicast, Distributing live television at scale over the Internet,*', https://www.bbc.co.uk/rd/projects/dynamic-adaptive-streaming-ip-multicast-dasm (last accessed Nov 6th 2024)

[165] 'CDNs: Best Practices for Scalability in Video Streaming,' *CacheFly,* 7th January 2024, https://www.cachefly.com/news/cdns-best-practices-for-scalability-in-video-streaming/ (last accessed Nov 6th 2024)

[166] C. Russel, 'Optimizing the CDN for Live Streaming,' *Edgio,* 7th October 2019, https://edg.io/technical-articles/optimizing-the-cdn-for-live-streaming/ (last accessed Nov 6th 2024)

[167] 'What is Multicast?,' *Ionos*, https://www.ionos.co.uk/digitalguide/server/know-how/multicast/ (last accessed Nov 6th 2024)

Where multiple users who are connected to the same network node are watching the same stream, that stream only needs to be delivered to the node once.

A potential barrier to multicast rollout is that it is only available where compatible equipment has been installed in the telecom operator's network and in the customer premises, although it is possible to configure networks so that a multicast-delivered stream can be viewed using a unicast device.

This means that multicast is typically only relevant to a service managed in some way by the telecom operator itself, and so cannot be applied uniformly across OTT services in general, which operate across multiple networks that the service provider has no commercial relationship with.

Multicast ABR is a recent development that aims to act as an enabler, bringing multicast technology up to date by replacing the MPEG Transport Stream container in a traditional multicast deployment with an Adaptive Bitrate (ABR) stream, using the MPEG-DASH protocol (see Figure 60 below).[168]

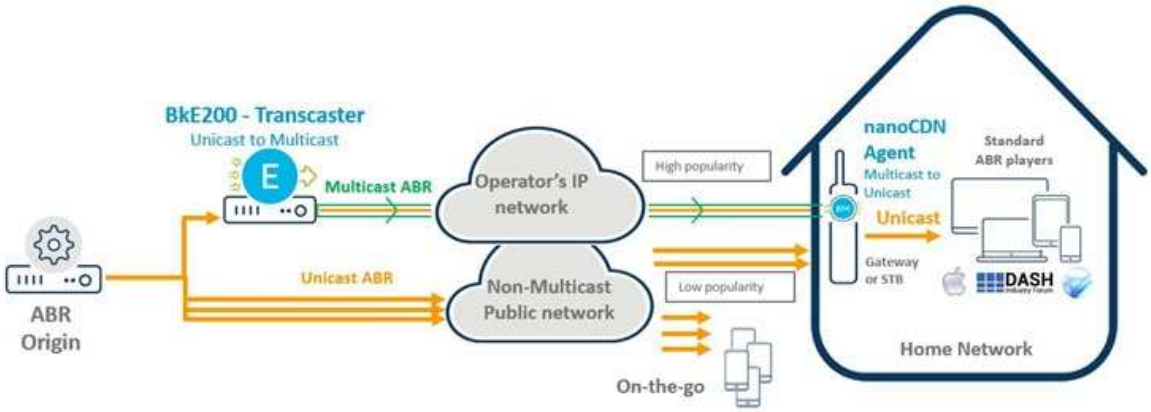
Theoretical bandwidth savings compared to unicast are the same as in legacy multicast, scaling with the number of concurrent views of specific content, but with several additional benefits:

- CDNs and client devices "see" unicast ABR streams so do not need to have implemented the technology.
- Latency can be reduced vs. unicast streams.
- In an environment with multiple live streams (e.g. a pub showing sport), multicast streams will be delivered simultaneously.

Legacy multicast equipment can continue to be used in the network. New equipment needs to be installed 1) between the CDN and the network to convert unicast to multicast, and 2) in the customer premises to convert back to unicast. The second of these conversions can be performed in the home's modem/router, meaning that customers can continue to watch services on unicast-only devices (e.g. laptops, phones) without those devices needing to support multicast themselves.

[168] 'Our Solutions, Multicast ABR,' *Broadpeak,* https://broadpeak.tv/our-solutions/multicast-abr/ (last accessed Nov 6th 2024).

Figure 60: Multicast ABR architecture (Broadpeak)



Source: Broadpeak

2.2.2.7.1 BT Research

BT Research has recently discussed their prototype approach to Multicast ABR, Multicast-Assisted Unicast Delivery (MAUD), to enable the use of multicast technology to assist with the unicast delivery of content, reducing the demand on broadband IP networks 'while avoiding the need for end devices to be upgraded to support multicast.'[169] Broadcasters such as the BBC will be involved in evaluating this technology for use with live content.[170]

2.2.2.7.2 Analysys Mason Summary for Ofcom, Technologies for distributing linear content over IP

In a 2023 report for Ofcom, TMT consulting firm Analysys Mason examined different technologies available for distributing linear content over IP. A model was used to view the impact of a peak IP viewing event when using either multicast or CDN-assisted unicast delivery. It was found that this event would more than double the traffic on backhaul lines in the CDN-based system, but see almost no change in traffic on backhaul lines when using multicast. However, Analysys Mason acknowledged that there are limits to multicast delivery, including that linear streams may need to switch between multicast and unicast, that multicast may only be implemented end to end by large ISPs and that the shift towards non-linear viewing means that peaks may also be created by non-linear events.[171]

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[169] M. E. Nilsson, R. S. Turnbull, T. S. Stevens and S. Appleby, (2023), Multicast-Assisted Unicast Delivery,' *BT Research and Network Strategy, UK,* https://www.ibc.org/technical-papers/ibc2023-tech-papers-multicast-assisted-unicast-delivery/10235.article (last accessed Nov 6th 2024)

[170] J. Priestly, 'BT Group unveils Multicast Assisted Unicast Delivery,' (2023), *TVB Europe,* https://www.tvbeurope.com/media-delivery/bt-group-unveils-multicast-assisted-unicast-delivery (last accessed Nov 6th 2024)

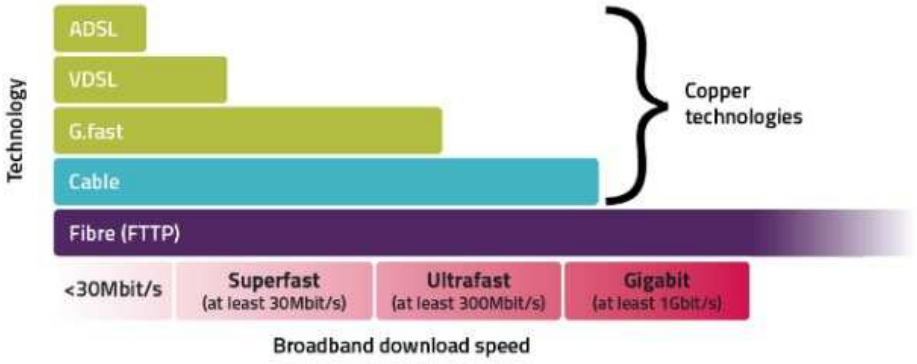
[171] 'Summary For Ofcom: Technologies for distributing linear content over IP,' *Analysys Mason* (2023), https://www.ofcom.org.uk/siteassets/resources/documents/research-and-data/technology-

2.2.2.8 Telecoms networks: Access

The access network is the final link from the ISP's network to the consumer premise.

The speed of broadband connections has grown rapidly through the adoption and rollout of new generations of technology, as shown in Figure 61.

Figure 61: Broadband speeds by technology (extracted from Ofcom report)



Source: Ofcom, 'Technology Futures, Spotlight on the technologies shaping communications for the future'[172]

In 2024, any access network connection using Very high-speed Digital Subscriber Line (VDSL)[173] or faster technologies should have sufficient capacity to easily support multiple high-definition streams, under normal circumstances. Ofcom's definition of "Superfast" broadband (at least 30Mbps), delivers UHD videos from Netflix reliably 99% of the time, according to Ofcom research (covered in more detail below).

However, we note that each household's use of its access network connection is unique, depending on number of users and applications, so whether a household's connection is "fast enough" is highly situational. In general, the faster the connection, the better – once homes reach "Ultrafast" speeds (>300 Mbps), provided by full fibre or equivalent connections, we would expect to see very few issues with streaming IPTV in the access network.

There are two key technical considerations for take up of high speed connections:

1) Rollout of Superfast/Ultrafast broadband and migration from copper connections (particularly ADSL and slower VDSL connections).

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research/2023/technologies-for-distributing-linear-content-over-ip.pdf?v=330115 (last accessed Nov 6th 2024)

[172] Ofcom *'Technology Futures, Spotlight on the technologies shaping communications for the future,'* (2021), https://www.ofcom.org.uk/siteassets/resources/documents/consultations/category-2-6-weeks/198737-emerging-technologies/associated-documents/report-emerging-technologies.pdf?v=325824 (last accessed Nov 6th 2024)

[173] ADSL = Asymmetrical Digital Subscriber Line; VDSL = Very high-speed Digital Subscriber Line; Both ADSL and VDSL are broadband technologies using a copper line to enter the home – ADSL uses copper all the way from the exchange to the premise, whereas VDSL uses fibre to the cabinet (sometimes called FTTC), and only uses copper from the cabinet to the premise.

2) Provision of Superfast/Ultrafast broadband to “hard-to-reach” premises.

Full fibre to the premises (FTTP, or “full fibre”), a broadband connection where optical fibres bring IP traffic all the way to the home, enables access network speeds at an order of magnitude higher than that required to deliver OTT video, even at ultra-high definitions.

Unlike copper connections, optical fibres do not experience degradation of signal over short distances.

Therefore, under normal circumstances, any household with full fibre will not experience streaming issues due to capacity constraint in the access network.

Those households still reliant on copper connections to the household will remain subject to quality dependent on the length of the final copper connection to their home, from the telephone exchange or street cabinet.

This particularly impacts those in more remote areas where copper connections tend to be the longest. These are also the locations where rollout of full fibre is most expensive and as such provide the most significant barrier to providing a suitable access connection for IPTV viewing.

Alternatives to full fibre connections for remote locations, such as microwave or satellite broadband, in general cannot replicate the speeds of full fibre.

Reliability needs of the access network should be considered in addition to capacity. Residential customers are unlikely to have any redundancy in their access connection to the ISP’s network, although some ISPs offer a slower, 4G back-up service should a customer’s fixed line broadband link fail. A fault in the access network generally means a complete loss of service that must be rectified by the ISP, or its suppliers, and in most cases, there is no contractual relationship between the ISP and the provider of IPTV services, acting as a potential barrier to IPTV performance.

This can be compared with DTT, where Arqiva (the regulated monopoly provider of DTT transmission services), has contractual response times for breakdown of services and overall downtime. As an example, its reference offer for Local DTT network services[174] states a target response time of 3-4 hours for any breakdown of services and a total time of service availability of 99.7% (note, actual availability is higher, as covered in previous sections).

2.2.2.8.1 Ofcom Technology Futures Report

While some households with copper connections may have issues obtaining a sufficiently fast connection for IPTV, the Ofcom “Technology Futures Report”

[174] Arqiva. *Reference Offer for the provision of Transmission Services in respect of Ofcom’s award of a licence for Local Digital Television Programme Services* (2012) https://www.arqiva.com/documentation/reference-offers/reference-offers-for-local-dtt/LDTPS%20Transmission%20Reference%20Offer%20(Version%203).pdf (last accessed Nov 6th 2024)

summarises developments in other kinds of broadband technologies. For example, the evolution of copper Digital Subscriber Line (DSL) technologies, including "G.Fast", progressively leads to higher speeds for homes that are a short distance from the cabinet (but is unlikely to provide significant benefits to those in hard-to-reach areas). The development of coaxial cable systems has led to the release of DOCSIS 4.0, which allows a maximum download speed of 10Gbps, albeit 'shared between the customers connected to the same node.' Evolution of FTTP technology means that download and upload speeds are increasing over time for fibre connections too, although this 'requires updates at the cabinet and the end-user device.'[175]

2.2.2.9 In-home networking

In-home networking provides the final link from the ISP to the customer device. While some households may have physical in-home networks, leveraging ethernet or other cabling, most devices connect to the internet via Wi-Fi.

Wi-Fi presents a key barrier in delivery of IPTV services due to several factors:

- It uses unlicensed spectrum meaning that the availability of radio spectrum can never be guaranteed, particularly in highly populated areas.
- Delivering high bandwidth over Wi-Fi to support full fibre speeds requires the use of higher frequency spectrum bands, which are less able to penetrate internal walls, and whose signal strength decreases more rapidly over distance.
- Consumers own a wide range of devices, which support different generations of Wi-Fi, but must all operate over the same in-home network, meaning that older devices can create bottlenecks that impact newer ones.

Additionally, ISPs have limited control over the operation of in-home networks. While they may provide advice and tools, and sometimes help with installation, typically consumers manage their own in-home networks.

This makes the performance of in-home networks unpredictable.

The Wi-Fi Alliance, a non-profit industry association, works on a number of technologies that can improve Wi-Fi. For example, Wi-Fi EasyMesh™ to increase Wi-Fi coverage areas, Wi-Fi Home Design™, and Automated Frequency Coordination (AFC) – which will help ensure that 'Wi-Fi devices operate in 6-GHz

[175] 'Technology Futures, Spotlight on the technologies shaping communications for the future,' 14th January 2021, *Ofcom,* https://www.ofcom.org.uk/siteassets/resources/documents/consultations/category-2-6-weeks/198737-emerging-technologies/associated-documents/report-emerging-technologies.pdf?v=325824 (last accessed Nov 6th 2024)

spectrum under favourable conditions, avoiding interference with incumbent devices.'[176]

The Wi-Fi Alliance also discusses the most recent Wi-Fi upgrade, Wi-Fi 7, which can provide fast performance, decreased interferences and reduced latency.[177]

However, device compatibility is a barrier to the benefits of Wi-Fi 7, increasing the time it will take for the full benefits to be realised.[178] In addition, the full potential of the speeds and reliability of Wi-Fi 7 are felt only by those with access to 6-GHz spectrum. In many countries, regulators have not given Wi-Fi access to the full 6-GHz band, due to potential use by mobile network operators for extended 5G coverage, including in the UK where Ofcom has made the lower 6-GHz band available for Wi-Fi[179], but not the upper band. The Wi-Fi Alliance advocates for access to the full 6-GHz spectrum for Wi-Fi to improve connectivity and performance.[180]

2.2.3 Summary of technical barriers and enablers

Figure 62: Barriers and Enablers to IPTV uptake

Barriers and Enablers to IPTV uptake		
	Barriers	**Enablers**
Service Provider Control and Platform	• Lack of control in key parts of the distribution chain for IPTV service providers.	• Technical development of IPTV platforms, such as white label OTT platforms, mature off the shelf components, and the growth of cloud computing.
Service	• Fragmented experience for the discovery of content. • The challenge of ensuring a more uniform user experience due to the range of operating	• Initiatives such as Freely from Everyone TV (creating a bespoke application for aggregated IPTV streaming of live TV). • Metadata standards such as DVB-I which enable

[176] 'Current Work Areas,' Wi-Fi Alliance, https://www.wi-fi.org/who-we-are/current-work-areas (last accessed Nov 6th 2024) 'Wi-Fi CERTIFIED EasyMesh™ enhances Wi-Fi® performance in multiple AP networks,' Wi-Fi Alliance, (2021) https://www.wi-fi.org/news-events/newsroom/wi-fi-certified-easymesh-enhances-wi-fi-performance-in-multiple-ap-networks (last accessed Nov 6th 2024)

[177] 'Current Work Areas,' Wi-Fi Alliance, *'Will 2024 be Wi-Fi 7's breakthrough year?*,' 30th January 2024, *Network World*, https://www.networkworld.com/article/1302097/will-2024-be-wi-fi-7s-breakthrough-year.html (last accessed Nov 6th 2024)

[178] 'Will 2024 be Wi-Fi 7's breakthrough year?,' (2024), *Network World*.

[179] Ofcom. *Improving spectrum access for Wi-Fi Spectrum use in the 5 GHz and 6 GHz bands* (2020) https://www.ofcom.org.uk/__data/assets/pdf_file/0036/198927/6ghz-statement.pdf (last accessed Nov 6th 2024)

[180] 'Blocking 6-GHz Wi-Fi Is Costing Consumers Money and Quality Experiences,' (2024), *EE Times Europe,* https://www.eetimes.eu/blocking-6-ghz-wi-fi-is-costing-consumers-money-and-quality-experiences/ (last accessed Nov 6th 2024)

	systems used by device manufacturers. • Availability of services such as Freely on secondary TV sets.	aggregated discovery of broadcast and IPTV content.
Compression/ Bitrates	• Rising average bitrates requested by users, through increase in demand for higher quality and higher resolution video.	• Continual improvements in compression reducing the bitrate required to deliver content at a given resolution and quality. • Prevalence of Adaptive Bitrate (ABR) streaming which adjusts the bitrate of the delivered content depending on available bandwidth.
Load on the core network and Network Capacity expansion	• Potential for congestion in the core network under widespread viewing of IPTV. • Reliance on commercial and operational decisions made by network operators to plan ahead and ensure capacity does not exceed thresholds.	• Technological improvements in fibre-optic communications delivering exponential increase in bandwidth available at a given cost over long time periods, and reducing the cost of upgrading capacity. • Telecoms operators incentivised to continuously plan and increase the capacity of their networks to meet IP traffic demand.
CDNs and Multicast	• The challenge of scalability with CDNs (dealing with high volume of simultaneous usage). • Multicast is only available where compatible equipment has been installed in the telecom operator's network and in the customer premises.	• The extensive use of CDNs by all IPTV services reduces traffic in the core network. • CDN technology is evolving to deal with spikes in demand. • Multicast can decrease traffic in the core network for live streams (for customers on compatible networks). • Multicast ABR increases the utility of multicast by reducing the requirement for CDNs and client devices to implement multicast-compatible technology.

Barriers and Enablers to IPTV uptake		
Telecoms Networks: Access	● While the proportion of households with FTTP connections is increasing, those in more remote areas who are still reliant on copper connections may not have sufficient connectivity for problem-free IPTV viewing, dependent on the length of the final copper connection to their home. ● Residential customers are unlikely to have any redundancy in their access connection to the ISP's network, leading to loss of service in the event of a fault.	● FTTP rollout and takeup continues to grow – households with FTTP connections should never experience bandwidth constraints for streaming in the access network under normal operating conditions.
In-home Networking	● Issues with in-home networking, particularly Wi-Fi, can present a range of barriers to the delivery of IPTV services, particularly since (in most cases) neither the IPTV service provider or the ISP has control over the operation of in-home networks. ● Wi-Fi operates on unlicensed spectrum, and in densely populated areas congestion of this spectrum can limit Wi-Fi performance and be difficult for users to troubleshoot. ● Non Wi-Fi based networking solutions can be expensive and difficult to install and are not routinely present in UK homes.	● New generations of Wi-Fi can improve networking performance (but only have a gradual impact as new compatible devices replace older non-compatible ones).

2.3 An assessment of the UK's digital infrastructure

This section assesses the UK's digital infrastructure to see if it is sufficient to enable widespread viewing of IPTV.

2.3.1 Device/Service

As discussed in the Audience Analysis section, the Freely service from Everyone TV launched on 30 April 2024 with the aim to 'replicate the terrestrial TV experience.'[181] The platform will initially support DTT and IP technologies, with the plan for satellite to follow later, supporting any future transition from delivery via DTT to IP only.[182]

Freely is based on HbbTV's Operator Application,[183] without leveraging DVB-I, which specifies how metadata for broadcast services (including DTT, satellite and cable) can be combined with unicast OTT services, allowing seamless switching between broadcast and OTT services (note, DVB-I does not specify anything relating to the broadcast standards themselves, e.g. DVB-T2, DVB-C).

DVB-I has been widely adopted by TV manufacturers and is being implemented in a number of European countries, including Germany and Italy, but not in the UK. It is seen as an important enabler for a smooth, transparent transition from DTT delivery to IP delivery of broadcast services.

There are risks that Freely may not be widely adopted in the UK, not least if the main TV set manufacturers decide not to implement Freely, a UK-only technology, in their products. They may decide to address the mainstream requirements of the European market using DVB-I, waiting for the UK to follow. A precedent for this has already been established with the UK's adoption of Europe-wide HbbTV standards to replace the earlier UK-only MHEG standard for interactive TV applications.

2.3.2 Core network

2.3.2.1 Cartesian analysis

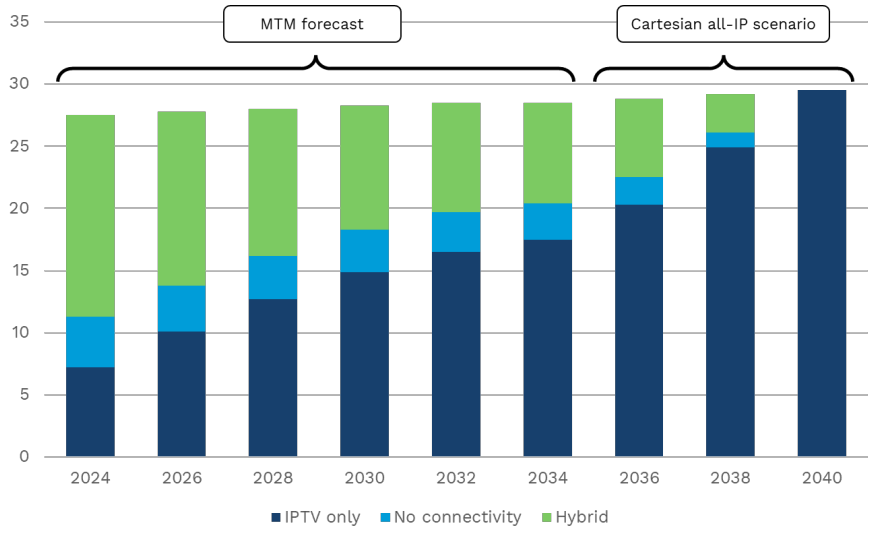
We have performed a high-level analysis on the potential impact of growth in IPTV viewing on peak traffic levels in the UK, based on MTM's household forecasts in the Audience Analysis section.

[181] 'New service from UK public service broadcasters will deliver live free TV via IP,' *Everyone TV,* (2023), https://www.everyonetv.co.uk/news/press-release/new-free-tv-service-via-ip (last accessed Nov 6th 2024)

[182] 'Consultation on Logical Channel Number Policy for a Next Generation Platform (Freely), Statement,' *Everyone TV* (2024), https://www.everyonetv.co.uk/sites/everyonetv/files/2024-01/freely-lcn-consultation-statement-jan-2024.pdf (last accessed Nov 6th 2024)

[183] DVB It comes down to DVB-I versus HbbTV OpApp, right? Wrong!, *MacAvock, Peter* (2024) https://dvb.org/news/it-comes-down-to-dvb-i-versus-hbbtv-opapp-right-wrong/ (last accessed Nov 6th 2024)

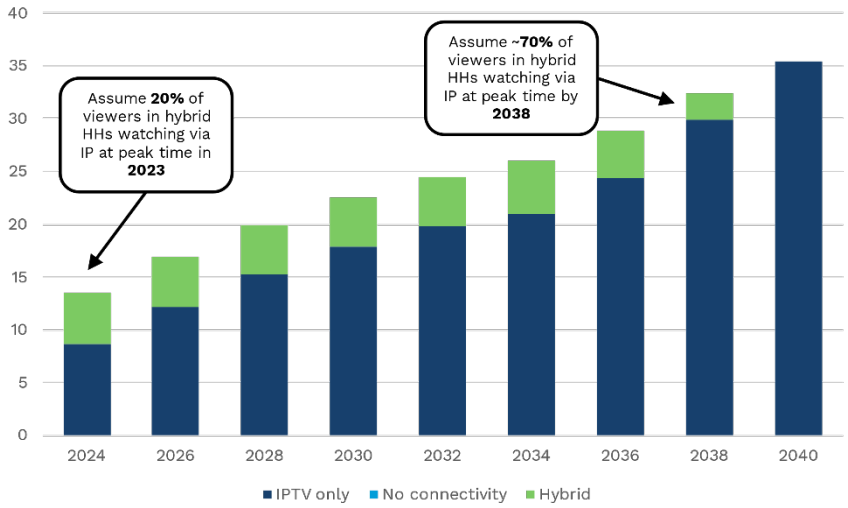
Figure 63: UK households (million) by connectivity (all IPTV scenario)



Source: Cartesian, based on MTM

Figure 63 above shows a forecast for the number of UK households by TV/connectivity type to 2040, where hybrid means the household watches a combination of broadcast and OTT video. We have used MTM's forecast but have adapted it from 2035-2040 to show an extreme scenario where all households watch all TV via internet by 2040. This scenario is unlikely but illustrates the capabilities of IP networks should all-IP TV distribution become a reality in the future.

Figure 64: UK viewers (million) watching via IP at peak time



Source: Cartesian analysis

Figure 64 above shows the result of estimating the number of viewers watching TV via IP at peak time in the UK. Viewers in IPTV-only households watch all TV via the internet, and those in no connectivity households watch no TV via the internet – hence we just need to estimate the percentage of viewers in hybrid households watching TV via IP at peak times. We have assumed a value of 20% growing to 80% by 2040, as a "worst case" in terms of level of IPTV viewing. For this calculation we

assume viewers per household at peak time of 1.2 (meaning a peak viewership of 35 million in 2040).

We then apply several assumptions to calculate the potential growth in IP traffic between 2023 and 2040 as shown in Figure 65. Note, these assumptions are not necessarily what we expect to happen in reality, but assumptions that can reasonably be viewed as a "high case" in terms of impact on peak IPTV traffic.

Figure 65: High-level peak traffic growth analysis, UK

Metric	Details	2023	2040	Multiple
IP viewers at peak (million)	# of viewers in the UK watching IPTV during peak event	11.6	35.4	3.0
Viewers per stream	Average number of viewers watching each stream (for a high case, assume falls as viewing is split across more screens in home)	1.6	1.3	0.8
# Streams (million)	Total streams delivered during peak event	7.5	27.2	3.7
Bitrate per stream	Average bitrate delivered for each stream (assume growth at 5% per annum)	4.2	9.6	2.3
Peak IPTV traffic (Tbps)	Total IPTV traffic across all UK networks during peak viewing event	31	261	8.4

Source: Cartesian analysis

We estimate here, in an extreme scenario, an annual peak IPTV traffic growth rate of 13%, resulting in an overall multiple of 8.4x from 2023 to 2040.

Note that this does not represent overall peak traffic growth, as IPTV only accounts for a percentage of peak internet traffic – indeed it only counts as a percentage of video itself, as short-form and social media video is not included.

As shown in the previous section (see *Load on the core network* in *Technical barriers and enablers to IPTV uptake*), this growth rate is well within the capacity of network operators in the UK. Further, the network operators such as TalkTalk are already planning for peak capacity growth of 13% per annum in coming years, and the cost of capacity falls at a rate in excess of 20% per annum.

Hence, there are unlikely to be technical or cost barriers to ensuring sufficient capacity in the core network, providing the industry has good warning of any changes and can plan accordingly.

2.3.2.2 BT comments on network scalability

During the Covid-19 pandemic, internet traffic increased significantly. In a May 2020 conversation with the Digital TV Group (DTG) and industry representatives, Ian Parr, BT's Director of Television and Broadband Infrastructure, argued that despite witnessing a 100% growth in the daytime consumption of content, the BT network was scaled and resilient enough to cope with demand.[184]

2.4.1 Access network

Ofcom conducts regular research into UK broadband coverage and home broadband speeds achieved across the country.

Its December 2023 Connected Nations report[185] and September 2023 UK Home Broadband Performance report[186] provide information on the coverage, take up and performance of broadband in UK homes.

According to Ofcom, full fibre broadband is available to 57% of UK homes, a significant increase from the 42% availability a year before.

97% of residential premises can now access at least superfast broadband (>30Mbps), while 78% can access gigabit-capable services. Just 0.2% of homes are unable to get decent coverage (10Mbps+).

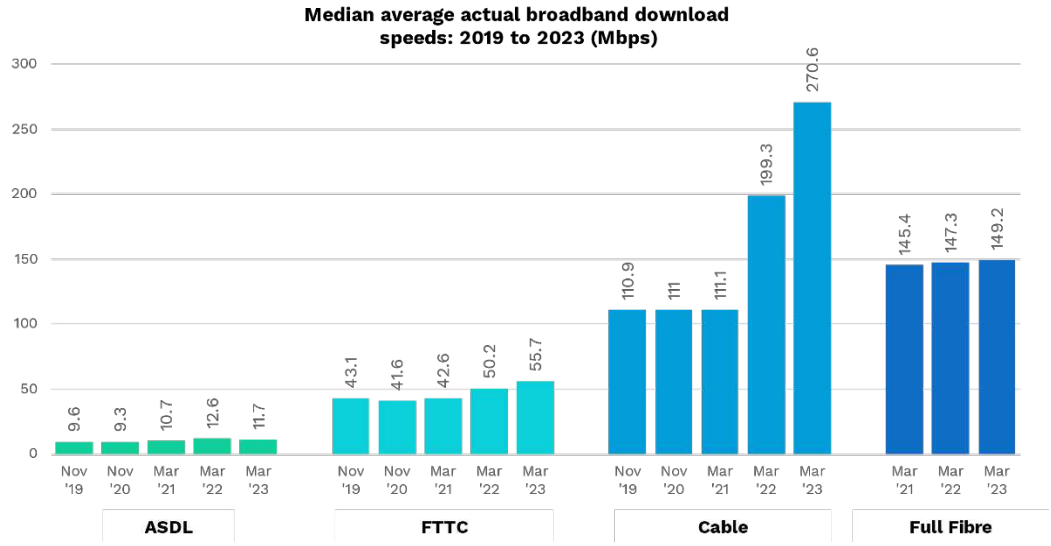
Figure 66 shows the median speeds attained by households using each broadband technology in the UK.

[184] 'COVID-19 | Transforming the TV Industry: The Resilience of the Internet with EY,' *DTG* (Webinar, 2020), https://dtg.org.uk/webcast/covid-19-transforming-the-tv-industry-the-resilience-of-the-internet-with-ey/ (last accessed Nov 6th 2024)

[185] Connected Nations UK Report 2023,' *Ofcom* (2023)

[186] 'UK Home Broadband Performance, The performance of fixed-line broadband delivered to UK residential customers,' *Ofcom* (14th September 2023) https://www.ofcom.org.uk/siteassets/resources/documents/research-and-data/broadband-research/broadband-speeds/home-broadband-performance-september-2023/march-23-home-broadband-performance.pdf?v=330131 (last accessed Nov 6th 2024)

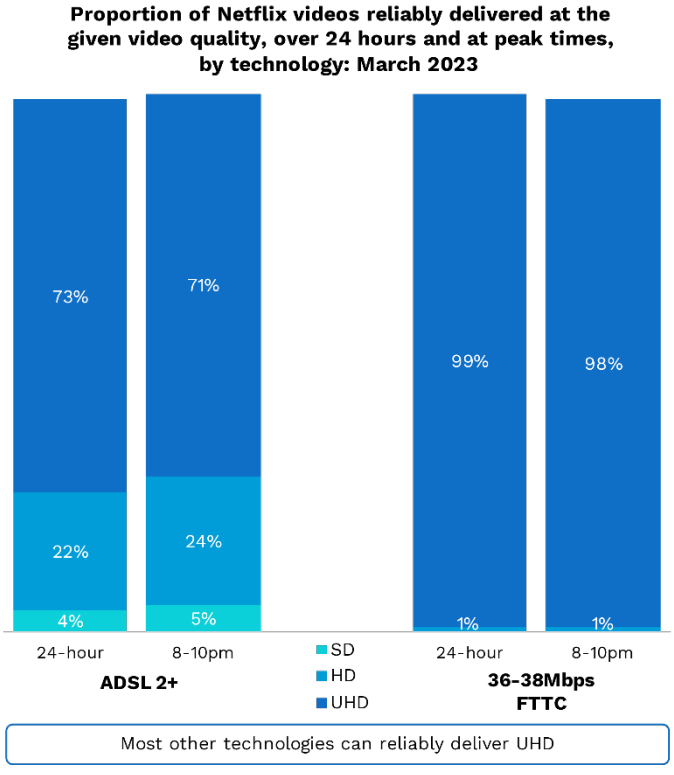
Figure 66: Ofcom home broadband speeds 2023



Source: 'Ofcom, UK Home Broadband Performance 2023' (using data provided by SamKnows)

Ofcom research into technologies' ability to stream Netflix videos (see Figure 67) shows that in homes with superfast speeds (>30Mbps), 99% of ultra-high definition (UHD) videos are delivered reliably, but where speeds drop below 30Mbps, homes may be limited to HD or SD only streams. It must also be noted that these statistics are based on one user streaming content and user experience may be impacted by multiple users streaming content over the broadband connection.

Figure 67: Ofcom, Streaming of Netflix in Ultra-High definition

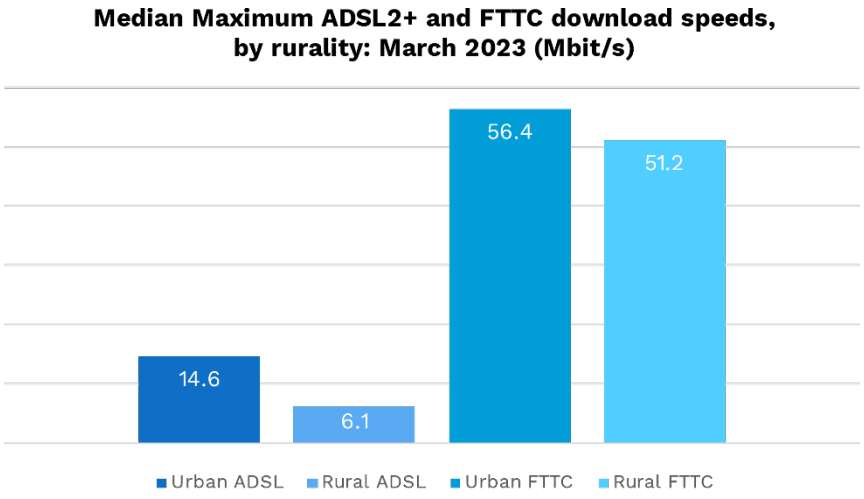


Source: 'Ofcom, UK Home Broadband Performance 2023' (using data provided by SamKnows)

However, coverage is not equivalent to take-up (which is covered in more detail in the Audience Analysis section). Ofcom's UK Home Broadband Performance report stated that 86% of UK households take fixed broadband and 93% of all home broadband lines are superfast (>30Mbps), an increase from 91% the year before. Despite the wide roll-out of full-fibre broadband, only 11% of lines were ultrafast (>300Mbps).

Residential broadband download speeds continue to increase over time as people upgrade their broadband services and the gap between rural and urban speeds is decreasing (see Figure 68). Ofcom recommends that ADSL2+[187] users upgrade to FTTC due to the faster speeds FTTC can provide. The report also looked at the decrease in average download speeds at peak times, with speeds averaging 95% of maximum speeds from 8-10pm, though this decrease was bigger for ASDL2+ products and lowest for full-fibre lines.[188]

Figure 68: Ofcom, Median Maximum download speeds by technology and rurality



Source: 'Ofcom, UK Home Broadband Performance 2023' (using data provided by SamKnows)

2.4.1.1 National Infrastructure Commission, Infrastructure Progress Review 2023

The National Infrastructure Commission published an infrastructure progress review in 2023, assessing progress by the Government towards the Commission's past recommendations. The review found that the Government 'continues to make good progress on supporting deployment of new digital infrastructure networks,' but must ensure that hard to reach areas do not get left behind. The commission recommended that 'Ofcom should promote network competition through

[187] ADSL2+ is a faster version of ADSL (Asymmetrical Digital Subscriber Line technology), used for broadband connections over copper from the exchange to the premise
[188] 'UK Home Broadband Performance, The performance of fixed-line broadband delivered to UK residential customers,' *Ofcom* (2023)

deregulation' to accelerate delivery and 'Government should improve processes to obtain wayleaves for telecommunications providers.'

One point that the review made was that commercially unviable properties do not only exist in rural areas, but that 'analysis suggests that around 20 per cent of towns may be reliant on government support to deliver gigabit capable broadband to more than 20 per cent of their premises.'[189]

2.4.1.2 Analysys Mason, Research on Very Hard to Reach Premises

In 2021, Analysys Mason published a report commissioned by the Broadband Stakeholder Group (now UK Digital Connectivity Forum) summarising research it had conducted into how to best serve the UK's 'very hard to reach premises' – the estimated 100,000 premises that will be left unserved by the Government's Project Gigabit programme.

The report considered several technologies that could be used to serve these premises, assessed their ability to deliver download speeds of 30Mbps and 300Mbps and the economic viability of deploying these technologies to the very hard to reach premises. The report reinforces the idea that public funding would be required to serve these premises due to their lack of commercial viability, as well as arguing for a mixed technology solution to serving these premises due to their differing requirements.

The report's overall conclusion is that macrocell Fixed Wireless Access (FWA) is the most cost-effective method of achieving speeds of 30Mbps and that a combination of Line Of Sight (LOS) FWA and Low Earth Orbit (LEO) satellites should be used to achieve speeds of 300Mbps.

The report also includes a conclusion regarding the contracting model for providing subsidy for connecting these premises. Analysys Mason argues that the right timeframe must be considered and this may need to be an extended period, e.g. 20 years, which could impact on the speed of transition to widespread IPTV.[190]

However, some vendors/platform providers advised DCMS that this report 'may not reflect the current or expected future capabilities of their technologies.'[191]

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[189] 'Infrastructure Progress Review 2023,' *National Infrastructure Commission* (2023), https://nic.org.uk/app/uploads/IPR-2023-Final.pdf (last accessed Nov 6th 2024)

[190] 'Research on Very Hard to Reach Premises: technical and commercial analysis,' *Analysys Mason* (2021), https://www.connectivityuk.org/wp-content/uploads/2021/09/Analysys-Mason_Report-for-BSG_Research-on-VHtRPs_technical-and-commercial-analysis_12-August-2021nc_v2.pdf (last accessed Nov 6th 2024)

[191] 'Digital Connectivity: Consultation on Improving Broadband for Very Hard to Reach Premises,' *Department for Science, Innovation & Technology* (2023), https://assets.publishing.service.gov.uk/media/651d79d86a6955000d78b2fb/improving_broadband_for_very_hard_to_reach.pdf (last accessed Nov 6th 2024)

2.4.1.3 PA Consulting, Future of Wireless Broadband Technologies, Ofcom

In a similar report, PA Consulting were appointed by Ofcom to review wireless technologies in the UK, especially regarding their application in rural and hard-to-reach areas. The report highlighted that in areas where Gigabit service is not likely to be available for some time, other options should be considered. Much like Analysys Mason, PA argues for a 'technology neutral' approach to the roll out of broadband. The report points out significant developments in wireless networking and the fact that some systems can even offer gigabit capable services with wireless technologies.

Potential wireless technologies considered by the report include FWA and satellite-based systems, including LEO satellites. However, the report sees high pricing and intermittent quality levels to be issues for satellite systems.

Another issue highlighted by the report is spectrum, given that this is an essential element for wireless technologies, and the recognition that spectrum sharing needs to be supported further. With access to the 3.8-4.2 GHz band, FWA systems can provide better service than when operating in the 5.8GHz band, which they have typically done previously.[192]

2.4.1.4 Ofcom, Connected Nations UK Report 2023

Ofcom also acknowledges the increased ability of wireless technologies to serve UK premises. In its 2023 Connected Nations report, Ofcom stated that more customers are receiving broadband via LEO satellites, which it agrees are a potential approach for serving those properties without access to decent broadband, supported by the fact that most of Starlink's LEO satellite customers are in rural areas. Ofcom also concurs that the availability of the 3.8-4.2 GHz band for Fixed Wireless Access is increasing the ability of FWA to serve areas where fibre has not been deployed.

The use of these technologies to serve rural and very hard to reach premises is being supported by government schemes which are trialling LEO satellite broadband and hybrid satellite and Fixed Wireless Access networks.[193]

2.4.1.5 Department for Science, Innovation & Technology, Digital Connectivity: Consultation on Improving Broadband for Very Hard to Reach Premises

In late 2023, following a DCMS call for evidence in 2021, the Department for Science, Innovation and Technology (DSIT) published a report on its plans to improve broadband for very hard to reach premises, requesting responses from stakeholders that are yet to be published.

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[192] 'Future Of Wireless Broadband Technologies, Ofcom, Final Report,' *PA Consulting* (23 March 2023), https://www.ofcom.org.uk/siteassets/resources/documents/research-and-data/technology-research/2023/future-of-wireless-broadband-technologies.pdf?v=330124 (last accessed Nov 6th 2024)

[193] 'Connected Nations UK Report 2023,' *Ofcom* (2023)

The government believes that fewer than 100,000 premises will fall into this category. The report supports the idea that these premises may need to be served by alternative technologies and lower speeds to those used in Project Gigabit[194] procurements. It states that for many very hard to reach premises, 'a satellite solution may be the best, or only way, to deliver' improved connectivity, but acknowledges the limitation of this technology due to its high cost and limited capacity. It also points out that restrictions on spectrum may limit the capabilities of Fixed Wireless Access and satellites.[195] However, Ofcom is aware of the range of developments in wireless networks and is committed to ensuring 'access to spectrum is not a barrier to network deployment' through a flexible approach to spectrum management.[196]

The DSIT report highlights the need to serve very hard to reach premises while Project Gigabit is still ongoing due to their relative lack of digital connectivity. However, it also draws attention to the risk of serving these households with a sub-gigabit solution as an interim measure, and in so doing, taking them out of the scope of Project Gigabit in future.

In 2023, the government committed £8 million to improving the connectivity for up to 35,000 of the most remote premises, which are likely to be in this very hard to reach category.

The government is still 'considering other policy solutions which could deliver better connectivity to very hard to reach premises.'[197]

2.5.1 In-home networking

In-home networking is a key potential barrier to the success of widespread IPTV performance and a difficult challenge to solve given the lack of direct control over the in-home environment by any of the players in the distribution chain. Industry bodies such as Ofcom, DTG, and the Wi-Fi Alliance have acknowledged this issue and discussed some potential solutions. We summarise these below.

Many second and third TV sets in the home are connected only to the DTT network and may not have a Wi-Fi connection that is suitable for watching TV over an IP network. There are two issues to be addressed: Wi-Fi coverage within the home, and

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[194] Project Gigabit is a government-led programme aiming to provide gigabit-capable broadband to the 20% of premises unlikely to be provided for in commercial plans (see https://www.gov.uk/guidance/project-gigabit-uk-gigabit-programme) (last accessed Nov 6th 2024)

[195] 'Digital Connectivity: Consultation on Improving Broadband for Very Hard to Reach Premises,' *Department for Science, Innovation & Technology* (October 2023), https://assets.publishing.service.gov.uk/media/651d79d86a6955000d78b2fb/improving_broadband_for_very_hard_to_reach.pdf (last accessed Nov 6th 2024)

[196] 'Spectrum Management for Next Generation Wireless Broadband Flexible access and spectrum sharing, Discussion Paper,' *Ofcom* (October 2023), https://www.ofcom.org.uk/siteassets/resources/documents/spectrum/spectrum-management/spectrum-management-for-next-generation-wireless-broadband?v=330283 (last accessed Nov 6th 2024)

[197] 'Digital Connectivity: Consultation on Improving Broadband for Very Hard to Reach Premises,' *Department for Science, Innovation & Technology* (2023)

the functionality of non-primary TV sets, which are often much older and lack IP connectivity.

2.5.1.1 Ofcom UK Home Broadband Performance

In its 2023 review of home broadband performance, Ofcom acknowledged the impact of in-home elements on broadband performance, such as Wi-Fi performance, in-home wiring, device limitations and the number of devices in use.[198]

2.5.1.2 DTG In Home Connectivity Guide

In its Home Connectivity Guide, DTG outlines best practice for in-home connectivity, so that people can experience the full benefits of full fibre delivery. The guide discusses how home environments make it difficult to get a reliable Wi-Fi signal, due to elements like insulated building materials affecting radio waves, interference from neighbour's Wi-Fi signals and many devices competing to use limited Wi-Fi channels.[199]

DTG argues that the best way to manage these issues is to combine wireless technologies with a 'robust wired infrastructure.' They explain best-practice for this infrastructure – the use of a control hub or 'head end' in the home where external connections enter, from which cable is run to each room in the house and Wi-Fi is used within the room itself.

However, DTG acknowledges that fitting homes with cabling is not always an option and provides alternative advice for mitigating issues with wireless signals, such as using newer routers - especially those which select frequency bands optimal for the situation or that provide options for configurable load balancing – or extending coverage with mesh networks, Wi-Fi extenders and powerline adapters.

2.5.1.3 Additional spectrum for Wi-Fi

During the World Radio Conference 2023 (WRC-23), which ended in December 2023, the upper 6 GHz band (6425-7025 MHz) was identified for International Mobile Telecommunications (IMT)[200] globally and left for the administrations to decide the usage between IMT (i.e. mobile service) or wireless access systems e.g. Wi-Fi. In the UK, Ofcom had already made available the lower 6 GHz band (5925 to 6425

[198] 'UK Home Broadband Performance, The performance of fixed-line broadband delivered to UK residential customers,' *Ofcom* (2023)
[199] 'In Home Connectivity Guide Vol. 02,' *DTG* (2021), https://dtg.org.uk/wp-content/uploads/2021/02/In-home-Connectivity-Guide-FINAL.pdf (last accessed Nov 6th 2024)
[200] IMT is the name used internationally (especially in the ITU) for commercial mobile broadband applications using mobile (e.g., 3G, 4G and 5G) technologies.

MHz) for licence exempt use spectrum to Wi-Fi,[201] but supports the decision of this hybrid approach for the upper part of the spectrum.[202]

2.4 Gaps in policy and evidence

Based on the research and evidence review, we see four key gaps in policy and evidence regarding the technology for spectrum efficiency and widespread IPTV viewing:

1. A policy direction on technology migration to increase the spectrum efficiency.
2. Ensuring households have access to IPTV services on main and secondary TV sets.
3. Solving in-home networking issues.
4. Reliability of IPTV vs. DTT.

2.4.1 Strategic options for DVB-T2 migration to improve spectrum efficiency

Deploying advanced and spectrally efficient technologies to deliver DTT content, such as DVB-T2 and HEVC, increases the efficient use of spectrum use by DTT technologies. It also enables better quality and wider choice for consumers. In 2023 many UK households were still receiving DTT over the DVB-T standard and MPEG2 compression technologies. Therefore, a case exists to upgrade the UK TV transmission networks to DVB-T2. Other countries such as France, Italy and Spain have already migrated entirely to DVB-T2 or have plans to migrate. These migrations take a long time to complete as they involve migrating all the transmission sites and the TV receivers at the user end. Accelerated migration will result in much higher costs compared to the natural migration. However, making plans with sufficient notice to users, e.g. giving a 5 to 10-year notice period to users, may keep costs down. The UK would need to address this in the near future to minimise costs and increase the efficient use of spectrum.

The current UK approach to upgrading the DTT network will become increasingly untenable over time. The costs borne by UK public service broadcasters for simulcasting DTT channels in SD and HD will continue while their cost base is under increasing pressure. It will also become increasingly difficult to retain the spectrum exclusively for a coherent DTT service at future WRC meetings unless it can be shown that the UHF band is being used efficiently and that broadcast TV is the highest value and appropriate use of that part of the UHF spectrum. Choosing to upgrade DTT networks would make a strong case at WRC to continue to keep the allocation of the UHF band for broadcasting services, while possibly releasing some

[201] Ofcom. *Update on the upper 6 GHz band Our current position in preparation for WRC-23,* (2023) https://www.ofcom.org.uk/__data/assets/pdf_file/0028/248770/update-on-upper-6hz-band.pdf (last accessed Nov 6th 2024)
[202] 'Sharing 6 GHz spectrum for Wi-Fi and mobile,' *Ofcom*, 6th July 2023, https://www.ofcom.org.uk/news-centre/2023/sharing-6-ghz-spectrum-for-wi-fi-and-mobile (last accessed Nov 6th 2024)

spectrum for other competing purposes and still meeting the need for TV distribution to all UK households.

2.4.2 Ensure access to IPTV services on the main and secondary TV sets

Freely, from Everyone TV, is the main industry initiative for ensuring access to "broadcast-like" TV services on the main TV set.

It bears similarities to the industry initiative from Everyone TV (then called Digital UK) during switchover from analogue to digital terrestrial television. The development of the Freeview DTT standards enabled the production of compatible TVs and set-top boxes by a wide variety of manufacturers, which, in combination with high demand, drove prices down to a level where minimal subsidies were required to ensure that all but a few households had no loss of service on switchover.

However, some differences should be considered by policymakers:

- Demand for devices may not be at the same level as seen during the digital transition.
- The UK-only Freely approach may not be adopted by some major TV manufacturers, which are committed to adopting DVB-I, the chosen approach to hybrid technology across other major European markets. Freely does not leverage DVB-I but is instead developing its own application, based on HbbTV standards, which needs to be specifically integrated into devices by manufacturers.

Freeview enforced a minimum set of standards that allowed manufacturers a degree of freedom over how to implement a compatible UI on their devices – this enabled a strong "horizontal" market to develop, with manufacturers able to design both low-end and high-end devices and reach a low price point, requiring minimal coordination with Freeview itself. It is not clear at the moment whether Everyone TV plans to give manufacturers equivalent freedom for Freely. Early plans indicate not, as Freely would like to maintain significant control over the user experience. While this is desirable for broadcasters, it may lead to a lack of affordable devices in the market for consumers.

The migration to IP delivered services on the large number of legacy secondary TV sets which rely on DTT will require the provision of Wi-Fi connections and, in many cases, the installation of an IP-enabled device supporting Freely (or equivalent service) to provide access to linear and on-demand content.

2.4.3 In-home networking issues

Potential technologies for improving in-home networks are discussed by industry players such as DTG and the Wi-Fi Alliance, but there is no quantitative analysis of how significant a problem in-home networking could be in the future and how it would affect widespread IPTV viewing. It is a difficult area to understand and implement solutions for, but should be considered carefully.

2.4.4 Reliability

As evidenced by the findings of the Audience Analysis section, reliability is one of the obstacles to the uptake of IPTV (see the outcomes of consumer perceptions research in Audience Analysis section). If IPTV becomes a mainstream TV delivery platform, the reliability requirements should match the DTT delivery requirements, or the Technical Performance Code should be revisited.

We have not found any research quantifying the reliability of IPTV vs. digital terrestrial television. We have good reason to believe that, by 2040, the distribution of IPTV over the core network and from the CDN to the access network should achieve high levels of reliability, but there are likely to be more issues in access network and in-home (Wi-Fi) reliability.

For instance, any failure of the access network or Wi-Fi will result in an inability to access TV services (albeit with mobile networks as a potential backup, but not for a full main TV experience). When these failures occur, they are likely to be outside the control of the TV service operator.

As internet services and Wi-Fi become more integral to our TV services, work quantifying their reliability will become increasingly valuable. This should be considered both from a Critical National Infrastructure point of view (critical failure of the telecoms network vs. critical failure of the DTT network) and from a user experience view (frequency and duration of “normal” failures, and ease of resolution).

3 Net zero Impact

This section reviews the evidence related to the environmental impact of different TV viewing methods. Firstly, it presents a comprehensive methodology for quantifying environmental differences between distribution platforms (DTT, satellite, cable and IPTV). Secondly, it applies this methodology to the environmental implications of growing IPTV usage. Finally, it examines the increase in IPTV viewing and environmental impact, determining if it follows a linear or non-linear trend.

Our methodology employs what's known as an attributional life cycle assessment (LCA)[203]. This includes all aspects of the carbon footprint created through the manufacturing of a device, like set-top boxes, modems, etc., and its use in the home and eventual disposal. To make comparisons easier, the energy used for one hour of viewing is calculated based on typical user behaviour patterns. This methodology has to be potential for refined to include regional variations, socioeconomic factors, and age-based viewing habits.

A key finding in our research using LCA of TV delivery methods is the lack of publicly available, reliable data. This limits the ability to assess accurately the environmental impacts of different options.

To gauge the environmental consequences of increased IPTV adoption, we start with the LCA methodology to establish a baseline scenario. We then perform sensitivity analysis on key input data affected by IPTV growth, including:

- Distribution Infrastructure (Data Centre).
- Internet Infrastructure (Access Network).
- Power Consumption of viewing devices and in-home peripherals (TV, Smart Phone, Tablet, Laptop, Modem/Routers, IPTV set-top boxes).

The environmental impact is assessed based on the LCA outcomes for respective years.

Finally, we address IPTV's potential environmental trajectory. In the near term, expect a linear impact driven by:

- Direct Scaling: Increased IPTV viewing will modestly increase energy consumption for data centres and networks.
- Steady Efficiency Gains: Predictable energy efficiency improvements will slow or potentially reverse IPTV's environmental impact.

Long-term, we should expect a non-linear trend driven by the following factors:

[203] See Glossary section *(Attribution Approach)*. Greenhouse Gas Protocol / World Resources Institute. *Product Life Cycle Accounting and Reporting Standard* (2011) https://ghgprotocol.org/sites/default/files/standards/Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf (last accessed Nov 6th 2024)

- Technology Generations Leaps**:** Breakthroughs in energy efficiency could dramatically alter the landscape in the area of semiconductor design, data compression algorithms or data centre cooling techniques.
- Device Flexibility: IPTV's cross-device availability could influence viewing habits and energy usage.
- Evolving User Behaviour: Widespread IPTV adoption may shift consumption patterns with environmental consequences.

IPTV's environmental impact requires continuous monitoring. Short-term trends are predictable, but long-term outcomes hinge on technological innovation and evolving consumer behaviour to ensure responsible growth, prioritise energy efficiency strategies and track the evolving interplay of IPTV with broader energy trends.

3.1 A methodology to effectively establish and measure the differences in environmental impact between TV distribution platforms.

This section provides information about the research framework or methodology that is required to establish and measure the differences in environmental impact between DTT, cable, satellite, and IPTV. We carried out a literature review of the existing frameworks available to measure the differences in environmental impact between these TV distribution platforms.

3.1.1 Literature review

This section summarises published papers or project reports to identify state of the art thinking on methodologies that are being refined to keep pace with the fast-changing technology landscape of TV delivery and content viewing. A single method of assessment is not appropriate as method choice depends on the desired scope and goals of the assessment.

Relevant papers and reports were selected based primarily on their geographical area, publication date and applicable technologies in the Information and Communication Technology and Entertainment & Media sectors.[204]

We performed a literature review of the following four papers and reports on TV to gain an understanding of methodologies.

1. BBC WHP 372 – Research and Development White Paper
2. LoCaT Project: Quantitative study of the GHG emissions of delivering TV content

[204] Carnstone report prepared for Ofcom. *Carbon emissions of streaming and digital terrestrial television* fig 3 (updated 2024) https://www.ofcom.org.uk/siteassets/resources/documents/research-and-data/technology-research/technology-research/2022/carbon-emissions-of-streaming-and-digital-terrestrial-television-v2.pdf?v=370627 (last accessed Nov 6th 2024)

3. Carnstone study on Carbon emissions of streaming and digital terrestrial (updated on 22/07/2024[205])
4. Carbon Trust– Carbon impact of video streaming

By examining the diverse methodologies used in these published papers and project reports, some key questions have been identified. These include the suitability of different approaches for various contexts, their relative strengths and limitations, and how well they adapt to technological advancements. By uncovering these underlying principles and identifying gaps in current knowledge, we are able to identify potential future research directions in this critical area.

3.1.1.1 BBC WHP 372 – Research & Development White Paper (Published September 2020, funded in part through the EPSRC Impact Acceleration programme, and by BBC R&D)

This white paper presents modelling and benchmarking of electricity usage for the distribution and viewing of television over different distribution platforms listed below:

1. Terrestrial
2. Satellite
3. Cable
4. Online Streaming (BBC iPlayer service, note: Excluded in our Literature review to limit our scope)

This paper builds upon methodologies and models from previous research papers published for estimating energy consumption in TV delivery systems and consumer electronics.[206] The methodology employed in this research has also been utilised in several other noteworthy reports[207] published in the UK related to energy consumption in TV delivery methods.

Summary of the report

1. The scope of the study was to calculate the energy consumption and assess the environmental impact by finding the greenhouse gas (GHG) emissions of four TV delivery methods (DTT, cable, satellite and online streaming).
2. The methodology used was based on an attributional Life Cycle Assessment (LCA).
3. It combines the use of detailed behavioural data obtained through user monitoring and analytics with an LCA approach. The distribution of annual energy consumed during the in-use phase for different platforms indicates TV

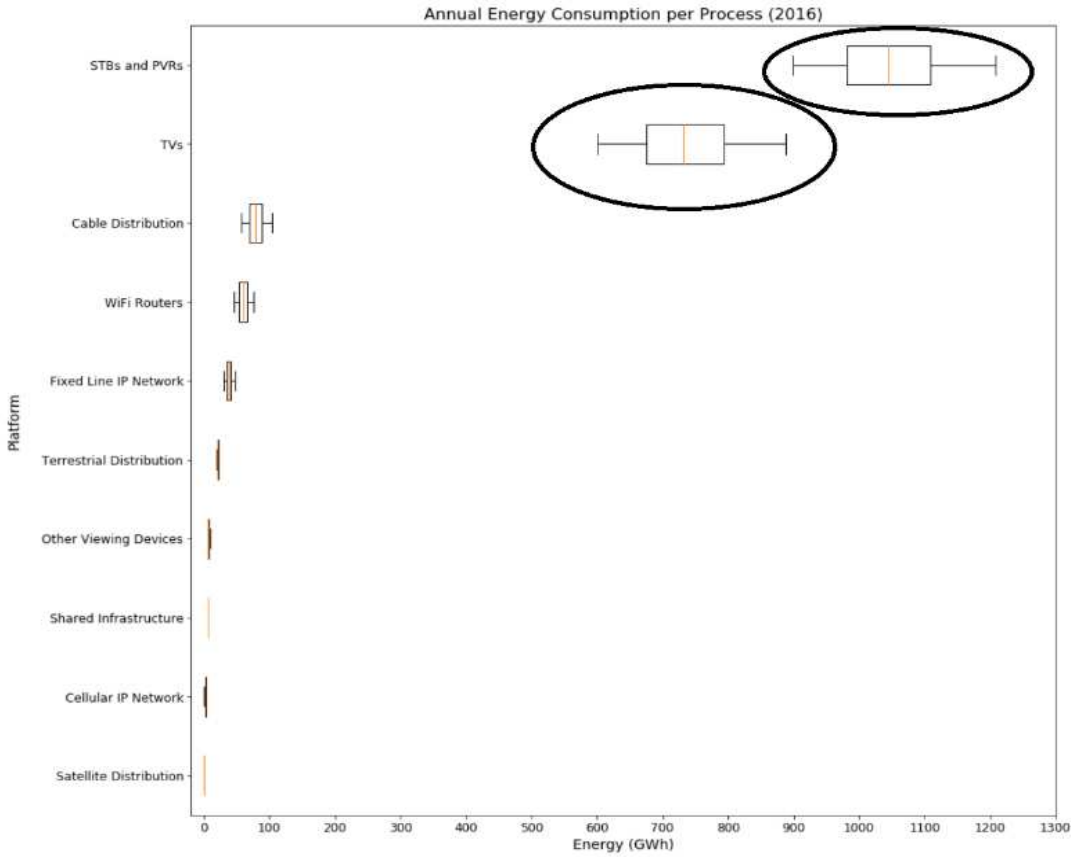
[205] Ibid

[206] Schien, Daniel et al. *Using behavioural data to assess the environmental impact of electricity consumption of alternate television service distribution platforms* (2021) https://www.sciencedirect.com/science/article/abs/pii/S0195925521001116 (last accessed Nov 6th 2024)

[207] Carnstone report prepared for Ofcom. *Carbon emissions of streaming and digital terrestrial television* fig 3 (updated 2024)

sets (see Figure 4)[208] and in-home devices are the major contributors to GHG emissions.

Figure 69: Breakdown of total BBC distribution and consumption energy use in 2016, based on different TV content delivery process [209]



Notable papers referenced to develop this model are Chandaria et al. (2011) who conducted a scoping LCA (Life Cycle Assessment) for emissions associated with electricity use for one hour of BBC viewing for a typical viewer via terrestrial broadcast and digital platforms. It also draws on articles that assess environmental impacts of both consumer electronics (Subramanian & Yung, 2016) and ICT products (Arushanyan et al., 2014).

Methodology

The overall methodology used in this study is explained below:

- It utilises the LCA methodology for estimating the environmental impact of associated services. The methodology aligns with the GHG Protocol ICT

[208] Schien, Daniel et al. *Using Behavioural Data to Assess the Environmental Impact of Electricity Consumption of Alternate Television Service Distribution Platforms* (2020) https://downloads.bbc.co.uk/rd/pubs/whp/whp-pdf-files/WHP372.pdf (last accessed Nov 6th 2024)
[209] Ibid See Figure 4

Guidance[210] (Chapter 4: Guide for assessing GHG emission of Cloud Computing and Data Center Services) and it adopted the GHG Protocol Life Cycle Reporting standard. The LCA methodology is then parameterised by using detailed behaviour data to obtain the total energy consumption and the associated environmental impact for a given service. A detailed process model is developed for the TV content delivery technology under study, for both in-home and mobile network viewing. Parameterisation allowed variations in factors such as TV screen sizes, time of viewing, and image bitrate.

- User behaviour data was collected and from this, different pathways were identified in the process model. Two sources of data were used. For internet access, user analytics data was used and for broadcast viewing, BARB survey data was used. They clustered the user data for each of these configurations and aggregated the data to give the total system usage for a given configuration.
- The LCA process model was used to calculate total energy usage.
- The assessed parts of the process model that are independent of user configuration (coding and multiplexing) are then added to the configuration result.

Gap Analysis

We identified the following gaps in the BBC WHP 372 study:

Behavioural Granularity:

- Focus on Device Types: While it identifies set-top boxes and home networks as hotspots, finer-grained analysis of the energy use of specific TV models and screen sizes could reveal greater variations linked to user choices.
- Dynamic Usage Patterns: The study assumes average viewing times for each household. Investigating peak demand periods, standby power consumption and multi-device use would create a more nuanced picture.

Broader Scope of Impacts:

- Embodied Emissions[211]: The focus is on electricity use. A full life cycle assessment should include embodied emissions from device manufacturing, increasing the relative impact of frequently replaced devices or those with energy-intensive production processes. Embodied emissions include emissions from all life cycle stages other than the use phase: raw material acquisition and preprocessing, production, distribution and transport,

[210] Global e-Sustainability initiative. *ICT Sector Guidance built on the GHG Protocol Product Life Cycle Accounting and Reporting Standard*.(2017) See Chapter 4 https://ghgprotocol.org/sites/default/files/2023-03/GHGP-ICTSG%20-%20ALL%20Chapters.pdf (last accessed Nov 6th 2024)
[211] Ibid. See Section 1.7.2

installation (by which is meant service deployment and build), and end-of-life treatment.

- End-of-Life Impacts: How discarded TVs and network equipment are handled influences the overall environmental burden. Analysis of e-waste flows and the potential for material recovery is needed.
- Technology Evolution: Innovations in Efficiency[212]: TVs and network infrastructure are constantly improving. The study is based on a snapshot in time; projecting potential efficiency gains is essential for future scenarios.
- Changing User Habits: The shift towards on-demand and mobile viewing could disrupt the findings. Ongoing monitoring of behavioural data is crucial.
- Regional Energy Mix: The paper uses an average grid emissions factor. Location-specific analysis would show how the same behaviours have disparate impacts depending on electricity sources.

3.1.1.2 LoCaT Project: Quantitative study of the GHG emissions of delivering TV content (Published in September 2021)

The sponsors of this study were:

- Association Technique des Editeurs de la TNT (ATET) – the trade organisation of TV channels delivered via DTT in France
- Broadcast Networks Europe (BNE) – the trade organisation of DTT network operators in Europe
- ORS Group – the main Austrian DTT network operator
- Quadrille – a French content delivery technology provider
- Salto – a French OTT streaming platform

The report's scope is to study the environmental impact by evaluating GHG emissions caused by the delivery of one hour of TV via the following delivery methods:

- Linear TV via DTT
- Over-the-top (OTT) services
- Managed IPTV

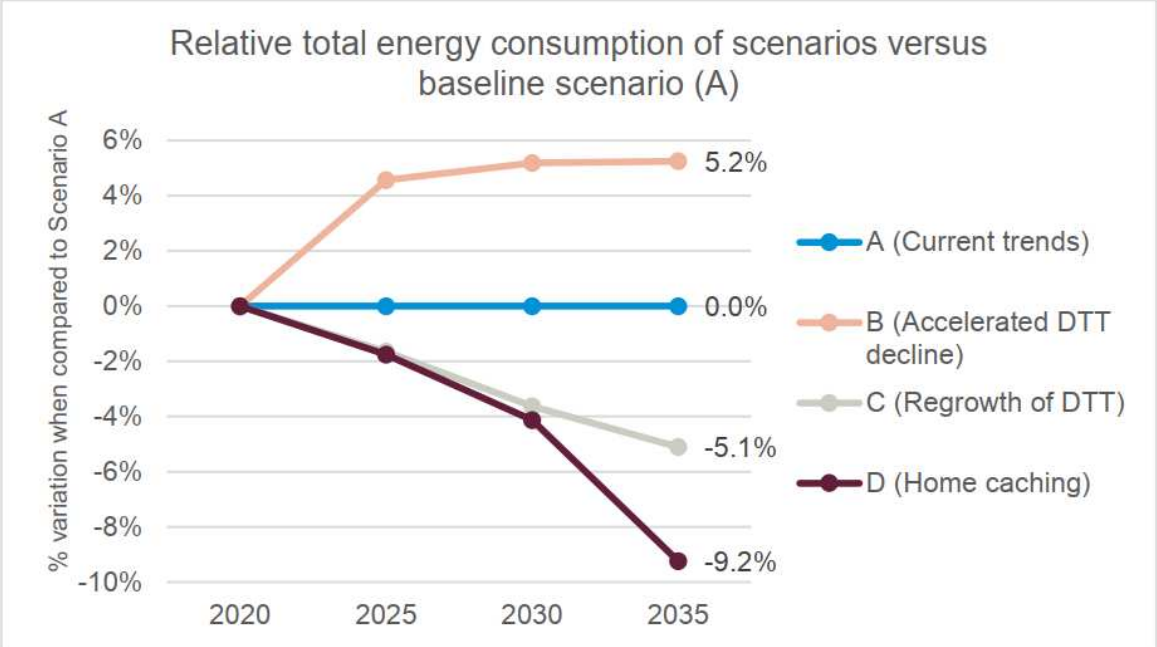
The report predicts future trends for total GHG emissions in the short, medium and long term based on an analysis of current viewership data and projected growth patterns. It offers valuable insights into the modelling for evaluating GHG emission evaluation.

[212] Malmodin, Jens & Lunden, Dag, *The Energy and Carbon Footprint of the Global ICT and E&M Sectors 2010–2015* (2018) Figure 8 and 17 https://www.mdpi.com/2071-1050/10/9/3027 (last accessed Nov 6th 2024)

Summary of report

- The study found that DTT had the lowest emissions per hour of viewing, followed by IPTV and then OTT. This is primarily due to the energy efficiency of terrestrial broadcast networks compared to internet-based delivery.
- The study also analysed potential future scenarios and concluded that shifting viewership towards DTT could further reduce the TV industry's carbon footprint.
- It is comprehensive in its scope, by considering various delivery platforms and their associated infrastructure.
- It uses a data-driven approach, utilising life-cycle assessment methodology and incorporating market research similar to the BBC WHP 372 user behaviour methodology.
- It analyses four future scenarios (A- Baseline IP Growth based on current trends, B- Accelerated IPTV Growth and DTT decline, C- Plateau IPTV and regrowth of DTT and D- DTT home caching for VOD- allows viewers to store VOD content locally after receiving content via DTT networks) providing insights into potential emissions reduction strategies.

Figure 70:[213] Relative total energy consumption of scenarios without considering TV sets and other viewing devices within the system boundaries.



[213] Carnstone, *Quantitative study of the GHG emissions of delivering TV content* (2021) Annex B https://thelocatproject.org/wp-content/uploads/2021/11/LoCaT-Final_Report-v1.2-Annex-B.pdf (last accessed Nov 6th 2024)

Gap Analysis

The study has several gaps, predominantly due to limitations in the scope of the study and uncertainties in the future of the TV industry.

- Full Scope of Environmental Impact: Expanding the analysis to include embodied emissions (from device manufacturing and disposal) would provide a complete life cycle perspective, essential for informed choices about technology and infrastructure investments.
- The Importance of End-User Devices: The study excludes viewing devices.

  To assess accurately the role of consumer choices and industry initiatives, the analysis should consider the environmental impact of primary viewing devices (TVs, mobile devices, etc.) as highlighted in the BBC WHP372 report, viewing devices are a significant contributor to GHG emission. This is key for evaluating the effectiveness of potential efficiency standards or consumer awareness campaigns.
- Need for Dynamic Monitoring: The TV delivery landscape is rapidly evolving. Continuous monitoring of the environmental impacts of established and emerging technologies is crucial for ensuring that assessments remain up-to-date and adaptable to innovation.
- Broader Comparative Analysis: Including satellite and cable delivery methods would create a broader foundation for comparison, informing decisions about infrastructure development, potential regulations, or incentives across the TV sector.

3.1.1.3 Carnstone study on Carbon emissions of streaming and digital terrestrial

Carnstone's study followed the same method as the LoCaT project study in calculating energy consumption and associated GHG emissions. The Carnstone study has additionally considered the impact of viewing devices. We summarise the impact of viewing devices and the methodology used to calculate the impact of GHG emissions of viewing devices below.

Summary of the methodology and impact of viewing devices

- The report investigated the GHG emissions and energy consumption associated with OTT and DTT viewing for one hour and associated annual consumption of energy and GHG emissions attributed to all device hours of the UK in 2021.
- The study found that approximately 89% of OTT and 96% of DTT energy consumption occurred within the home concentrated around viewing devices and in-home networks (Customer Premises equipment and Peripherals).
- It uses the methodology of attributional life-cycle assessment consistent with BBC WHP 372, the LoCaT project and DIMPACT project.

- Unlike the LoCaT Project, this study expanded its scope to include viewing devices (television sets, tablets, smartphones)

A location-based approach is used for energy procurement, meaning the average emissions from energy generation in the United Kingdom are considered.

Gap analysis

- This study did not include embodied and end-of-life assessments of viewing devices, identifying this as a research gap.
- Other notable exclusions in this study are mobile network transmission, production of TV content, and impact on other sectors beyond the boundary of TV viewing methods.

3.1.1.4 Carbon Trust– Carbon impact of video streaming

The report analysed the amount of carbon emissions per hour of video streaming in Europe.

Summary of the methodology and report

- The study revealed that data centres (including hosting, encoding, and CDNs) contribute less than 1% of total emissions and energy consumption per hour of video streaming. In contrast, user devices account for 51% and home routers for 38% whereas network transmission (Network transmission for video streaming refers to the methods and protocols used to transmit video content over computer networks or the internet to viewers) accounts for 10%.
- The report presents two methods of allocation of energy to video streaming services,
    - A conventional method which uses average allocation methodology, where the internet network energy is allocated using an average energy per data volume (kWh/GB), a similar approach to that followed in the LoCaT project.
    - A power model approach which uses a marginal allocation methodology, where network baseload power is allocated per user/subscriber, and the marginal network component is allocated by the volume data.
- The study examines the entire video streaming ecosystem, encompassing data centres (including hosting, encoding, and CDNs), fixed and mobile transmission networks (core and access), home routers, and end-user devices.
- The study highlighted that the local electrical grid's carbon intensity has a critical effect on the carbon impact of video streaming.

Gap analysis

The study did not include embodied emissions and end-of-life management of end-user devices.

3.2.1 Recommended methodology to measure differences in the environmental impact of DTT, cable, satellite and IPTV

3.2.1.1 Introduction

Our literature review identified a body of research on the environmental impact of various television delivery methods. Existing studies have established methodologies for evaluating the energy consumption of different viewing methods. However, a gap exists in comprehensively quantifying the environmental impact across the entire life cycle of TV content delivery, encompassing all stages from resource extraction and device manufacturing to disposal and the influence of user behaviour, predominantly due to the scope of studies not covering the entire life cycle of TV delivery.

3.2.1.2 Methodology Recommendation Process

We suggest a methodology to assess the environmental impact of different TV delivery methods and content consumption taking into consideration the literature review above and the standard methodology and frameworks developed for the Information and Communication Technology (ICT) and Entertainment and Media (E&M) sectors by different global standards bodies.

Standard Methodology for Environmental Impact on ICT and E&M Sector

There are several established guidelines and standards for assessing environmental impact in the ICT and E&M sectors. One prominent example is the GHG Protocol standard, which aligns with ISO LCA standards (ISO 14040 and ISO 14044). Other standard development bodies like ETSI (European Telecommunication Standard Institute) and ITU (International Telecommunication Union) have built upon this framework to create ICT-specific standards widely used for environmental impact assessment.

The guidelines for the ICT sector are developed by GHG Protocol standards.[214] This is a global body and its process is explained in section 1.4.[215]

This standard follows a lifecycle of GHG assessment of products and services. It is built on the framework and established methodology in the ISO LCA standard: ISO 14040: 2006 Principles and Framework, and ISO 14044: 2006 LCA assessment: Requirements and Guidelines. Based on these ISO standards the LCA methodology and those of other standards development bodies (ETSI and ITU) developed ICT-specific standards that have been widely used by LCA practitioners and researchers for environmental impact assessment.

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[214] GHG Protocol Standards https://ghgprotocol.org/about-us

[215] Global e-Sustainability initiative. *ICT Sector Guidance built on the GHG Protocol Product Life Cycle Accounting and Reporting Standard*. Section 1.4 (2017)

We have also noted that all studies done on the TV delivery methodology for energy consumption and associated GHG emissions assessment are based on the life cycle assessment[216] of services.

By analysing the entire life cycle of products and services, we can identify their hotspots and make informed choices for sustainability.

The outcome of Literature Review

1. Methodology: Attributional Life Cycle Assessment (LCA) is the established method for quantifying the environmental impact of TV delivery. However, existing studies focus primarily on energy consumption during the use phase.
2. Scope: Current research focuses on energy use during the use stage and neglects the embodied emissions in ICT equipment, waste management, and the complete product life cycle.
3. Data Sources: Researchers often calculate energy consumption using figures provided by service providers and data centre operators, employing an attributional approach.
4. Commonalities: All studies prioritise measuring energy consumption and environmental impact in the use phase. The BBC WHP 372 methodology has been widely adopted due to its focus on demographics and user behaviour.
5. Limitations: Consequential[217] Life Cycle Assessment is not used, as studies aim to specifically determine the energy implications of TV content delivery and viewing.

Key areas for the proposed methodology to address.

Extend scope to a Full Cycle Assessment: Expand the assessment scope beyond the operational use phase to include:

1. Embodied emissions: Calculate energy and emissions associated with manufacturing TV sets (UHD, HD, SD[218] and smart TV) and in-home devices such as modems/routers, complex STBs and PVRs for different TV viewing methods (DTT, cable, satellite, IPTV) using the method called life cycle ratio as described in GHG Protocol[219]-ICT Sector Guidance (see chapter 2). In this method, the use stage GHG emissions are modelled as a percentage of the

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[216] Environment Agency, *Life Cycle Assessment* https://www.eea.europa.eu/help/glossary/eea-glossary/life-cycle-assessment (last accessed Nov 6th 2024)

[217] Brander, Matthew, *The most important GHG accounting concept you may not have heard of: the attributional-consequential distinction* (2021) https://ghginstitute.org/2021/04/21/the-most-important-ghg-accounting-concept-you-may-not-have-heard-of-the-attributional-consequential-distinction/ (last accessed Nov 6th 2024)

[218] Morrison, Geoffrey, *From 4K to UHD to 1080p: What You Should Know About TV Resolutions* https://www.cnet.com/tech/home-entertainment/from-4k-to-uhd-to-1080p-what-you-should-know-about-tv-resolutions/ (last accessed Nov 6th 2024)

[219] https://ghgprotocol.org/sites/default/files/2023-03/GHGP-ICTSG%20-%20ALL%20Chapters.pdf (last accessed Nov 6th 2024)

total life cycle GHG emissions, accounting for the equipment type, usage profile and country/region of usage. The ratios were developed based on historical life cycle assessments for different ICT equipment types. The breakdown of embodied and use phases of different TV delivery methods components highlights those in-home peripherals and devices. TV sets have a considerable percentage of embodied emissions compared to network infrastructure and storage components.

Rapid technological advancements and evolving user behaviour drive the need to include embodied emissions for all home viewing devices and peripherals within Life Cycle Assessments (LCAs) across different viewing methods. This comprehensive approach will enable tracking of the environmental impacts of policy shifts, technological innovations and changing consumer preferences

Figure 71[220]: Calculation of Embodied/use phase ratio

Component	Use Phase CO2e (%)	Embodied CO2e (%)	Reference grid intensity (g/kWh)	Use phase (Wh)	Embodied (gCO2e per Wh use)
DTT Infrastructure	95	5	500	190	0.03
Servers (cloud and CDN)	95	5	500	190	0.03
IP networking infrastructure	90	10	500	180	0.06
Home router	85	15	500	170	0.09
Home peripherals	80	20	500	160	0.13
TV	20	80	500	40	2.00

2. End-of-Life Impacts: These account for the energy and emissions involved in disposing of, or recycling, viewing devices and other in-home devices. They can be considered part of embodied emission as life cycle assessment studies have indicated that the GHG emissions tend to be very small and sometimes negative if recycling credit is applied to raw material acquisition and processing.[221]

[220] Carnstone, *Quantitative study of the GHG emissions of delivering TV content* (2021) https://broadcast-networks.eu/wp-content/uploads/LoCaT-Final_Report-v1.2-Annex-B-1.pdf (last accessed Nov 6th 2024)
[221] Global e-Sustainability initiative. *ICT Sector Guidance built on the GHG Protocol Product Life Cycle Accounting and Reporting Standard*. Section 1.4 (2017) Page 2-51

Impact of energy sector transformation

The ongoing energy transition towards Net Zero and sustainability is changing how we assess the environmental impacts of products and services. Declining carbon intensity of electricity means we need dynamic analysis. GHG emissions data can be presented over time to demonstrate this shift.[222] The use of the latest data on GHG emissions is recommended as released by the Government.[223] For accurate results, factor in location-specific data and consider Scope 2 emissions where the data available is associated with service providers.

User behaviour

1. Demographics and user choice:

   The BBC white paper (WHP 372) does provide solid foundations for accounting for user behaviour and its approach is also used in other studies. Further enhancements can be introduced by including regional variations, socioeconomic factors, and different age demographics influenced by viewing habits.

2. Awareness and influence:

   Other factors to be accounted for in an Attribution Life Cycle Assessment include any changes in user behaviour due to awareness campaigns, energy consumption monitoring and wastage monitoring, and any changes over time in the energy efficiency of consumer electronics goods.

3.2.1.3 Methodology

We propose a methodology to perform Attributional Life Cycle Assessment for the use phase and embodied phase, only for viewing devices, STB, PVR, in-home peripherals - routers/modem, for one hour of device viewing for different TV delivery methods. This is based on the BBC White Paper 372 for Satellite, Cable and DTT TV viewing methods and IPTV services based on the LoCaT project study. This methodology included embodied emissions for viewing devices and in-home peripherals including set-top boxes and personal video recorders for assessment of the relatively complete environmental impact. A user behaviour model follows the BBC White Paper 372 and can be further enhanced to introduce regional variations, socioeconomic factors, and different age demographics influenced by viewing habits. A sensitivity analysis can be conducted to investigate how variations in these user behaviour factors influence the environmental impact outcomes.

Core Framework: Life Cycle Assessment (LCA)

[222] Circular Ecology, *Defra 2023 Emissions Factors Released* (2023) https://circularecology.com/news/defra-2023-emissions-factors-released

[223] Document Conversion factor 2023, *Greenhouse gas reporting: conversion factors 2023* (2023) https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2023

The overall approach of Life Cycle Assessment is based on the ISO 14040 standard using attributional methods of assessment. According to the standard, the four phases of a LCA study are:

1. Goal and scope definition
2. Inventory Analysis
3. Life cycle impact assessment
4. Life cycle interpretation.

Goal

The purpose and objectives of the methodology are to measure more effectively the environmental impact of different TV viewing methods (DTT, cable, satellite and IPTV).

Scope

The scope includes the in-use phase of the lifecycle for different TV viewing methods covering distribution (temporary storage, local access network and in-home peripherals) and consumption phase (viewing devices, STBs, PVR). The in-use phase will be based on an attributional life cycle assessment.

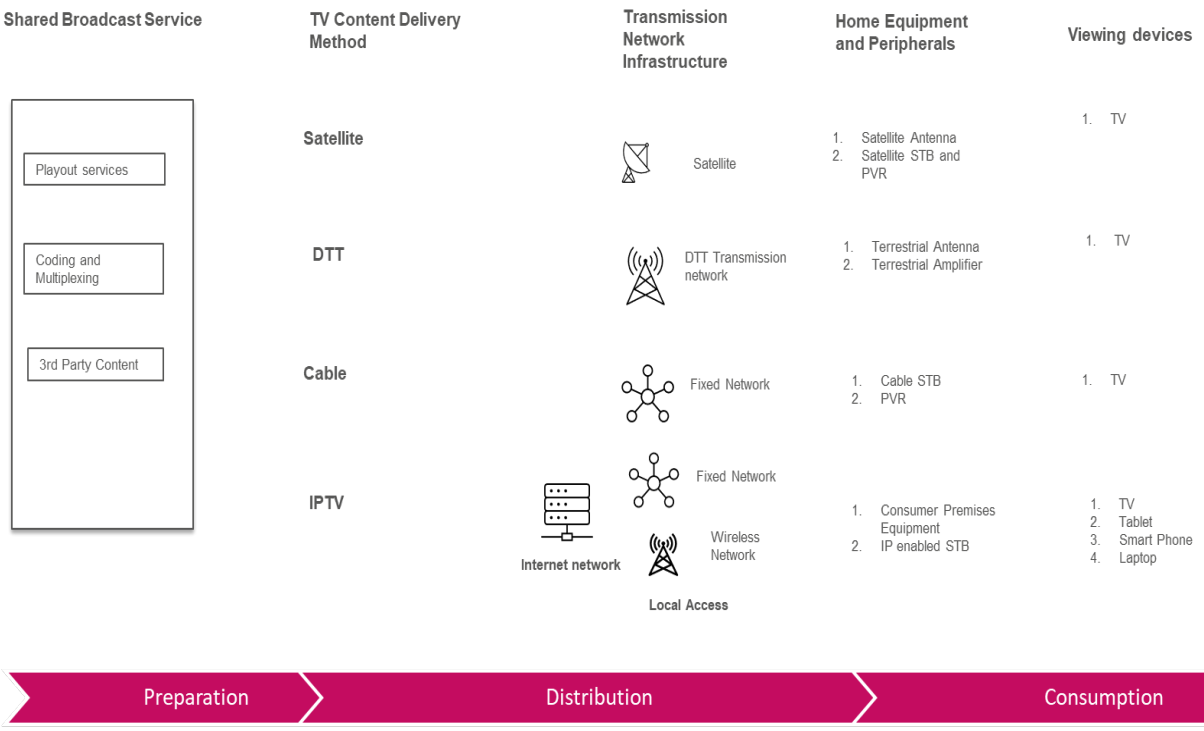
Functional Unit

According to GHG Protocol Guidance a Function Unit is defined as the quantified performance of the product being assessed and is used as the reference unit against which the product is measured. In this case one device hour of TV viewing.

System Boundary

Distribution and consumption phases only are to be considered within the boundary of the study. For each process, we map the data collection and inventory analysis.

Figure 72: TV delivery method process map



The table below provides the data for each TV viewing method.

Figure 73: Data Collection and Inventory Analysis of use phase of TV viewing

TV Viewing Methods	Device Types	Data Source	Attribution Types	Data Unit
DTT	DTT Network Transmission	DTT Service Provider	Total UK network energy consumption	Total Watt
DTT	Terrestrial Antenna	Product Data Sheet	Fully allocated to DTT (incl. TV not viewed	Watt
DTT	Television Set	Latest market research information for different sizes and picture quality	Time-based approach to viewing hours. Use the EnergyStar database to group power consumption based on sizes	Watt
DTT	Personal Video Recorder	Latest Market Research information.	A time-based approach based on viewing hours and power consumption of devices with different states. (The EnergyStar model could be applied for on, active, and passive standby).	Watt
DTT	Complex Set-Top Box	Latest Market Research information.	A time-based approach based on viewing hours and power consumption of devices with	Watt

TV Viewing Methods	Device Types	Data Source	Attribution Types	Data Unit
			different states. (The EnergyStar model could be applied for on, active, and passive standby)	
Cable	Cable Network (Fibre Link)	Energy Consumption data reported by the operator.	Apply energy consumption only for the TV service and the number of viewing hours	Watt
Cable	Set-top Box	Latest Market Research information.	A time-based approach based on viewing hours and power consumption of devices with different states. (The EnergyStar model could be applied for on, active, and passive standby)	Watt
Cable	Television	Latest market research information for different sizes and picture quality	Time-based approach to viewing hours. Use the EnergyStar database to group power consumption based on sizes	Watt
Cable	Personal Video Recorder	Latest Market Research information.	A time-based approach based on viewing hours and power consumption of devices with different states. (The EnergyStar model could be applied for on, active, and passive standby).	Watt
Satellite	Satellite Distribution network	Service Provider	Fully allocated power consumption (incl. TV not viewed)	Watt
Satellite	Complex Set-Top Box	Latest Market Research information.	A time-based approach based on viewing hours and power consumption of devices with different states. (The EnergyStar model could be applied for on, active, and passive standby)	Watt
Satellite	Television	Latest market research information for different sizes and picture quality	Time-based approach to viewing hours. Use the EnergyStar database to group power consumption based on sizes	Watt
Satellite	Personal Video Recorder	Latest Market Research information.	A time-based approach based on viewing hours and power consumption of devices with different states. (The EnergyStar model could be applied for on, active, and passive standby).	Watt
IPTV	Fibre Network	Network operator or publicly available data from the operator	Time-based approach to viewing hours.	Watt

TV Viewing Methods	Device Types	Data Source	Attribution Types	Data Unit
IPTV	Mobile Network	Network operator or publicly available data from the operator	Time-based approach to viewing hours.	Watt
IPTV	Content Delivery Network	From the Data centre operator	Data volume-based approach consumed per household	kWh/GB
IPTV	Television	Latest market research information for different sizes, picture quality and technology.	Time-based approach to viewing hours. Use the EnergyStar database to group power consumption based on sizes	Watt
IPTV	Consumer Premises Equipment (Modem/Routers)	Latest Market research information	Data volume-based approach per household	Watt
IPTV	IPTV Set Top Box	Latest Market Research information.	A time-based approach based on viewing hours and power consumption of devices with different states. (The EnergyStar model could be applied for on, active, and passive standby)	Watt

Embodied Emissions

This uses the method described in GHG Protocol Guidance for the ICT sector by using secondary data called life cycle stage ratio modelling for viewing devices and in-home peripherals.

Figure 74: Embodied emission and use phase life cycle ratio

Product Types	Use Phase (CO2e)	Embodied Phase (CO2e)
TV	20%	80%
Home Router/Modems	85%	15%
Set Top Up Box	80%	20%
Personal Video Recorder (Modelled as STB)	80%	20%
Smart Phone	30%	70%

Product Types	Use Phase (CO2e)	Embodied Phase (CO2e)
Laptop	30%	70%
Tablet	30%	70%

(Source: From Table 5.9 and Table 5.10 section 5 GHG Protocol ICT Sector Guidance[224])

Figure 75: Emission factor guidance for the methodology

Emission Factor	Conversion Factor (kg CO_2e/kWh)	Definition
GHG intensity of electricity generation	Year 2023 value: 0.207074 UK Government website[225]	The emissions of the electricity provided to the grid that is purchased by the user.
Transmission and distribution losses	Year 2023 value: 0.017915 UK Government website[226]	Emissions associated with grid losses (the energy loss that occurs in getting the electricity from the power plant to the organisations that purchase it).
Well to Tank emission factor	Year 2023 value: 0.05629 (Generation)	Emissions for electricity are those emitted in the upstream of the electricity production.
Total	0.281279	Final conversion factor.

Total GHG emission = electrical energy per period (kWh/period) * carbon intensity electricity used (kgCO2e/kWh)

- Impact Assessment

  The results of the inventory analysis will be used in a life cycle assessment (LCA) to evaluate the potential environmental impacts of different TV delivery methods.

- GHG Impact Assessment: The Global Warming Potential (GWP) is a metric used to calculate how much each specific greenhouse gas (GHG) contributes to climate change. When emissions are multiplied by GWP they become CO_2 equivalent or CO_2 e.

  kg CO_2e = Direct Emissions Data x GWP (kg GHG) [kg CO_2e/kg GHG]

[224] Global e-Sustainability initiative. *ICT Sector Guidance built on the GHG Protocol Product Life Cycle Accounting and Reporting Standard*. Section 1.4 (2017) Page 2-51
[225] UK Government, *Government conversion factors for company reporting of greenhouse gas emissions* (Updated 2023) https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting#history (last accessed Nov 6th 2024)
[226] Ibid

The latest value of GWP should be used for calculation, as released by the Intergovernmental Panel on Climate Change (IPCC).[227] The most recent published data was released in 2021 as part of the IPCC Assessment Report Global Warming Potential.[228]

LCA is an iterative process, and impact assessment may include the iterative process of reviewing the goal and scope of the LCA study to determine if the objective of the study has been met.

Interpretation

The interpretation of results from LCA analysis will provide information for different TV delivery methods:

- Identifying hotspots across the stages of different TV delivery methods.
- Environmental impact of different TV delivery methods (DTT, satellite, cable, IPTV).
- Identifying which TV delivery method has the greatest environmental impact.
- Identifying which viewing device has the greatest environmental impact, based on 1 hour of usage.
- Identifying where changes in user behaviour could potentially impact the environment.
- Highlight recommendations for service providers, manufacturers and viewers on usage of different TV viewing methods.

3.3 Research framework to effectively measure the environmental impact of an increase in the use of IPTV

As the Audience Analysis section shows, the UK television landscape is transforming significantly from traditional broadcast to internet-enabled distribution, propelled by several interconnected factors, including advancements in telecommunications,[229] the rapid pace of technological innovation in consumer electronics (underscored by Moore's Law[230]), and user behaviour shifts towards greater use of on-demand services in the longer term. However, alongside this, concerns are emerging regarding the environmental impact of this transition. While IPTV offers potential benefits in terms of shared physical infrastructure compared to traditional broadcasting, its energy consumption is much higher (see Figure 76). Note that the Lo-Cat report separately identifies the energy consumption of OTT and managed

[227] https://www.ipcc.ch/about/

[228] ERCE Group News, *IPCC Sixth Assessment Report Global Warming Potentials* (2021) https://erce.energy/erceipccsixthassessment/ (last accessed Nov 6th 2024)

[229] UK Government, *Project Gigabit* (Updated 2024) https://www.gov.uk/guidance/project-gigabit-uk-gigabit-programme (last accessed Nov 6th 2024)

[230] Britannica, Moore's Law (updated 2024) https://www.britannica.com/technology/Moores-law (last accessed Nov 6th 2024)

IPTV, as subsets of IPTV. Energy consumption hotspots are data transmission, server operation, in-home peripherals and user devices. These require closer examination.

Figure 76[231]: Breakdown of average energy consumption (Wh) for Europe by components

Components	DTT	OTT	Managed IPTV
Distribution infrastructure (Incl. Data Centres)	8	34	39
In-home network interface (e.g. signal booster, modem)	3	55	88
Viewing peripherals (e.g. STB, streaming devices)	3	20	26

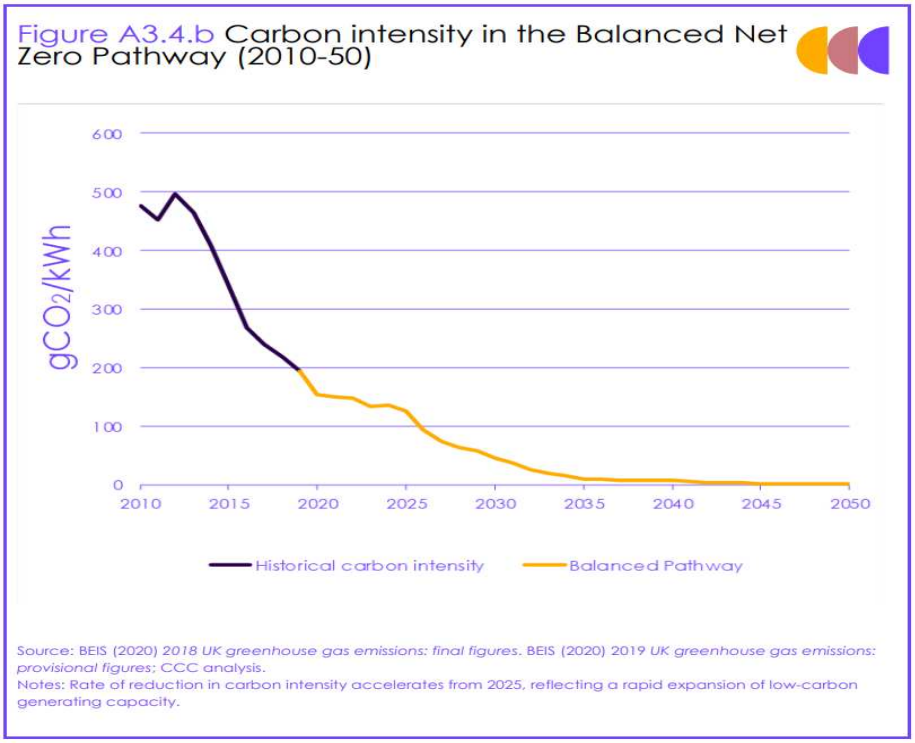
The environmental implications of IPTV cannot be understood in isolation. Transformation in the television sector may create ripple effects across other industries. For example, declining demand for traditional broadcast infrastructure might influence material sourcing and manufacturing practices.

Additionally, evolving energy policies focused on sustainability are likely to shape how data centres and network service providers manage energy needs within the IPTV delivery system. This will particularly impact their response to shifting demand and supply patterns, alongside the increasing use of renewable energy sources.

The Government's Net Zero 2050 target is expected to drive a significant decline in the GHG emissions intensity of electricity over the next 14 years, becoming a key factor impacting total GHG emissions.

[231] Carnstone, *Quantitative study of the GHG emissions of delivering TV content*. (2021) See Table 4 https://broadcast-networks.eu/wp-content/uploads/LoCaT-Final_Report-v1.2-Annex-B-1.pdf (last accessed Nov 6th 2024)

Figure 77[232]: Carbon intensity projection



(Source: Figure A3.4b Sixth Carbon Budget Electricity Generation)

Consequently, a comprehensive assessment of IPTV's environmental impact necessitates a broader systems-thinking approach.

3.3.1 Recommended Framework or Methodology

We propose an Attributional Life Cycle Assessment methodology as described in section 4.2.2 to create a baseline scenario. Following that, sensitivity analysis can be conducted on input data to assess how changes in those inputs might affect the environmental impacts associated with the growth of IPTV viewing. This analysis systematically tests how changes in input parameters related to energy usage influence the calculated environmental impacts.

3.3.1.1 Attributional Life Cycle Assessment

Replicating the Attributional Life Cycle Assessment methodology will provide a suitable baseline for Life Cycle Assessment.

Purpose of LCA: Quantification of environmental impact due to the shifting landscape of TV viewing methods where IPTV viewing increases.

Goal: To quantify the environmental impact of the IPTV delivery method within the use phase, and the embodied emissions associated with the hardware for a medium-

[232] Climate Change Committee, *The Sixth Carbon Budget Electricity generation* (2020) See Page 39 https://www.theccc.org.uk/wp-content/uploads/2020/12/Sector-summary-Electricity-generation.pdf (last accessed Nov 6th 2024)

to-long term time frame (up to 2040), based on the projected increase in IPTV usage.

Scope: Use Phase

This analysis will cover the energy consumption associated with transmission (including data storage) and consumption of IPTV viewing projected until 2040. IPTV infrastructure and usage patterns represented within the geographic regions of the United Kingdom.

System Boundary

This is similar to the recommended methodology as described in the IPTV viewing method.

The baseline environmental impact for IPTV viewing can be derived from the methodology explained in Section 3.1.2.3.

Exclusions from the System Boundary

- Core internet networks. Their energy consumption is negligible in the case of IPTV.[233]
- Granular energy consumption data of individual equipment such as servers, routers, and switches energy consumption at data centres.
- Ripple effects outside the system boundaries and can be considered for a future study using consequential LCA methodology.

Sensitivity Analysis

A sensitivity analysis will examine how changes in input data, updated due to the following factors affect LCA compared to the baseline scenario.

Data Collection Inventory Analysis

Based on the projected growth of IPTV viewership the impact on distribution, transmission and consumption can be assessed as below.

Distribution Infrastructure:

- Data Centres
    - Additional data centres constructed due to growth in IPTV.
    - Expansion of existing data centres in terms of storage, processing servers and energy use.
- Internet Infrastructure
    - Access Network: Additional infrastructure to increase IPTV upstream and downstream data flow capacity, such as additions to the fibre

[233] Carnstone, *Quantitative study of the GHG emissions of delivering TV content*. (2021) see page 38

network, additional routers, switches or cellular network towers and associated network infrastructure.

Consumption:

In-home peripherals -

- Consumer premises devices
    - Additional energy consumption in CPE (modems/routers) is attributed to IPTV content consumption through increased viewing hours per device.
    - Additional homes equipped with CPE devices (modems/routers) due to the expansion of IPTV.
- IPTV set-top boxes
    - Increased number of IPTV STBs due to increase in adoption of IPTV viewing.
    - Additional energy consumption due to an increase in IPTV viewing hours.

Viewing devices -

- TV Sets
    - An increased number of newer TV sets (e.g. hybrid TVs, smart TVs) is projected due to an acceleration in the replacement cycle, predominately led by technological advancements in picture quality and screen size, coupled with improvements in IPTV quality of service.
    - Projected trends for energy consumption of the latest TV models for IPTV viewing.
- Other viewing devices (mobile, laptop and tablets)
    - Additional number of viewing hours on different user devices.
    - Different viewing methods in various family demographics.
- Functional Unit
    - One hour of IPTV viewing.
- Time Frame
    - Based on IPTV growth projections for the next 16 years.

Energy emission:

- Use projected energy emissions factor for respective years.

GHG emission impact assessment: The potential changes in GHG emissions due to each year of projected IPTV growth can be quantified, with sensitivity analysis used to explore how variations in input data influence these results.

Interpretation: The interpretation of results from LCA analysis will provide the following information for different TV delivery methods.

- Identifying potential drivers influencing change in environmental impact.
- Identifying where changes in user behaviour due to increased IPTV service could potentially impact the environment.

3.4. Expected growth of the environmental impact of IPTV

As IPTV disrupts traditional broadcasting models, understanding its potential environmental impact becomes essential and a core question emerges: as IPTV adoption increases, should we expect a linear increase in environmental impact, or might non-linear patterns emerge due to factors such as technological advancements, energy efficiency measures, or shifts in consumer behaviour?

This research aims to investigate whether the environmental impact of IPTV is likely to grow linearly or non-linearly. There are several factors that require closer examination to establish whether it has a linear or non-linear impact on the environment.

3.4.1 Linear Growth Factors

3.4.1.1 Environmental impacts that grow linearly with increases in IPTV consumption.

Direct Scaling: IPTV's fundamental reliance on data centres, network infrastructure, and user devices implies a direct relationship between IPTV growth and resource use. As more users join, more equipment and energy are inherently required.

Even if there is a direct scaling of IPTV growth and energy usage, its impact on emissions will result in modest linear growth because of other linear trends reducing those emissions, as predicted by IEA.[234]

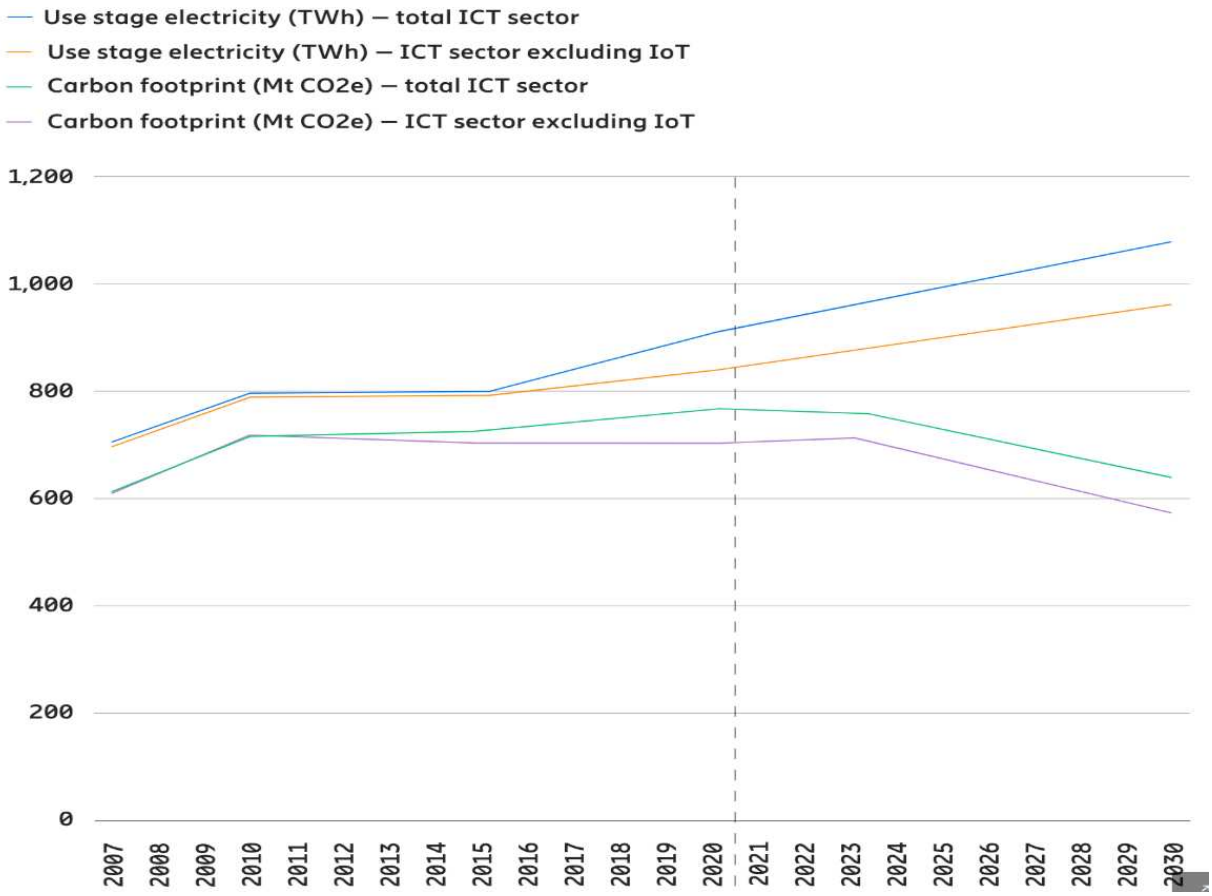
*'*The data centres and data transmission networks that underpin digitalisation accounted for around 330 Mt CO^2 equivalent in 2020 (including embodied emissions), equivalent to 0.9% of energy-related GHG emissions (or 0.6% of total GHG emissions). Since 2010, emissions have grown modestly despite rapidly growing demand for digital services, thanks to energy efficiency improvements, renewable energy purchases by information and communications technology (ICT) companies and broader decarbonisation of electricity grids in many regions. However, to get on track with the NZE (Net Zero Emission) Scenario, emissions must halve by 2030.*'*

[234] Data Centres & networks – IEA, https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks (last accessed Nov 6th 2024)

Steady Efficiency Gains: If improvements in areas like energy efficiency occur at a predictable rate, the environmental impact may grow more slowly, or decline, but in a relatively linear fashion alongside the expansion of IPTV services.

According to an Ericsson report on the environmental impact of the ICT sector, greenhouse gas (GHG) emissions are projected to decline linearly even as data storage and transfer increase, because of these steady efficiency gains.

Figure 78:[235] Sustainability and ICT – Mobility Report - Ericsson



In the short term, IPTV's environmental impact is predicted to increase linearly due to rising adoption rates. However, this impact will be moderated by improvements in data centre efficiency, energy-efficient ICT equipment, and the shift towards renewable energy sources.

[235] *Sustainability and ICT* – Mobility Report - Ericsson, https://www.ericsson.com/en/reports-and-papers/mobility-report/dataforecasts/ict-sustainability. IoT (Internet of Things). (last accessed Nov 6th 2024)

3.4.2 Non-Linear Growth Factors

3.4.2.1 Generation changes in technological advancement lead to step changes in performance and energy efficiency.

Technology Leaps: Breakthroughs in semiconductor design, compression algorithms, or data centre cooling could suddenly reduce energy consumption per user, offsetting linear growth.

Changes in Network Technology: Deployment of more energy-efficient network infrastructure (e.g., fibre optics vs. older technologies in the access network) could mitigate the impact of IPTV growth. Conversely, if IPTV drives demand for ultra-high bandwidth technologies, that might have an unforeseen negative impact.

3.4.2.2 The flexibility provided by IPTV with its wide selection of viewing devices and picture quality choices.

Device Trends: If viewers primarily shift towards smaller, more efficient mobile devices instead of large TVs, it could limit the environmental impact compared to linear expectations. Conversely, if multiple high-resolution screens per household become common, it could accelerate impact. As mobile markets saturate, growth in uptake of high-resolution smart TV choices around OLED technology[236] (Organic Light-Emitting Diodes) and screen size become pivotal in determining the non-linear trajectory of environmental impact.

3.4.2.3 Consequential impact of IPTV growth on technology advancement in network access and delivery methods.

IPTV growth has the potential to drive a significant change in technology in the delivery of content that could have a non-linear growth factor.

Some areas where we could see technology enhancement are:

Enhanced optical network: Growth in IPTV could increase demand for expansion of the fibre network. Some of the technology in the medium to long term could be deployed such as multi-core fibre. Breakthroughs in photonics could make networks more energy efficient.[237]

Multicast delivery: IPTV could prefer multicast for more popular programmes and live events, which could increase efficiency.

Adaptive Bitrate: Dynamically adjusting the bitrate according to bandwidth and other network conditions will reduce energy consumption.

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[236] Morrison, Geoffrey, What is OLED and what can it do for your TV? (2019) https://www.cnet.com/tech/home-entertainment/what-is-oled-and-what-can-it-do-for-your-tv/ (last accessed Nov 6th 2024)

[237] Slijkerman, Jan ING, *Fibre technology and photonics are advancing at speed* (2023) https://think.ing.com/articles/telecoms-outlook-fibre-technology-and-photonics/ (last accessed Nov 6th 2024)

3.4.2.4 User behaviour, driven by increased IPTV adoption, may result in non-linear impacts due to increases in the number of viewing devices and in-home peripherals.

If IPTV enables more viewing hours per person, or if users keep old devices rather than replacing them with more efficient ones, the environmental impact will grow faster than anticipated by a linear model.

In the long term, IPTV's environmental impact is predicted to deviate from a linear trend due to unprecedented advancements in high-performance and energy-efficient information transmission links, distribution, and storage systems. Additionally, changes in user behaviour driven by the availability of a wider range of viewing devices are expected to contribute to this non-linearity

3.5 Summary

IPTV's environmental impact demands continuous monitoring. While short-term trends are predictable, the long-term trajectory remains uncertain. Technological innovation and evolving consumer behaviour will be key drivers of impact. Prioritising energy efficiency strategies and tracking how IPTV interacts with broader energy trends (network demand, energy sources and device trends) will be crucial in understanding the scale and pace of change. We should be prepared for non-linear growth patterns, where seemingly small shifts in technology or behaviour could have significant consequences.

4 International Comparisons

This section examines international territories in terms of DTT usage, general broadcast system usage and IPTV penetration. We consider whether there are any countries that are comparable with transition timelines, policy and potential future trends in the UK for full conversion away from DTT to IPTV. We explore the changes and trends in TV viewing habits in comparable jurisdictions to the UK where a significant proportion of viewers use DTT, the rate of IPTV uptake in those jurisdictions and whether there are any examples of state intervention that have accelerated transition to IPTV outside of the UK.

Case studies on France, Spain, the US and Canada examine individual territory trends.

We found there are no obvious direct territory comparisons to the UK. There are very differing levels of DTT and IPTV usage across other countries, each with their own unique political contexts, regulatory frameworks, individual histories and cultures of broadcast technologies and audience behaviour, all of which prevents direct comparison. However, three territories that have some comparable aspects to the UK are Spain, Italy and France due to their high DTT usage. Each of these territories also has very high levels of fixed broadband take-up with many households using their main TVs for hybrid viewing.

Although Switzerland and Belgium have advanced towards minimal free-to-air DTT usage, cultural and historical broadcast infrastructure factors are distinct in each country.

Transition to the second generation DTT delivery standard, DVB-T2, varies significantly between countries, but is a growing trend due to its spectrum efficiencies and ability to deliver Ultra High Definition [UHD] capabilities.

There are no significant examples of state intervention in terms of accelerated crossover from DTT to IPTV. However, there are examples of state intervention and state aid to assist the crossover from analogue to DTT, such as in France and Spain.

4.1 Methodology

Data for this section came from desk-based research accessing organisation reports, trade press articles, governmental reports and academic articles. Academic research was limited from papers published in 2018 onwards. There were challenges to accessing uniform and comparative data due to differing collection methods in each territory, with stronger data sets held behind paywalls of organisations such as the European Broadcasting Union (EBU).[238] Internationally there are also several organisations and groups for the preservation of DTT that have an interest in retaining the technology, such as Broadcast Networks Europe (BNE).[239] A portion of

[238] https://www.ebu.ch/

[239] https://broadcast-networks.eu/

their data and arguments for DTT preservation lean towards the aspects of DTT that could be replicated through IPTV with regulation and policy support.[240]

A large amount of international data comes from Statista,[241] who provided the broadest range of territory overviews. While there were other data sources available for a few select territories, Statista proprietary data forms the most comprehensive overview. Their data is formed from a combination of sources including their own Global Consumer Survey[242], aggregation of data by secondary research companies and a range of unnamed international institutions, although general reference is made to the International Monetary Fund (IMF), the World Bank and the United Nations, national statistics offices, trade associations and the trade press. Statista note that datasets can be incomplete for certain years so where their data is predictive Statista assumes an ongoing trend based on actual data. As such, Statista data can be viewed as indicative but not independently verified.

An interview was conducted with several executives at a major UK PSB to garner their opinions on international territories, how it informed their thinking, and whether there were comparable territories to the UK. They were also asked where they felt common factors existed across other territories that could accelerate a potential transition.

A second interview was conducted with a leading UK expert on TV distribution. Further interview requests were made but due to timelines or disinclination, were not able to be completed.

The section on DVB-T2 and the evolution of broadcast technologies in Europe is based on desk research, summarising a series of open access reports from a variety of sources including the EU Commission, several commentaries on the World Radio Conference and reports from a variety of other organisations.

4.2 Examination of broader European attitudes to future spectrum use from 2031 onwards

4.2.1 Prioritising of DTT over the 470-694 MHz band until 2031

Negotiations about spectrum availability in the multilateral World Radio Conference (WRC) process focus on what some describe as a “sweet spot”, which is the upper part of the Very High Frequency (VHF) band and the whole of the Ultra High Frequency (UHF) band. Despite the probable inevitability of an eventual migration of broadcasting services toward IPTV, broadcasters may require a significant runway

[240] Digital Terrestrial Television A EUROPEAN SUCCESS. Broadcast Network Europe. (2021). https://broadcast-networks.eu/wp-content/uploads/Bne_brochure_A5_June21_final_2.2.pdf last accessed 13th May 2024

[241] https://www.statista.com/

[242] Statista Consumer insights methodology. Statista Inc. https://www.statista.com/study/116580/statista-consumer-insights-methodology/ last accessed 13th May 2024

period to conduct an orderly mutation and absorb the costs of decommissioning legacy infrastructures.

As the world's largest organisation of public sector broadcasters with a remit for universal coverage, the EBU have been campaigning for maintaining the primary status of broadcasting services in the 470-694 MHz band, as have the Broadcast Network Europe (BNE), a trade association that gathers delivery systems' operators for terrestrial TV from 19 European countries. In the run-up to WRC-23, the EBU stressed that "substantial social and cultural value is generated by the use of radio spectrum," and that the benefits concerned both content production and distribution.[243] The perspective of the EBU and its constituent members is that DTT continues to provide unbeatable public value to all EU citizens: "It is efficient to deliver linear services to very large audiences, it provides near-universal reach (92% population covered on average, in many countries 98% or more). It is free-to-air, and it is resilient in times of crisis and emergency situations. Today no other platform on its own can offer the same public value to society as DTT in the UHF band."[244]

4.2.2. The current advantages of DTT according to broadcast TV operators

The EBU notes that the amount of spectrum used by terrestrial broadcasting services has halved in the past 20 years, whilst the offer of TV services on DTT has been increased substantially. The EBU's WRC-23 Position Paper considers the fact that spectrum previously used by television broadcasting in the 700 and 800 MHz band before the roll-out of DTT had been re-assigned to 5G and 4G deployment. Although the EBU recognises that this was needed to support the availability of mobile broadband services in difficult-to-reach places such as rural areas, current deficiencies in mobile coverage in such areas ought to be resolved "by further investment in network infrastructure, not with additional spectrum in the UHF band."

BNE and the EBU's advocacy for maintaining DTT as a driver for the delivery of content services finds an echo in the EU's Radio Spectrum Policy Group's own thinking on the sustained advantages of DTT over new technology options, such as IPTV:

- DTT is an easy-to-access and inexpensive platform for consumers (the most popular model involves a small annual fee).
- The investments of broadcasting operators in technological evolution (e.g. DVB-T2 and HEVC) and innovation need adequate time for return on investment.
- Convergence of DTT and IP services can be offered by technologies like HbbTV (Hybrid broadcast broadband TV).

[243] EBU Response to the Radio Spectrum Policy Group Draft Work Programme for 2022 and Beyond (2022) https://www.ebu.ch/files/live/sites/ebu/files/News/Position_Papers/open/2022/220111_RSPG_Draft_Programme_2022_Consultation.pdf last accessed 13th May 2024

[244] ibid

- The licences of current operators expire near 2030 (before or after), with a reasonable possibility of renewal for another 10-15 years.
- Free accessibility of content remains a politically supported value for its social and democratic benefits, including pluralism, diversity of opinion, cultural importance and entertainment.
- Non-traceable access is recognised as a particular value for the protection of personal privacy (a delicate and difficult issue in IP-based broadband distribution modes).
- Well-designed DTT networks are efficient with respect to energy consumption and fit in well with climate change objectives.
- Broadcast networks, including DTT, provide national resilience.[245]

These statements are all supported by the technological and net zeros sections of this report and based on factual evidence.

4.2.3 European Broadcasters preparing for the post-2030 horizon

European broadcast network operators and broadcasters say they are committed to innovating and deploying new services using cutting edge technologies,[246] with an emphasis on innovations that will help support hybrid solutions as part of the transition to a future in which broadcast linear channels use IP networks as the predominant or exclusive means of delivery. Both BNE and the EBU stress that, in years to come, DTT will benefit from improvements in the use of the UHF band. These include transition programmes towards the new DVB-T2 transmission standard, and the introduction of new compression standards, which will enable the conversion of current TV channels to UHD.

Under the EU Decision 2017/899 on the use of the 470–790 MHz band in the Union and the GE06 Agreement,[247] the UHF spectrum will also enable the introduction of standalone 5G Broadcast, which will greatly facilitate reaching broadcast TV consumers on the move, through mobile devices (e.g. their smartphones, tablets, cars). In an interview conducted for this report, a leading UK expert on television distribution commented: “It’s fair to say that there will be an implementation period between a possible WRC31 decision to make the 600 MHz band co-primary and its implementation. However, there will be considerable pressure from mobile operators to implement the change quickly and governments will also have a major financial

[245] RADIO SPECTRUM POLICY GROUP *Strategy on the future use of the frequency band 470-694 MHz beyond 2030 in the EU* (2023) https://radio-spectrum-policy-group.ec.europa.eu/system/files/2023-06/RSPG23-021final-draft_RSPG_Opinion_on_UHF_beyond_2030.pdf (last accessed 13th May 2024)

[246] *Building The Future of Europe - The Value and Contribution of Digital Terrestrial Television - A South 180 Report for Broadcast Networks Europe* (2023) https://broadcast-networks.eu/building-the-future-of-europe-the-value-and-contribution-of-digital-terrestrial-television/ (last accessed 13th May 2024)

[247] GE06 Procedures and List https://www.itu.int/en/ITU-R/terrestrial/fmd/Pages/ge06-list.aspx (last accessed 13th May 2024)

incentive to auction off the spectrum to raise billions in each country affected. In the US in 2017 they raised $19.8bn from auctioning off 84MHz of spectrum in the 600MHz band. More than half of the proceeds went to broadcasters as they 'reverse auctioned' off the DTT bandwidth they were using."[248]

The BNE's innovation roadmap includes combining 5G Broadcast with unicast technologies to deliver a more efficient use of the assigned spectrum and an improved user experience on mobile devices. It promises a seamless access to both linear and non-linear, on-demand content, using recent technologies such as HbbTV[249] and DVB-I.[250] However, the business case for assigning any spectrum use for 5G broadcast is still under discussion and has yet to be established, current smartphones do not support 5G broadcast services. In interview our UK expert stated the logic against using mobile networks to carry all broadcast signals was that: "you would have all the problems […] of changing using DVB-T2 to using 5G broadcast, you'd have all the expense of adding it to new TV sets and persuading the manufacturers to include it, but you wouldn't be using the spectrum any more efficiently."

Greater spectrum efficiency will be made possible by a transition from DVB-T to DVB-T2 as well as the introduction of highly efficient compression codecs, including HEVC. BNE sees those innovations as paving the way to delivering higher quality across the range of broadcast services, thus paving the way for the roll-out of 5G Broadcast for predominantly mobile applications.

The EU is committed to a Digital Decade[251] strategy that should see all European households having access to 5G coverage and Internet speeds of no less than 1 Gigabit, with a focus on fixed and mobile broadband access. This would comprise a combination of fibre networks for indoor connections (where most broadcast and other content tends to be consumed) and outdoors, with growing on-the-move consumption requiring the large-scale deployment of mobile broadband technologies such 3G, 4G or 5G.

4.2.4 Transition Challenges

By holding out for – and obtaining - a 'no change' option at WRC-23 on the occupancy of the sub-700MHz band, DTT operators in Europe have secured the

[248] Interview conducted for study with UK expert in TV Distribution – see full interview transcript in appendices.
[249] Hybrid broadcast broadband TV – see HbbTV website for detail: https://www.hbbtv.org (last accessed 13th May 2024)
[250] Building The Future of Europe - The Value and Contribution of Digital Terrestrial Television - A South 180 Report for Broadcast Networks Europe (2023) https://broadcast-networks.eu/building-the-future-of-europe-the-value-and-contribution-of-digital-terrestrial-television/ (last accessed 13th May 2024)
[251] Europe's Digital Decade: digital targets for 2030 https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030_en (last accessed 13th May 2024)

long runway they believe is necessary to operate a managed transition towards IPTV.

Some broadcast TV operators in Europe see the transition to IPTV as not only inevitable, but wholly desirable, in part due to the infrastructure costs of running a hybrid service. Other research shows that the transitional barriers to all-IP TV delivery for mainstream, popular channels are likely be too large to make it feasible for at least the next decade [citation needed].

The transition towards IPTV in Europe is, and will likely remain, heterogeneous: while France, Italy and Spain are taking important steps to update their DTT networks, Germany's DTT network has already shifted to advanced broadcast and encoding standards (DVB-T2, HEVC), indicating that broadcasters in these countries all envisage a lengthy timeframe for full transition to IPTV.

4.2.5 An EU-wide strategy for the future of the sub 700MHz band after 2030

In its Opinion of October 2023, the EU's Radio Spectrum Policy Group (RSPG) considered in detail Europe's 'Strategy on the future use of the 470-694 MHz band beyond 2023'.[252]

The paper notes that the sub-700 MHz band is widely harmonised for digital terrestrial television (DTT) all over the EU. Its analysis of the current situation across the EU breaks Member States into two broad categories.

In the first category are Member States where fixed broadband access has increased and is offering a possible alternative to DTT, under different access conditions. "Such alternative subscription-based services (Pay TV delivered via satellite and cable, providing both linear and on-demand content) offer various media contents through fixed broadband. In some cases, as for example Belgium, the Netherlands, Sweden, Finland, Malta, Slovenia, and Germany, this has led to a decrease in the use of DTT. This trend is expected to have an impact on media distribution in the coming years, as media publishers will begin to prioritise the use of alternative platforms that are already prevalent. New distribution media will be needed, in addition to DTT in the 470-694 MHz band […] Nevertheless, this situation regarding media consumption patterns, evolution of DTT services and availability of high-speed internet connection varies from country to country and across generations."

In the second category are Member States where free to air DTT is still very significant, and where in some cases there is little to no prospect in the short term of reducing DTT spectrum needs, due to factors that are both technical and political. The Radio Spectrum Policy Group (RSPG) cites Spain, France, Poland, Croatia, Italy, and Czech Republic as countries broadly in that category. It notes however,

[252] RADIO SPECTRUM POLICY GROUP Strategy on the future use of the frequency band 470-694 MHz beyond 2030 in the EU (2023) https://radio-spectrum-policy-group.ec.europa.eu/system/files/2023-06/RSPG23-021final-draft_RSPG_Opinion_on_UHF_beyond_2030.pdf (last accessed 13th May 2024)

that there is no uniformity in the technological profiles of these Member States: some have no current alternative platform for the universal distribution of media, whereas others already have “extensive fibre optic fixed broadband networks and/or high-speed networks deployed or planned.”

The authors of the Opinion conclude that varying approaches to the management of spectrum and broadcasting needs may result in significantly different scenarios in different Member States.

The RSPG also discusses three different national scenarios for the future.

The first scenario would see DTT in the sub-700 MHz frequency band remaining the most widespread means for accessing linear audio and video, for the decade beyond 2030. This factor – stable DTT occupancy of the sub-700 – could take place alongside an increase in access to audio-visual content via broadband systems, with a net overall increase in content consumption options made available to the consumer, through a variety of different modes.

As a result, these Member States may see the growth of hybrid distribution platforms. This scenario would see simultaneously some continuous improvements in DTT delivery technologies, such as better encoding standards and the roll-out of UHD, combined with the rapid deployment of fibre optics with attendant opportunities to deploy IPTV services that would take advantage of higher Internet speeds.

The second scenario envisages a quite similar emphasis on DTT as the main means for accessing linear audio-visual content in the 470-694 MHz spectrum. Where it differs from the first scenario is that the Member State may see a need specifically to address frequency availability for PMSE, depending on the spectrum that continues being used by DTT.

In the third scenario, a specific Member State has far less need for maintaining DTT as primary in the 470-694 MHz, with attendant opportunities to introduce, for example, mobile broadband through implementing the 600 MHz band plan.

Access to audio-visual content on linear delivery systems could in most of these cases be delivered through alternatives to DTT. These would include fixed broadband, satellite, Fixed Wireless Access (FWA), Multichannel Multipoint Distribution Service (MMDS), cable TV or 5G Broadcast. There could be an evolutionary phase out of DTT as the shrinkage in consumer demand and use would reach a stage at which broadcasters could struggle with maintaining viable DTT business models.

The transition entailed by this scenario may be conducted through national consultation processes assessing the long-term needs of DTT and the impact of transition. Such consultations would likely emphasise policy issues over spectrum management considerations, e.g. how best to serve the public interest in devising universal access to content, bearing in mind the public value of free-to-air TV services, including the supply of reliable and independent public information.

Scenarios one, two and three would probably develop differently within each country implementing them, depending on the national spectrum needs for broadcasting, PMSE or other uses, as well as cross border coordination, needed in case of different usage scenarios in neighbouring countries.

The RSPG concludes: “a common path for all Member States seems difficult even after 2030, due to different national spectrum needs and cross border issues.” On that basis, the Group makes a few key strategic recommendations:

- Any future EU regulatory action to facilitate the implementation of various scenarios among Member States, emphasises the pursuit of compatible uses and focuses on the means to achieve them.
- In the border areas of EU, successful coordination negotiations could rely on spectrum regulation at the International Telecommunication Union Radiocommunication Sector (ITU-R) level.
- There are needs, at national level, for several mobile usages other than Wireless Broadband Electronic Communication Services (WBB ECS) and PMSE, such other usages being Public Protection and Disaster Relief (PPDR) and defence. Therefore, RSPG recommends that in case of decreasing needs for broadcasting at national level, spectrum should also be made available nationally for these usage cases.
    - Those Member States introducing other usages than broadcasting, should preserve sufficient spectrum for PMSE needs, also taking into account possible evolutions of PMSE towards new technologies. The RSPG recognises that the evolution of UHF band broadcasting reception during the current decade, including factors such as the number of programmes, the content format (HD/UHD) and technological advancements (e.g. DVB-T2/HEVC, 5G Broadcast) play a role in shaping any timeline post 2030;
    - Member States wishing to continue to use sub-700 MHz band primarily for broadcasting, strive to implement the most efficient technologies (such as DVB-T2/HEVC).

One of the key factors in driving towards the hybrid distribution model is the need for broadband networks to be significantly overhauled in order to carry the full breadth of linear TV services currently available on traditional platforms. This evolution will require innovative standards to enable multicast distribution to a multiplicity of devices, in order to deliver linear channels to the quality and reliability that European customers have been accustomed to through DTT and other legacy platforms.

The switchover to an all-IP delivery infrastructure may also encounter user resistance in various forms. As broadcasters introduce encoding and definition standards to the existing platforms that can be used for hybrid delivery options (e.g. DVB-T2, H264), in some countries, many viewers may be reticent to replace their legacy TV sets. Whilst the TV operators understand the advantage these technologies bring (e.g. a more effective use of bandwidth), persuading consumers

to follow the technological innovation curve is proving a challenge. Hence, the schedule for a full migration of DTT from DVB-T to the more hybrid-friendly standard DVB-T2 was paused in France (2019) in response to cost-of-living protests by the Gilets Jaunes movement. Italy also delayed its planned migration from the MPEG2 standard in 2022, because there were still 2.6 million households with TV sets with non-H264 capability.

Managing these complex intersections between technological advances and sociological factors will take time, and the persistence of popular attachment to legacy paradigms suggests hybrid delivery solutions may be required for a transition timeline well over the 2030 horizon in other European territories.[253]

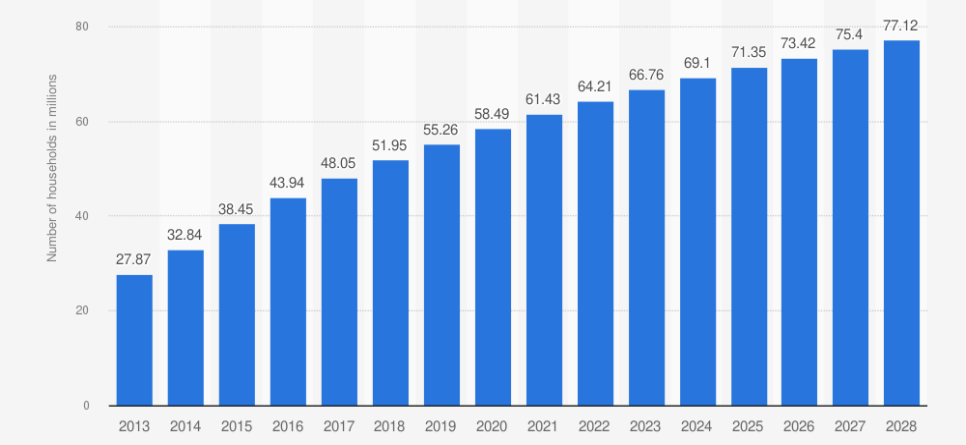
The success of the UK's Freeview, public sector adaptation to the DTT roll out, is a persuasive case study in successful integration of channels from a wide range of providers into a single electronic programme guide, and broadcasters in other European markets are now imagining similar solutions for IPTV transition to ensure consumers are offered a seamless experience. Spain's LOVEStv is a recent example of integrated solutions offering the consumer a mix of linear broadcast and IP-delivered services with an easy-to-use navigation and recommendation engines.

4.3 European region – Usage and transition

As of November 2022, more than 90 million households, which accounts for approximately 30% of European TV homes, still relied exclusively on free-to-air channels for their TV consumption. These households continue to use traditional terrestrial or satellite and cable infrastructure to watch linear TV.[254]

Figure 79: Number of IPTV households in Europe from 2013 – 2028 (published Aug 2023). [255]

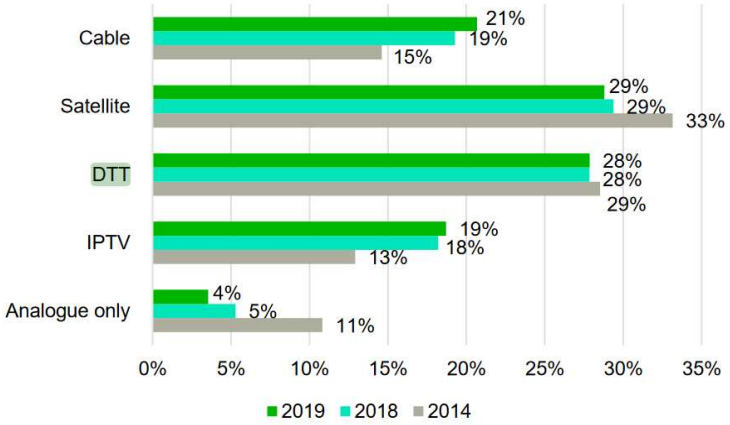
[253] Broadcast Distribution Strategies and Plans in Key European Markets – a Report by Graham Mills for Ofcom, (2022)
[254] Report: How resilient is DTT is Europe? | Advanced Television https://advanced-television.com/2022/11/30/report-how-resilient-is-dtt-is-europe/ (last accessed May 13th 2024)
[255] Statista. (2023). Number of IPTV households in Europe from 2013 to 2028 (in millions). Statista. Statista Inc.https://www-statista-com.uoelibrary.idm.oclc.org/forecasts/1139737/iptv-households-in-europe (last accessed 13th May 2024)



Most of these free-to-air households use DTT networks, representing around two-thirds of the total free-to-air households. Figure 79 shows a rapid increase in IPTV usage in the EU within the last ten years.

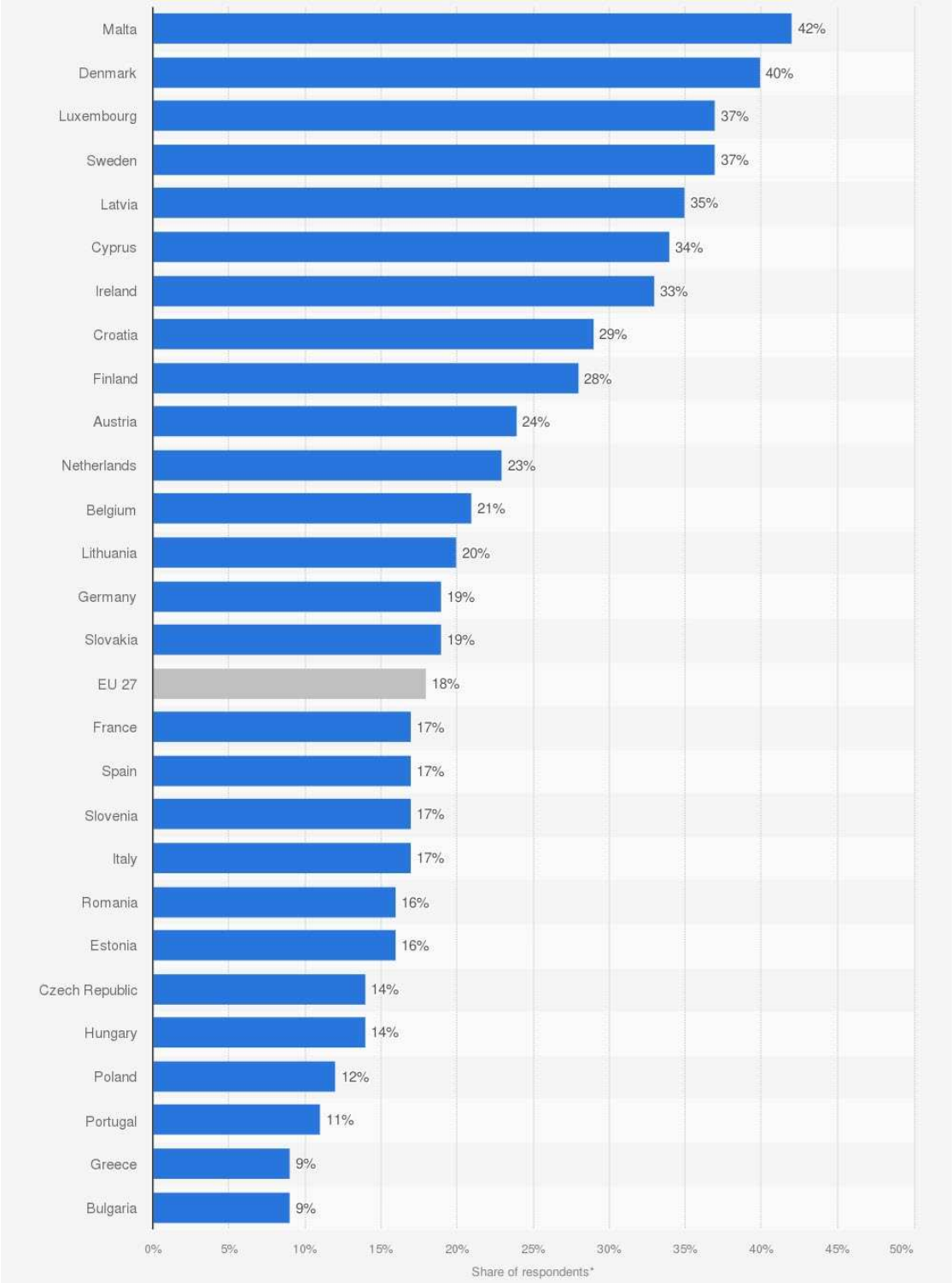
Below Figure 80 shows the reliance on satellite is still prominent for European households in 2020, although it has experienced a marginal decline since 2014. Notably cable usage represents the most significant increase, alongside a similar increase in IPTV, while DTT usage remains relatively consistent. However, some major countries in Europe have had prior substantial investment in cable infrastructure, which prevents uniform trends.

Figure 80: Methods of receiving television in European households 2014-2020[256]



[256] European Commission, Directorate-General for Communications Networks, Content and Technology, Mosoreanu, M., Podobea, V., Ulicna, D. et al., *Study on the practical implementation of the provisions of the audiovisual media services directive concerning the promotion of European works in audiovisual media services – Final report* (2023), https://data.europa.eu/doi/10.2759/211481 (last accessed 13th May 2024)

Figure 81: Share of people who watch TV via the internet every day, or almost every day in the Eu in 2023[257]



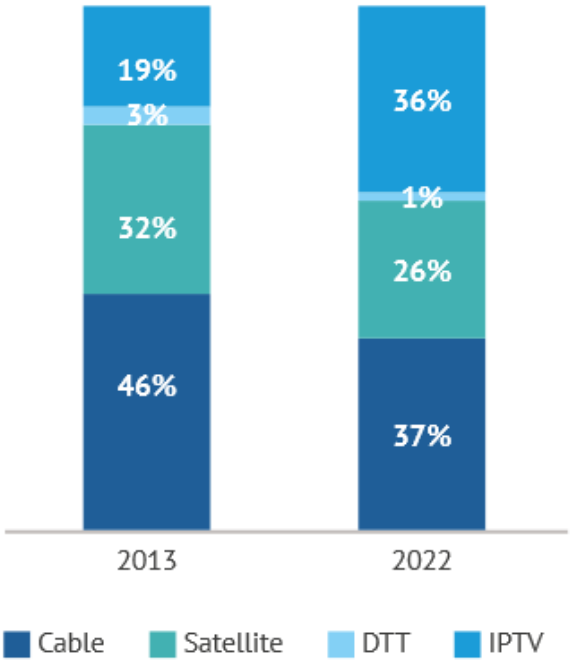
[257] European Commission. (2023). Share of people who watched TV via the internet every day or almost every day in the European Union in 2023, by country. Statista Inc https://www-statista-com.uoelibrary.idm.oclc.org/statistics/452479/daily-online-tv-viewing-penetration-in-europe/ last accessed 13th May 2024

Figure 81 illustrates the contemporary picture, showing daily, or near daily, usage of IPTV viewing by country from a 2023 survey with the mean average of the 27 EU countries at 18%.

Although a UK statistic directly comparable to data in Figure 81 is not available, Screenthink 2023 data shows that the daily VOD viewing share of the UK internet population is 19%, rising to 23% for viewing several times a week (but not daily). This figure excludes both BVOD (catch up television) and linear viewing through IPTV. The data shows that 25% of the UK internet population watch BVOD several times a week.[258]

IPTV was the only distribution network to grow faster than the Pay TV network across the EU (+9.8% up to EUR 11.8 billion).[259] The European Observatory Yearbook 23-24 records that Pay-DTT revenues reduced by 18.3% in 2022, down to EUR 0.58 billion. Italy accounted for over 75% of that net loss, following Sky's decision in April 2022 to terminate its terrestrial offer to make room for a new technical solution combining both DTT and Internet delivery.[260] Figure 82 shows the relative splits in European Pay TV distribution by delivery type in 2013 and 2023.

Figure 82: Pay TV distribution by subscriptions in Europe (2013 and 2022 in %).[261]



[258] Screenthink 2023

[259] European Observatory Yearbook 23-34 P48 (2024) https://rm.coe.int/yearbook-key-trends-2023-2024-en/1680aef0c0 (last accessed 13th May 2024)

[260] ibid

[261] Ibid

4.4 Conversion to DBV-T2 in Europe

In terms of conversion to, or adding DVB-T2 to DVB-T transmission by territory, for some broadcasters that favour DTT, this was perceived as a possible answer to DTT becoming more efficient in spectrum use and beginning to deliver UHD broadcasts. 28 out of the 50 EU countries have now made the second generation of DVB system for terrestrial broadcasting available to their population. Poland, Italy and Spain are the three latest countries to have completed their transition to DVBT-2 for PSBs in 2022.[262] Spain has committed to turning off all standard definition broadcasts and a full switch to high definition in 2024 for all linear TV.[263]

4.4.1 Interview with a UK PSB on international comparisons

The full transcript of this interview is in Appendix D. Additional data and context has been provided to explore some of the points discussed,

Within Europe there are a variety of individual factors in each territory that affect usage of DTT and IPTV. In interview, the UK PSB executives noted that in their research they quickly accepted the reality that each country was very different – with a huge variance in regulators, IP infrastructure, take up of broadband and policy by territory. Their view was that the US sat apart from the rest of the world as their PSB offering was minimal, whereas most of Europe, Australia and New Zealand had inherited the UK's PSB model.[264]

In terms of a rapid move away from DTT to IPTV for PSBs, they noted two early territories to transition were Belgium and Switzerland.

To provide context, in Belgium there are no national TV networks in Belgium, with broadcast split into separate markets, The Dutch language broadcaster VRT closed its DVB-T1 service in 2018 due to a low user base – with only 1% of Flemish households using the service (45,000 people), against an annual overhead of EUR 1 million. VRT announced its intention to invest in its free-to-use online platform, through DVB-T2 delivery via a local Pay TV service[265]. RTBF, the French language broadcaster in Belgium has declared plans to switch off DTT by 2020 with a phase-out starting in 2027.[266]

In Switzerland in 2019, the public broadcaster SRG SSR turned off its DVB-T transmission, moving hosting of its channels to cable or satellite transmission.

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[262] Ibid

[263] Ángel García Castillejo and Javier Sánchez Pérez. EBU.(2023) RTVE takes DTT to the next level with UHD launch https://tech.ebu.ch/news/2023/12/rtve-takes-dtt-to-the-next-level-with-uhd-launch (last accessed 13th May 2024)

[264] Ibid

[265] Robert Briel. Broadband TV News. (2018) https://www.broadbandtvnews.com/2018/05/18/belgian-pubcaster-vrt-terminates-dtt-broadcasts/ (last accessed 13th May 2024)

[266] Julian Clover. Broadband TV News. (2022) https://www.broadbandtvnews.com/2022/01/05/rtbf-wants-to-switch-off-fm-and-dvb-t/ (last accessed 13th May 2024)

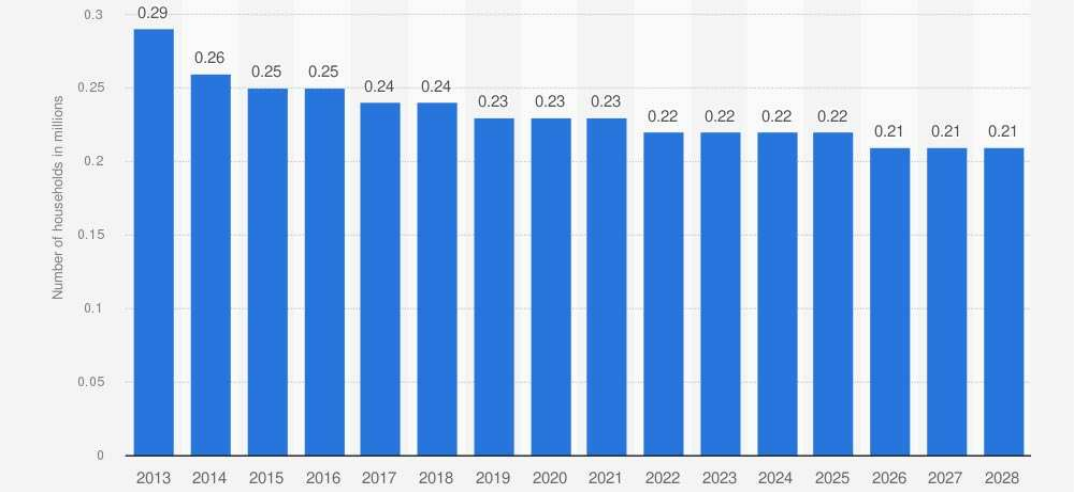
The UK PSB noted that in Switzerland DTT has “to all effects and purposes been switched off. There’s one or two corner cases where it hasn't, but primarily it's gone”[267]. It is important to note, however, that this shift from DTT is not completely to IPTV, but shared amongst other delivery formats, including satellite and cable.

Historically, both Belgium and Switzerland have long invested in cable and IPTV infrastructure, with the combination serving more than 90% of households as the main reception mode, followed by satellite and DTT. DTT has never exceeded 5% penetration as the main reception mode in either Belgium or Switzerland.[268]

During the PSB interview, it was noted that Italy in stark relief to Belgium and Switzerland still experienced over 90% of TV viewing via DTT, and was resistant to IPTV transition.

Below Figure 83 shows a continued and predicted decline in IPTV in Italy from 2013 to 2028.

Figure 83: Number of IPTV households in Italy from 2013 to 2028 (published Aug 2023) [269]



Italy, alongside Greece, Czechia, and Austria recorded the lowest coverage in Europe in 2022 for supporting gigabit speed as demonstrated below in Figure 84. However, Italy is introducing a digital video broadcast interface (DVBi), which allows the user to switch between DTT, satellite, cable broadcast and broadband networks including fibre, 5G and beyond in a unified interface. This allows smaller internet

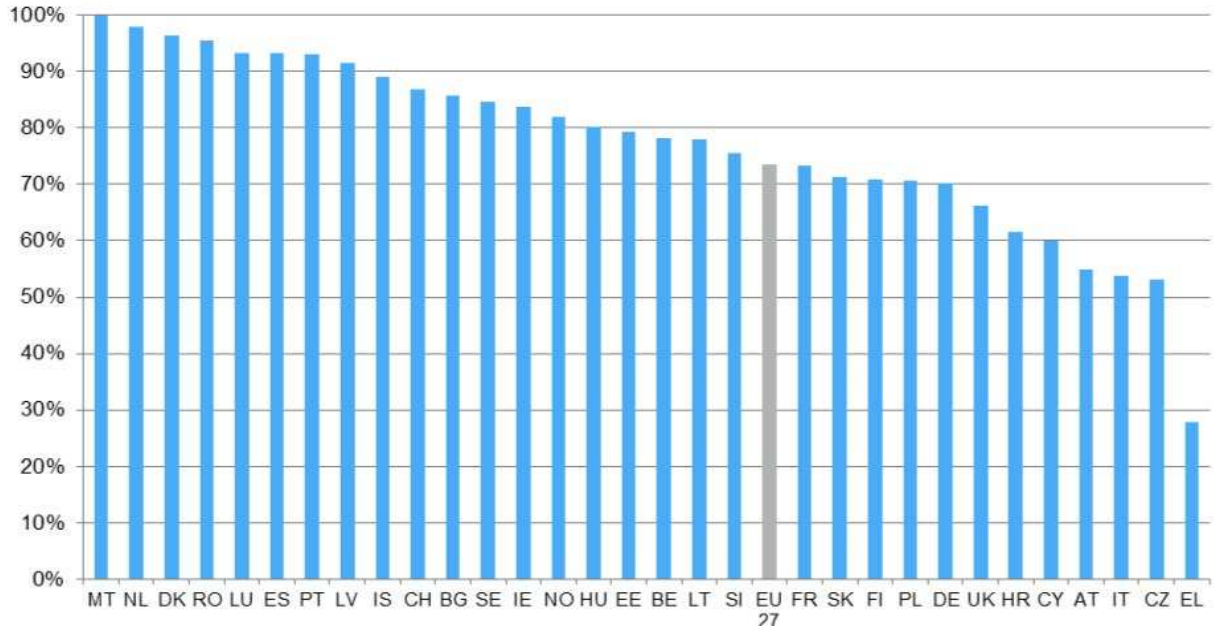
[267] Interview with UK PSB conducted for the study

[268] Broadband TV News. (2018). https://www.broadbandtvnews.com/2018/12/20/ebu-not-worried-about-dtt-shutdowns-in-belgium-and-switzerland/ (last accessed 13th May 2024)

[269] Statista. (2023). Number of IPTV households in Italy from 2013 to 2028 (in millions). Statista Inc.https://www-statista-com.uoelibrary.idm.oclc.org/forecasts/1139603/iptv-households-in-italy (last accessed 13th May 2024)

delivered channels an equal access point but will increase the volume of choice alongside established channels.[270]

Figure 84: Overall Fibre to the Premises (FTTP) & Data Over Cable Service Interface Specification 3.1 (DOCSIS) coverage by country, 2022[271]



Finland was noted as moving quite fast away from DTT – potentially to IPTV as well as other delivery forms, but the PSB felt that this was more due to the lack of Finnish language content produced by anyone apart from the Finnish PSB, resulting in a minimal amount of home grown material.

A report on TV viewing from 2021 states: “In 2021, 74% of all TV viewing in Finland was still based on antenna or cable reception (broadcasting) while 26% was using broadband instead. Among people under 45 years, broadband TV is already 54% of viewing.”[272]. While broadband speeds might explain the Italian case, in Finland the speedier move towards IPTV could be explained by the limited content output and quality of its PSB.

In terms of whether strong PSM funding and high FTV channel consumption is connected, a 2019 study by OMDIA for the Canadian Radio & Television Commission shows an absence of correlation as evidenced in figure 82. Although FTV is not fully defined as a sector in this data so could act as a broad definition, the

[270] Marco Pelllegrinato. DVB.org.(2022) https://dvb.org/news/developing-a-dvb-i-strategy-for-broadcasters-in-italy/ (last accessed 13th May 2024)
[271] A study prepared for the European Commission DG Communications Networks, Content & Technology OMDIA. (2022). By https://www.astrid-online.it/static/upload/bce_/bce_2022_final_report_.pdf (last accessed 13th May 2024)
[272] Lena Brun. Finnpanel (2022) P15 https://www.finnpanel.fi/lataukset/tv_year_2022.pdf (last accessed 13th May 2024)

high usage in Brazil and the US is in contrast to the lack of PSM funding in these territories.

Figure 85: Public broadcaster funding vs. free TV penetration, 2019[273]

Country	Public broadcaster funding (%)	Free TV penetration (%)*
France	39%	56%
UK	23%	45%
Australia	13%	71%
Netherlands	11%	5%
Sweden	10%	7%
Canada	5%	7%
Taiwan	3%	8%
Brazil	1%	77%
US	0%	27%

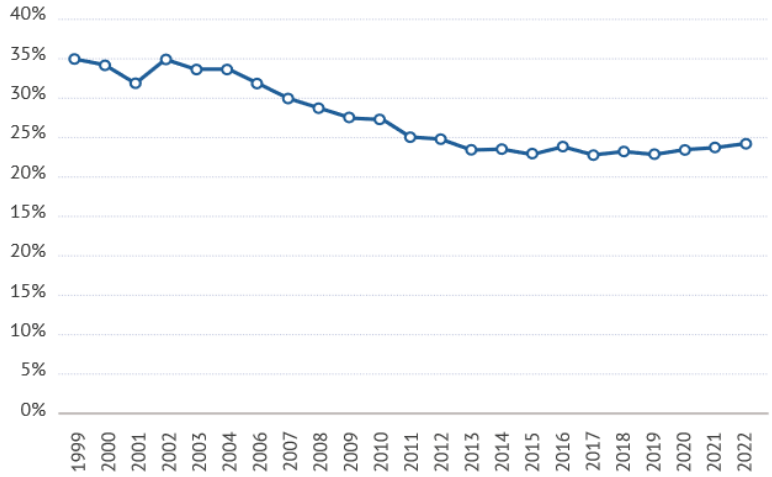
Note: * The percentage of TV households that use a free TV platform to watch TV
Source: Omdia

In Denmark, which has one of the higher rates of IPTV penetration (and is also a small language market), the linear market share for the two PSMs remains high with DR at 28% and TV2 at 53%. DRTV (DR's VOD) has a 66% average quarterly reach.[274]

Figure 86 shows the reduction in audience share of PSMs in Europe over an extended period, although it also records a plateau and a slight resurgence in 2022, recording its highest level since 2012 by a slight margin. As the data examines Europe as a block it does not show individual territory results which could add a skew. However, pandemic lockdowns leading to increased TV viewing combined with the exhausting of content on SVOD and Pay TV channels may be a factor in a lean back into PSM.

[273] Harnessing TV Distribution for Canadians in the Digital Age – A Report prepared by OMDIA. P13 https://publications.gc.ca/collections/collection_2021/crtc/BC92-111-2020-eng.pdf (last accessed 13th May 2024)
[274] Nielson data

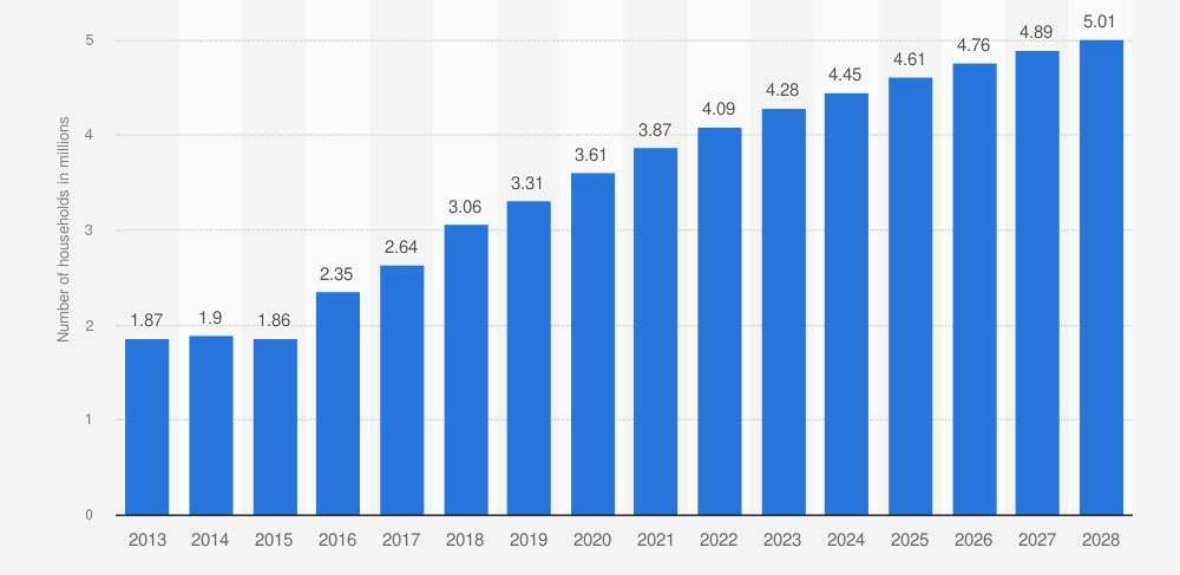
Figure 86: Average audience share of PSMs in Europe in %.[275]



In Germany it was noted that there was a mix of public service and commercial broadcasters and that penetration in DTT overall was low because the country had invested very heavily in cable infrastructure over the last 50 years, as had Belgium and Switzerland.

Figure 87 shows a steady rise in IPTV households in Germany from 2016 onwards after a relative plateau.

Figure 87: Number of IPTV households in Germany from 2013 to 2028 (published Aug 2023)[276]



[275] European Observatory Yearbook 23-34. (2024) P30 https://rm.coe.int/yearbook-key-trends-2023-2024-en/1680aef0c0 (last accessed 13th May 2024)

[276] PwC. (2017). Number of television households with IPTV connections in Germany from 2007 to 2021* (in millions). Statista. Statista Inc.https://www.statista.com/statistics/460345/iptv-number-housebolds-germany/ (last accessed 13th May 2024)

Estonia was cited by the UK PSB as an interesting case where a high proportion of audiences were watching TV through IPTV. Yet the country was still not at a point where they felt they could completely move away from DTT, primarily for political obligations and national security concerns, which require a universal emergency network.[277]

In Sweden, the costs of DTT to the public broadcaster were noted as high by the PSB, which created a motivation to move more quickly to IPTV, but again, the PSB cited political considerations as an obstacle.[278]

The PSB team had also met with Nippon Hōsō Kyōkai (NHK) in Japan, who felt the UK PSB sector was far more advanced as a territory, and transition to IPTV was not a factor NHK were considering at that time, despite the traditionally advanced technological status of their society.

Political factors that the PSB cited as universal concerns were the need for a universal emergency broadcast network, security considerations which included having guaranteed reach in case of emergency, user data privacy and the need to protect vulnerable audiences, ensuring no part of the population were disconnected due to access issues from lack of connection or lack of digital skills.

4.4.2 Interview with a UK expert of television distributions on international comparisons[279]

The full transcript of this interview is available in Appendix D.

It was noted by the UK expert that, in terms of DTT usage, Italy, France and Spain "share many similarities with UK. They each have very popular DTT networks, with viewing hours that are comparable or larger than any other way of viewing TV nationally. They each have very high levels of fixed broadband take-up with most households using their main TVs for hybrid viewing, a combination of SVoD, catch-up and linear broadcast content. Unlike the UK, however, they are each implementing coherent strategies during the 2020s to make better use of their DTT networks including more HD or UHD services and new hybrid TV interfaces based on recent open standards including HEVC, DVB-T2 and, in Italy, DVB-I."

Scandinavia was excluded as a comparison due to their high level of mobile

communications, together with extensive broadband communications and a population density much lower than the UK.

Germany was also excluded as a potential comparable country by the expert as they are "dominated by satellite and cable TV delivery of their broadcast TV. In the case of cable [it's often used to deliver] their broadband as well. And whilst they do have a digital terrestrial TV system that's got state-of-the-art technology, in terms of DVB-T2

[277] Ibid.
[278] Ibid.
[279] Interview with UK expert in TV distribution for this report

and the coding technology, they're using HEVC [which was] state-of-the-art when they were introduced a few years ago."

It was noted that a key differential between many other territories and the UK was that the UK had maintained the same broadcast systems for the last 14 years, in contrast to implementation of new DTT systems in Spain, Italy and France.

Spain, similar to France, was noted as committed to using its digital terrestrial TV network and launching some ultra-high-definition services, alongside high-definition services. Standard definition services are no longer transmitted via DTT in Spain since early 2024. The UK expert noted: "In Spain it's one of the major public service broadcast organisations [RTVE] that seem to be driving a lot of this. And they are also making sure they retain their regionality and all their regional services as well as doing these national channels, which I think helps politically, given that they've got separatists in various different parts of their country."

In terms of Italy as a comparison, the expert notes: "they ended up with the

national broadcasters, RAI and the commercial broadcasters [MediaSet and Discovery] who were given public service broadcasting licences. But there were lots of, 'informal' broadcasters that […] put up a transmitter, found an empty frequency and started using the frequency without proper licensing or regulation or technical coordination. And that gave the Italians a huge number of analogue TV channels before (they) went digital. They were able to replicate more or less the same amount of capacity when they went digital. In fact, [capacity] increased for the formal public service broadcasters, but they managed to accommodate everybody by using single frequency networks (SFNs)." It was noted by the expert that delays occurred in Italy in terms of a full conversion toDVB-T2 broadcasts due to consumer retention of hardware that was too old to receive the new broadcast system. The expert noted that the advantage of the new Italian DVB-I system (an interface that could aggregate broadcast signals through DTT, IPTV, cable and satellite) was the agnosticism of signal type. With emerging DVB-T2 channels also increasing spectrum efficiency and enabling more HD broadcasts via DTT. Whereas the BBC could only deliver UHD via IPTV, and pushed viewers back down to HD when capacity was not great enough to support them all with a UHD delivery.

It was noted: "The same is pretty much happening in Germany with their network", and that "DVB-I is very strongly supported by the major TV set manufacturers. They can put it on to their TV sets as an extra software module, and it's standardised throughout Europe so they've got a huge market and they see this as the way forward."

This approach is similar to the UK's Freely service. However it was noted by the UK expert that the UK service was mostly proprietary, in that they are "requiring TV set manufacturers to sign up with them, with [Everyone TV] the organisation behind Freely – a public service broadcasters' organisation." Whereas manufacturers may question why there was a requirement for Freely when DVB-I was so uniformly accessible and standardised across Europe. A potential advantage for Freely was

being able to prioritise PSM channels on the interface. The UK expert commented that with DVB-I, “some modest, appropriate regulator intervention could absolutely retain the prominence that public service broadcasters have while at the same time letting people choose what they watch, rather than being restrictive, which is the Freely model”.

In broader terms it was discussed whether the move to IPTV across Europe was seen as inevitable. The UK expert noted: “going back to (a prior 2021) Ofcom study, almost universally the people interviewed in key positions in TV distribution throughout Europe, were of the opinion that IP delivery is on its way. It's likely to become economic in the next decade to go to IP delivery, but there are these huge barriers to making the transition and none […] apart from the Scandinavians, seem to have a clear understanding of how they were going to get over those final hurdles to be able to go to universal IP delivery.”

In terms of looking to the potential time after the WRC 2031 review, when spectrum may go co-primary with mobile, the expert noted that the issue for the UK was that it was “still using 1990s’ technology called DVB-T and MPEG2. You're using [up to] four times as much bandwidth as you need to carry these services. Other European countries, particularly France, Spain, Italy will all be using DVB-T2 and more modern codecs. […] If that [WRC31 change] would happen in the UK, you'd suddenly find a load of people would lose many of their channels because we're not using spectrum efficiently. […] The efficiency of DVB-T2 [and newer codecs] would then be required to retain the current volume of DTT channels on reduced spectrum.”

The UK expert noted that in terms of other countries likely to make a full transition to IPTV, “you've seen Finland recently announce they're closing down their standard definition version, and my personal interpretation is that Scandinavia is likely to be one of the first countries or regions in Europe to make this decision to close down DTT to go on to IP. I'm excluding Switzerland here, which I think is shutting down DTT. So, they're just switching to cable and satellite, which have been dominant anyway. And Belgium is in a similar situation, which has very high cable penetration. Switzerland's got its mountains, Belgium is generally hilly or flat, but the important bit is many people live in apartment blocks. Many of them are fed by cable. It's just so easy to do it that way. But this is why I said France, Spain, Italy are much more similar to the UK because we've got very large DTT communities and we're not a country that's got cable everywhere. You know, we've 50% or so cable available in the UK haven't we? And that's an economic limit.”

In reference to whether Pay TV services on DTT in Italy, France or Spain will have made a difference to the high DTT usage, the expert noted: “in all three of those countries, the majority of DTT viewing hours and channels are free-to-view, after Mediaset closed their Italian DTT pay TV service in 2019, there are four Discovery Pay TV channels, including Eurosport, and in France there’s a Canal+ Pay TV channel, which is free-to-view for part of the day. The majority of Pay TV viewing and channels are on satellite or IPTV in all three countries, which is similar to the UK.” As such there does not seem to be an obvious causal link between the small number of

Pay TV channels on DTT in these countries and the strategic decisions taken in each country to modernise and invest in their DTT networks. The expert concluded: "it appears that their (Italy, France and Spain) strategies are primarily driven by the need to have greater digital capacity to carry services that were previously on the 700MHz band, which was released for mobile data, and to add more HD or UHD services."

"The consequences of their strategies are that their DTT services retain their competitive position against satellite and IPTV, both in the number of channels available and the (improving) quality of those services (HD and UHD). These are mainly free-to-view services that, I understand, all depend on advertising for at least part of their revenues. Their political decisions are to support DTT, including its news and current affairs programming and that supports their democracies as they are available to all, now and for the longer term."

In contrast, the expert noted, with no upgrade to broadcast systems in the UK, DTT has gradually declined from its competitive position in 2010 against satellite and IPTV, with reducing quality versus the increasing range of HD and UHD services offered on other platforms. And as stated, the UK also risks a major reduction in free-to-view channels at some point after the WRC review in 2031 if the spectrum becomes co-primary with mobile operators, limiting capacity for DTT. The expert also noted that in terms of the Scandinavian countries, migration to all IPTV is the most likely outcome.

4.4.3 France

DTT was launched in Metropolitan France on 31 March 2005. The law of 5 March 2007 'Television of the Future' set the conditions for the deployment of DTT in 1626 designated territorial zones, eventually leading to DTT coverage of over 97% of the French population.

The installation of the DTT technical infrastructure was completed by 30 November 2011, the deadline specified in the March 2007 law. The France Télé Numérique consortium ("GIP" Groupement d'Intérêt Public) tasked with this operation consisted of the French State and the legacy national channels (the French terrestrial public channels' group France Télévision, the Franco-German PSB Arte and the commercial operators, including ad-supported M6 and Pay TV monopoly Canal Plus).[280]

France Télé Numérique reported total costs of €150 million by the end of the switchover in November 2011. This was less than 50% of the original estimate of €333 million. The largest savings were in the €180 million general social fund, which had been designated to assist households in adapting their sets to digital receptions and was a 100% State procurement. Only €40 million was spent from this fund, due to a lower volume of demand from French households than anticipated. Many chose

[280] J-N Escudié. Audiovisuel – La France est désormais entièrement couverte par la TNT (2011) https://www.banquedesterritoires.fr/la-france-est-desormais-entierement-couverte-par-la-tnt (last accessed 13th May 2024)

instead to take advantage of the switchover to buy new DTT compatible sets. There were nevertheless 500,000 recorded technical visits in French households – to mainly older viewers – and the toll-free call centre dispensing technical advice logged a total of 2.5 million calls over two years. France Télé Numérique co-financed the new transmission technology in partnership with local governments.[281] Original aid was focused on low-income households, with grants ranging from €25 for an adaptor to €120 for a DTT compatible aerial.

Government funding in aid of individual household's conversion to DTT reception was not discontinued until December 2015. Individual household grants were capped at €250 as reimbursement of receipts for qualifying expenditure on improving DTT signal reception through a different medium than the legacy rooftop rake receptor.[282]

In October 2008, in compliance with dispositions in the 2007 'Television of the Future' statute, R5 was introduced as the first HD-capable multiplex facility, enabling some channels to switch over from standard definition. The full transition to an all-HDD DTT accelerated from 2016, with the introduction of the MPEG4 standard.

Between April 2016 and June 2019, the frequencies in the 700MHz bandwidth were gradually freed up.[283]

DTT audience profile

There are currently eight privately-owned audio-visual sector groups and two public sector groups whose services are available. With the exception of the news channel LCI and Paris Premiere, all other services are broadcast in HD standard.

As of 2022, the TV set remained the most widespread technical medium to access audio-visual media services in France, with 90.1% of metropolitan homes, ahead of the home computer (86.2%) and tablets (46.9%) [284]. 90.5% of homes have sets equipped with DTT HD adapters.

By spring 2022, the percentage of French homes with DTT reception was 46.6%, with 19.8% of those having DTT as the only mode of reception. This latter category were primarily people aged 50, living in smaller towns or villages, and not currently employed. There are substantive regional variations: in Brittany and Normandy, half of households depend on DTT whilst the rate of reception through IPTV is below national average.[285]

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[281] Le Passage au numérique a coûté 150 millions d'euros – article in French economic journal Les Échos, 07.10.2011, by Grégoire Poulsielgue

[282] Le Fond d'Accompagnement Numérique prolongé jusqu'en décembre 2015 - TousAuNumérique website: https://www.tousaunumerique.fr/le-fond-d-accompagnement-numerique-prolonge-jusqu-en-decembre-2015.html (last accessed 13th May 2024)

[283] La place de la télévision numérique terrestre dans le paysage audiovisuel français – a White Paper by TDF - 2019

[284] Observatoire de l'équipement audiovisuel des foyers en France métropolitaine au second semester 2022, Médiamétrie data for Arcom.

[285] Ibid

Additionally, 16% of the population over the age of 15 is categorised as not having basic competencies to access any form of digital delivery and had not used the Internet for over 12 months by spring 2022. Whilst this “illelectronisme” (a French neologism that is the digital equivalent of illiteracy) affects only 3% of people aged between 15 and 44, the percentage goes up to 67% in the over 75 age group.[286] Arcom’s Impact Study concludes that “DTT is therefore likely to remain essential to this segment of the population”.

Bandwidth protected till 2030

At present, DTT in France benefits from Article 21 of the law of September 1986, which established that the 470-694 MHz band is to remain principally the preserve of terrestrial broadcast services until at least December 2030. French domestic law has been reinforced in this regard by the European Parliament’s 2017 Decision [EU 2017/899], which established a similar protective timeframe for the whole of the EU. More recently, the ITU’s WRC Conference’s Final Act also upheld the cordoning off of the sub-700 MHz band till 2031 for ITU Region 1.

The decline of linear Pay TV offers on DTT

According to Arcom, DTT in France is principally a free-to-air proposition, with Pay TV offers having receded over time since the advent of DTT between 2005 and 2011. After 2008, the number of pay channels went down, with no new requests from pay operators in the call for authorisations issued by the broadcast regulator in 2011 and 2015 for DTT channels in the HD standard. In response to the 2020 call, Canal+ alone applied and received authorisation for a limited three-year period only, at its own request.

Increasing competition from IPTV

Arcom observes that over the past decade, the rapid digitisation of modes of communication and services has led to a diminishment of the place of linear DTT in French consumer uses. “One of the specificities of the French audio-visual market is in the weight of ‘triple play’ offers (Internet access, telephony and TV services) from ISPs, which have enabled the precocious and massive development of IPTV, as early as 2003”.[287] Arcom sees these types of offers (which combine a range of non-linear services, including catch-up TV) as a key historical factor in the delayed penetration of OTT services.

However, the generalisation of high-speed broadband Internet, which reached 20 million French homes by the third quarter of 2022,[288] combined with the arrival of

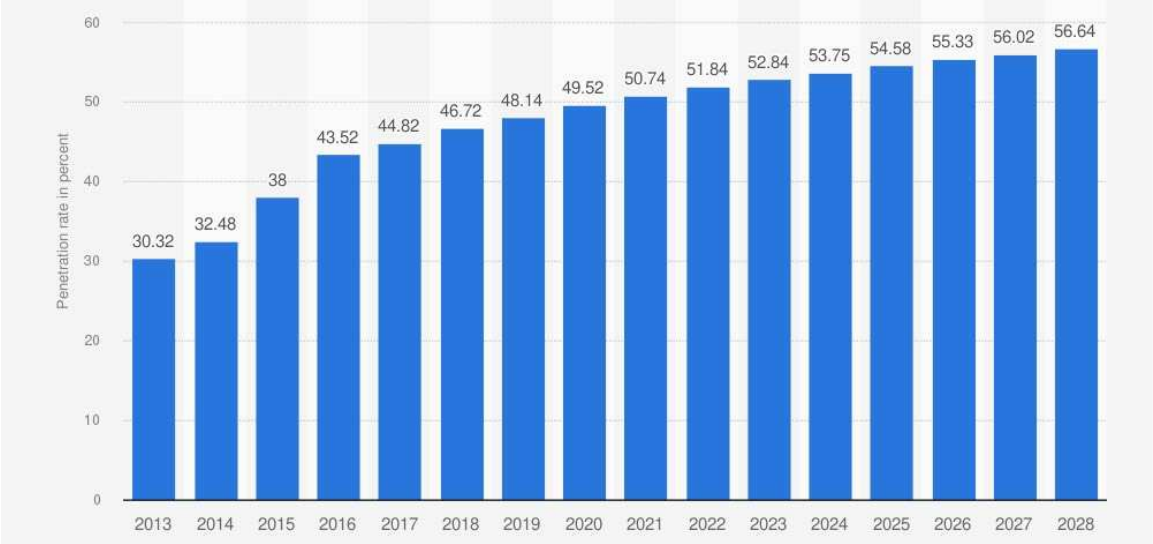
[286] Aline Branche-Seigeot, « *Davantage d’illectronisme dans les communes éloignées des villes et les petits pôles urbains* », *INSEE Analyses*, n°85, 22 June 2023.
[287] Étude d’impact préalable à la délivrance d’autorisations de services de télévision numérique terrestre en métropole – Arcom – December 2023
[288] Marché des Communications Électroniques en France – les chiffres du 3ème trimester 2022, Arcep, 12.01.2023

new international streaming services (e.g. Disney+, Amazon Prime Video, Netflix, MyCanal) after 2014, have led to a rapid acceleration of OTT deployment in France.

Whereas the leading mode of connection remains TV decoders supplied by ISPs for homes equipped with TV sets and with access to broadband internet, connected smart TVs increased their market share by 15% in three years, to attain 43% of homes and growing, as are TVs with black boxes, both of which contribute to the rise in OTT usage. Arcom notes that 51% of homes subscribed to at least one VOD platform by mid-2023.

By the end of 2022, there were 360 audio-visual content services registered with Arcom. 41% were VOD subscription services, 32% were either free VOD or TVOD models and 27% were catch-up services adjacent to linear channels. Additionally, Arcom noted the fast growth of FAST channels in the French media market. Oher than Netflix Direct, these new offers include Pluto TV, Mango and Samsung TV+. In all, there were 540 such services available to French consumers by end of March 2023.[289]

Figure 88: Household penetration rate of IPTV in France from 2013 to 2028[290]



UHD to buffer public sector DTT's attractiveness

In May 2023, the French Government asked Arcom to ascribe to the public sector broadcasting group France Television usage rights to the section of the public spectrum enabling broadcasting in Ultra High Definition (UHD). Authorisations were duly delivered to France 2 and France 3 in October 2023. The two national channels will be accessible on the UHD standard for homes equipped with the technical norms

[289] Baromètre OTT NPA Conseil/Harris Interactive – quoted by Thierry Wojciak, CB News, 24.04.2023

[290] Statista. (March 6, 2023). Household penetration rate of IPTV in France from 2013 to 2028 [Graph]. In Statista. Retrieved March 14, 2024, from https://www-statista-com.uoelibrary.idm.oclc.org/forecasts/1137479/iptv-penetration-forecast-in-france (last accessed 13th May 2024)

of DTT UHD, including the newly introduced DVB-T2 and HEVC. Most of the TV sets sold in France since 2017 incorporate these standards. The R9 multiplex will host France 2 and France 3 in UHD in a phased roll out between January and the end of the second quarter 2024. Arcom is also in discussion with some private sector DTT operators with similar UHD plans.

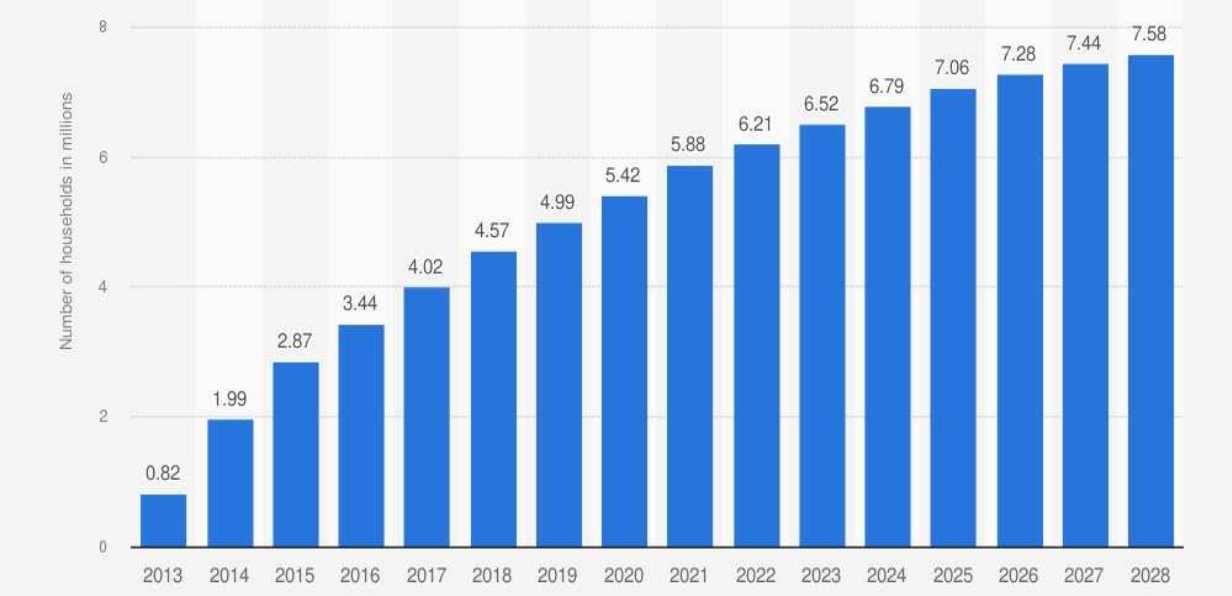
Arcom notes the resilience of DTT in France, and the positive association it retains with much of the French public, largely due to its offer being diversified, accessible over most of French territory and available free of charge without necessitating the sharing of personal data.

4.4.4 Spain

In Spain the switchover to DTT from analogue signal was finalised in 2010. Since 2016 DTT has experienced a decline as viewers moved across to IPTV and satellite TV. DTT usage reduced from 60.3% of households which were watching daily TV via terrestrial in 2016 to 41.1% in 2020, according to a report from SES Astra Spain quoted by Advanced-Television. The report was also quoted as noting growth in IPTV, from 21.5% to 30.8% in the four-year period (2016-2020), with satellite also increasing its penetration from 10%to 16.5% to reach 2.8 million homes.[291]

Figure 89 records the increase in IPTV households in Spain, with a predicted growth pattern continuing between 2023 and 2028.

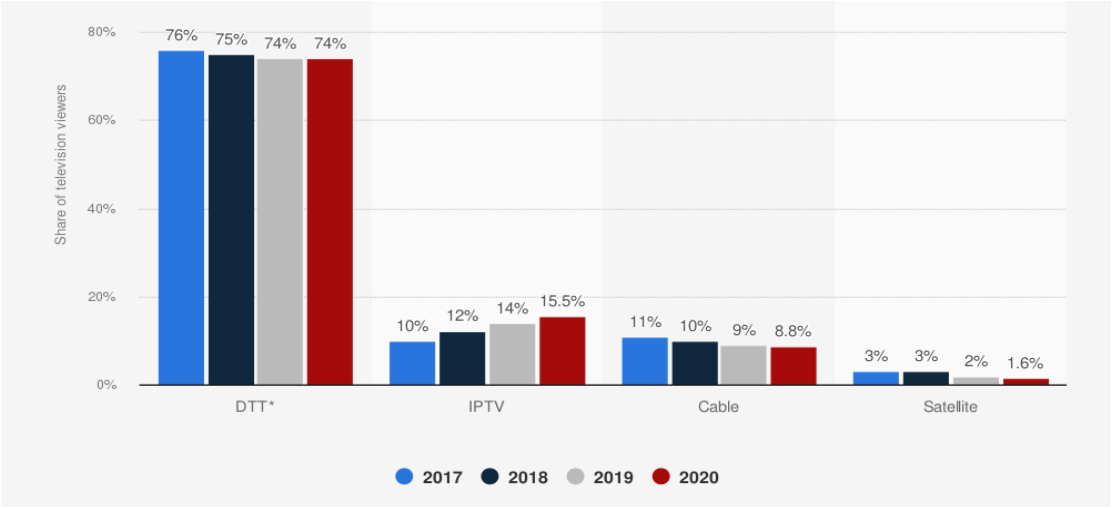
Figure 89: Number of IPTV households in Spain from 2013 to 2028[292]



[291] Del Valle, David. *Spain: DTT loses ground* (2021) https://advanced-television.com/2021/04/06/spain-dtt-loses-ground-2/ (last accessed Nov 6th 2024)
[292] Statista. (2023). Number of IPTV households in Spain from 2013 to 2028 (in millions). Statista. Statista Inc.. Accessed: March 27, 2024. https://www.statista.com/forecasts/1139616/iptv-households-in-spain

Below figure 90 shows the three-year trend of broadcast system type in Spain between 2017 and 2020, showing the strength of DTT compared to the relatively marginal nature of other forms, but noting the gradual rise of IPTV

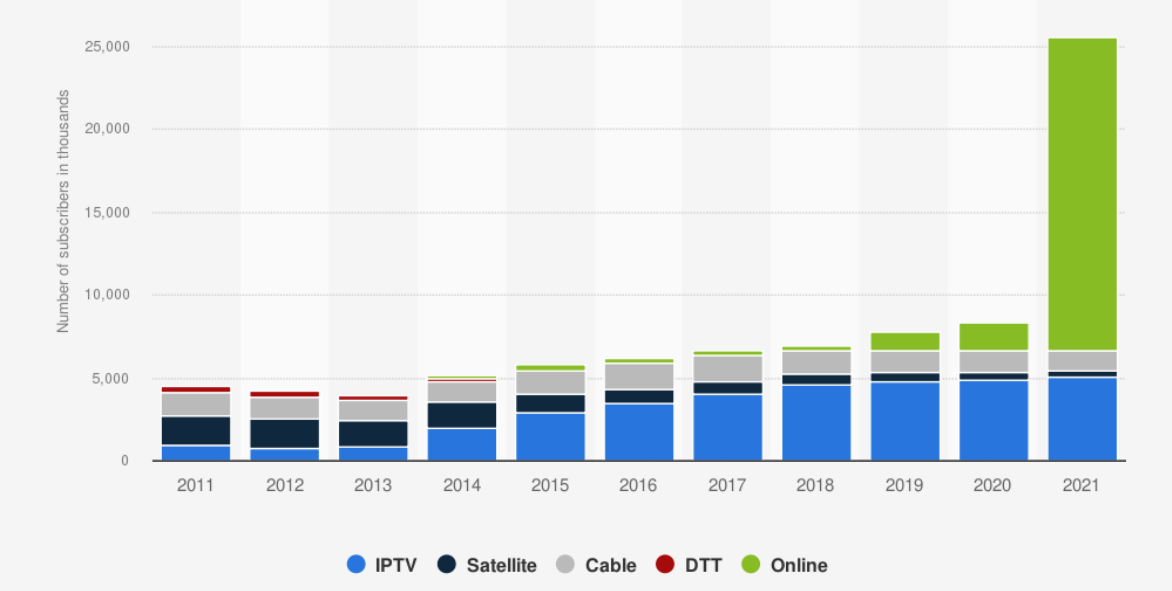
Figure 90: Distribution of TV viewers in Spain from 2017 to 2020, by broadcast system[293]



Below in figure 91 a marked increase is shown in Pay TV users through online subscription. The data does not delineate between global SVOD and local Pay TV platforms, but is likely to have been driven by pandemic lockdowns and the launch of new global SVOD platforms.

[293] Barlovento Comunicación. (December 31, 2020). Distribution of television viewers in Spain from 2017 to 2020, by broadcast system [Graph]. In Statista. Retrieved March 27, 2024, from https://www.statista.com/statistics/459211/television-viewership-distribution-in-spain-by-broadcast-system/

Figure 91: Number of pay TV subscribers in Spain from 2011 to 2021, by platform [294]



Although there is no indication of an advanced transition to IPTV, for this study Spain is notable as it has experienced a rare occurrence of state intervention in the form of subsidies in 2009 for DTT companies to assist in the switchover from analogue TV in remote and less urbanised areas. A major satellite operator appealed against this decision to the European Commission, claiming that it represented an unfair market advantage that would result "in a distortion of competition between the satellite and terrestrial broadcasting platforms."[295]

In February 2024 Spain completed a full transition away from SD channel broadcasting to full HD delivery on DTT, a move which freed up sections of the spectrum that were utilised by SD transmission.[296] In July 2024 Spanish public service broadcaster RTVE approved a proposal to begin regular UHD broadcasts from spring 2024 via DTT. The new commitment to HD and forthcoming UHD DTT content is a potential indicator that a future switchover to IPTV is seen as a longer-term outcome than in other territories.[297]

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[294] Comisión Nacional de los Mercados y la Competencia. (2022). *Number of pay TV subscribers in Spain from 2011 to 2021, by platform (in 1,000s).* Statista. Statista Inc.. Accessed: March 27, 2024. https://www.statista.com/statistics/682644/pay-tv-subscribers-by-platform-in-spain/

[295] Strada lex Europe, *2014/489/EU: Commission Decision of 19 June 2013 on State aid SA.28599 (C 23/10 (ex NN 36/10, ex CP 163/09)) implemented by the Kingdom of Spain for the deployment of digital terrestrial television in remote and less urbanised areas (outside Castilla-La Mancha) (notified under document C(2013) 3204) Text with EEA relevance* (2013) https://www.stradalex.eu/en/se_src_publ_leg_eur_jo/document/ojeu_2014.217.01.0052.01 (last accessed Nov 6th 2024)

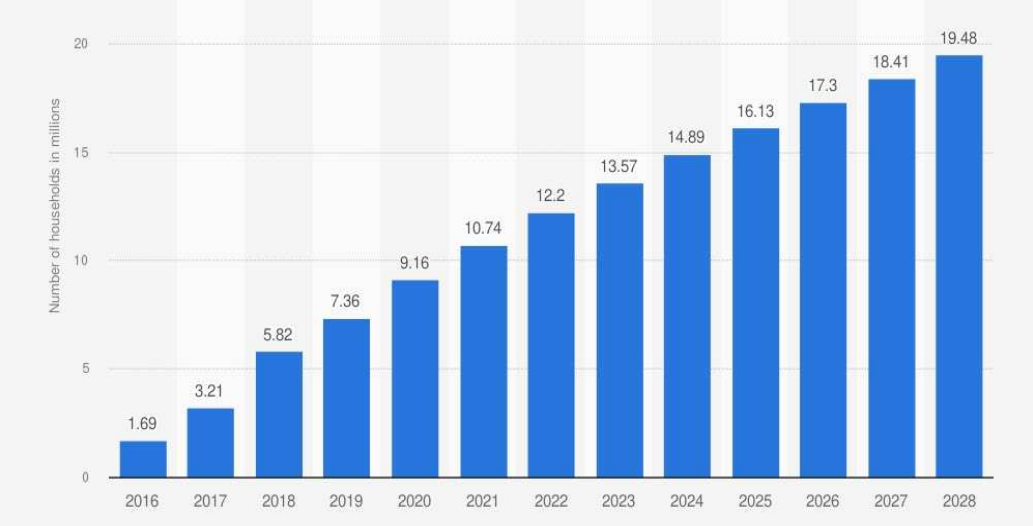
[296] David Del Valle. Advanced Television. *Spain Finalises HD DTT migration* (2024) https://advanced-television.com/2024/01/23/spain-finalises-hd-dtt-migration/ (last accessed May 13th 2024)

[297] Colin Mann. Advanced Television. *RTVE UHD set for Feb 2024 Launch* (2024) https://advanced-television.com/2023/07/24/rtve-uhd-set-for-feb-2024-launch/ (last accessed May 13th 2024)

4.4.5 United States

In the United States the recent rise in Free Advertising Supported Television (FAST) - linear ad supported television that is delivered online, could be a key factor in driving increased IPTV usage. With over half of US households using a FAST service in the average week, it is the fastest growing streaming type in 2024"[298], demonstrating a keen ongoing engagement in the US with linear TV. Figure 92 shows the significant increase in the number of IPTV household since 2016.

Figure 92: Number of IPTV households in the United States from 2016 to 2028 (published Aug 2023).[299]



Other potential factors driving the increase of FAST channel usage may be cost of living challenges resulting in cancellation of SVOD and cable subscriptions, and password sharing crackdowns by SVOD platforms. Cable subscriptions in the US are significantly higher than the UK[300]. However, TV viewing hours of SVOD have also grown since 2021 and 2023, as figure 90 shows.

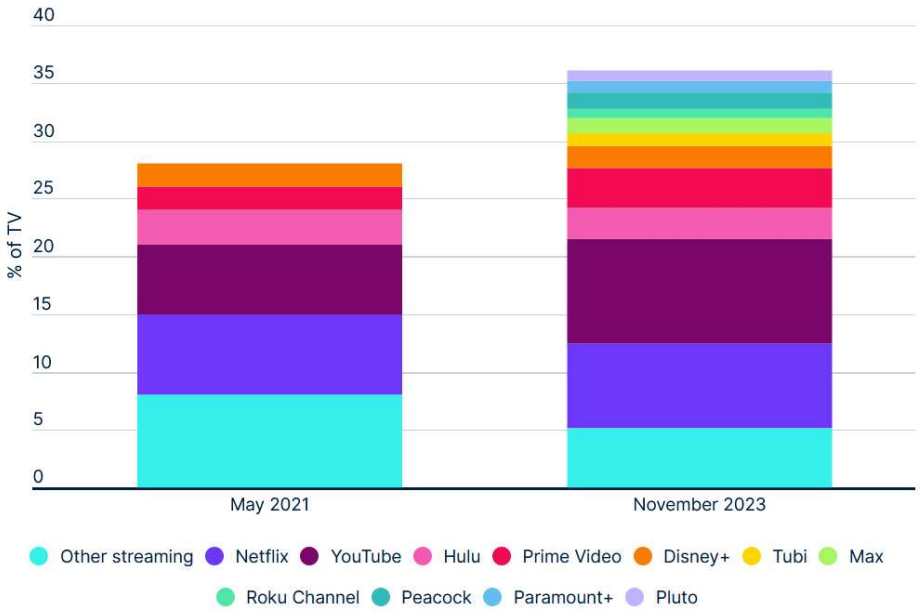
A 2023 Emergen research report quoted by Global Newswire states that "the North America market accounted for largest revenue share in the global IPTV market in 2022. […] According to Google […] 6 out of 10 people prefer to watch online video

[298] *Data: Over half US homes watching Fast TV*. (2024) https://advanced-television.com/2024/01/25/data-over-half-us-homes-fast-users/ (last accessed May 13th 2024)
[299] Statista. (March 6, 2023). Number of IPTV households in the United States from 2016 to 2028 (in millions) [Graph]. In Statista. Retrieved March 21, 2024, from https://www-statista-com.uoelibrary.idm.oclc.org/forecasts/1139666/iptv-households-in-the-united-states
[300] Potter, A. and Johnson, C. Understanding the changing television market: A comparison of the macroeconomy of the United States, United Kingdom and Australia (2022) P10 https://eprints.whiterose.ac.uk/202237/8/Macroeconomics%20Lotz%20Potter%20JohnsonAccepted2.pdf (last accessed May 13th 2024)

content rather than television."[301] Using an IPTV box is a more cost-effective solution than cable TV services, and the user owns the hardware.[302]

Since 2020 additional streamers have been available to US households with content that was once focused through Netflix and Amazon, now fragmented across new propriety streaming platforms belonging to most of the major studios. Figure 90 shows the increase in both volume of streaming platforms, and the shift towards SVOD consumption in overall total TV viewing hours.

Figure 93: Streaming's share of total US TV[303]



Below in figure 94, the breakdown of TV and video platform type in autumn 2022 show that FAST TV channels have now surpassed over the air channels.

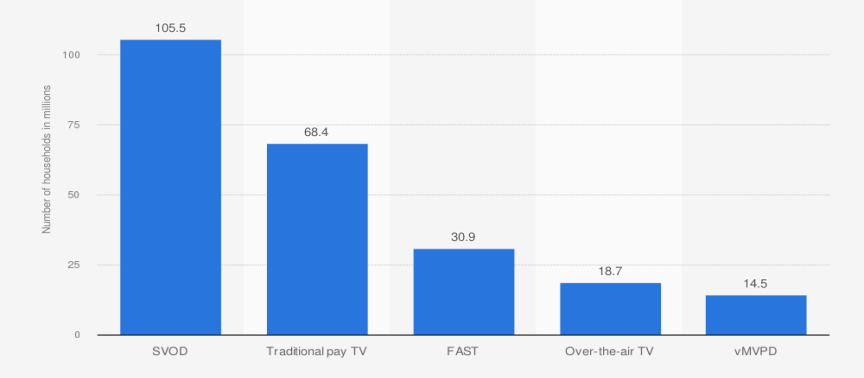
Figure 94: Number of households using selected TV and video platform types in the United States in 3rd quarter 2022[304]

[301] Emergen Research. Global Internet Protocol Television (IPTV) Market Size to Reach USD 309.63 Billion in 2032. (2023). https://www.globenewswire.com/en/news-release/2023/09/25/2748489/0/en/Global-Internet-Protocol-Television-IPTV-Market-Size-to-Reach-USD-309-63-Billion-in-2032-Emergen-Research.html (last accessed May 13th 2024)

[302] Ibid.

[303] Nielsen. Amid the fragmented TV landscape, time spent with content is the best planning data there is (2024) https://www.nielsen.com/insights/2024/amid-the-fragmented-tv-landscape-time-spent-with-content-is-the-best-planning-data-there-is/ (last accessed May 13th 2024)

[304] nScreenMedia. (December 12, 2022). Number of households using selected TV and video platform types in the United States in 3rd quarter 2022 (in millions) [Graph]. In Statista. Retrieved March 21, 2024, from https://www-statista-com.uoelibrary.idm.oclc.org/statistics/1356381/tv-video-households-us-platform-type/



Part of the success of FAST TV can also be attributed to the sheer volume of offerings. Deadline noted that as of January 2024 there were over 1500 FAST channels available in the US. Executives commented that they expected channels to cull back to approx 1000 over the following 18 months.[305]

Over the air (OTA) television via antennae is still prevalent in the US, but normally blended with another form of TV delivery as figure 95 shows.

Figure 95: Over the air (OTA) access in US TV households[306]

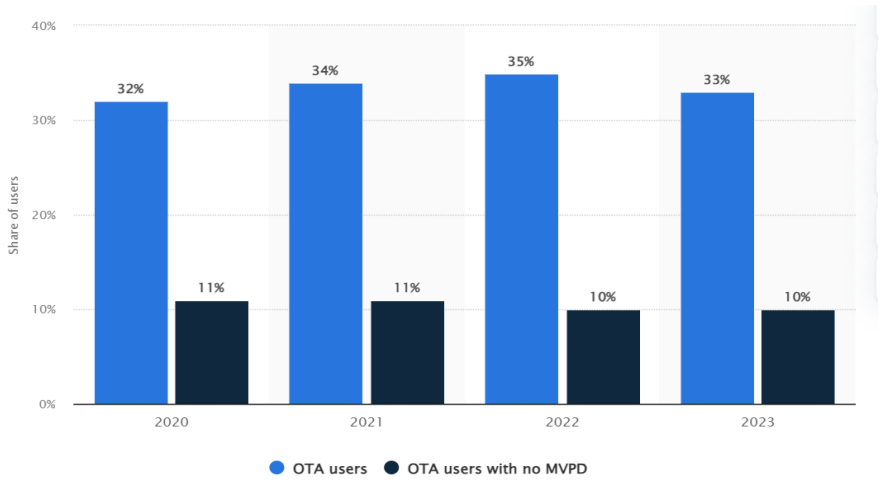
	Jul-23	Oct-23	Nov-23
OTA with a vMVPD	2.10%	2.10%	2%
OTA without a vMVPD	12.40%	12.30%	12.40%
OTA without a vMVPD and without SVOD	3.60%	3.70%	4.10%
Presence of OTA sets*	18.20%	18.10%	18.10%

However, over the air viewing has experienced a slight growth between 2020 and 2023 according to figure 96 below, although there was a decline from 2022 to 2023 which may be due to the pandemic.

[305] Dade Hayes. *Are We Reaching Peak FAST? With The Number Of Channels North Of 1,500 In The U.S., Industry Execs See A Shakeout Coming – But That May Not Be A Bad Thing* (2024)https://deadline.com/2024/01/fast-channels-tv-viewing-natpe-executives-1235794437/ (last accessed May 13th 2024)

[306] The Nielsen Company. *Beyond Big Data: The audience watching over the air* (2024) https://www.nielsen.com/insights/2024/beyond-big-data-the-audience-watching-over-the-air/ (last accessed May 13th 2024)

Figure 96 : Share of adults using over-the-air antenna (OTA) to watch TV in the United States from 2020 to 2023



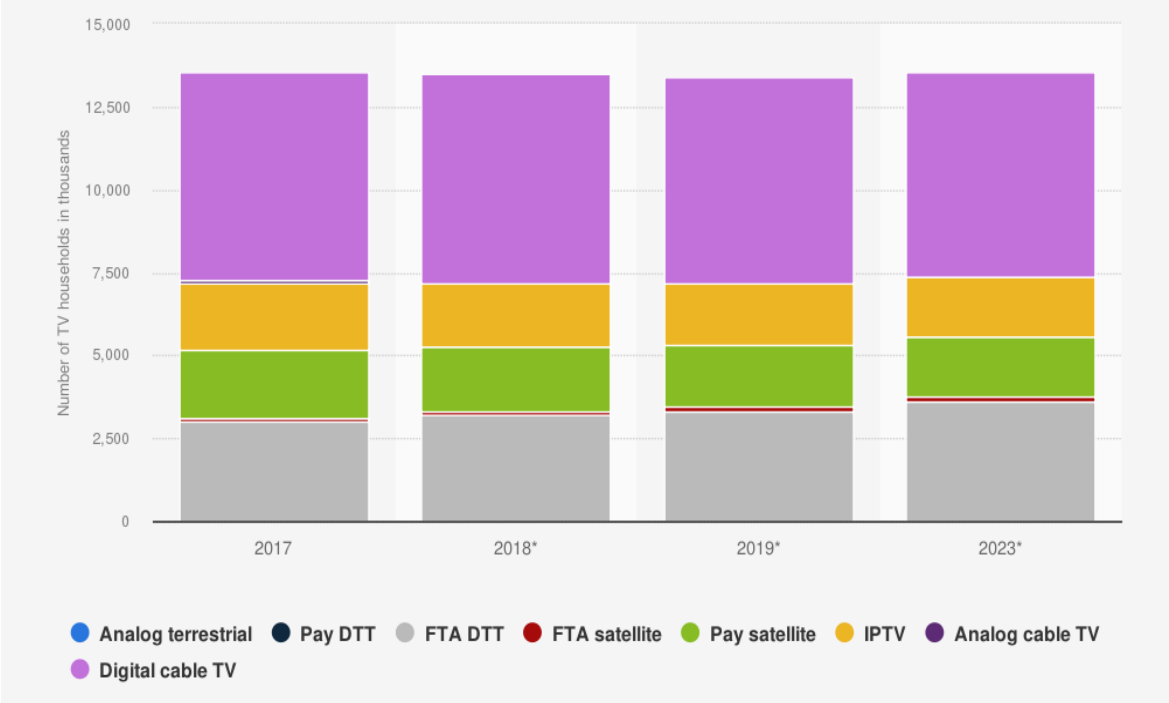
4.4.6 Canada

In Canada many channels are delivered via subscription television services termed Broadcasting Distribution Undertakings (BDUs). These tend to come via cable, IPTV and national Direct To Home (DTH) satellite service providers. These sit apart from the OTT services, which include the studio streamers, Netflix, Amazon and more niche SVOD services. Online delivered programming is categorised as Digital Media Broadcast Undertakings (DMBUs). As of 2024 there is still limited free terrestrial TV, and there are still very limited low power analogue TV stations available with limited local reach.[307] The population that lives near the US border can receive DTT signals from both countries. As well as English and French language segments of the population, Canada also has numerous indigenous languages that it is committed to support through broadcast media. In 2024 BDU subscriptions fell by 5.7% and DMBU subscriptions increased by 9.9% in a year.[308]

Figure 97 shows the trend in TV households and consumption methods between 2017 and 2023.

[307] Canadian Radio-television and Telecommunications Commission. Local and Community TV (2017) https://crtc.gc.ca/eng/television/services/local.htm (last accessed May 13th 2024)
[308] Olivia Bush. Television Industry and Audience Statistics In Canada (2024) https://madeinca.ca/television-industry-audience-statistics-canada/ (last accessed May 13th 2024)

Figure 97: Number of TV households in Canada from 2017 to 2023, by platform[309]



The Canadian Radio-television and Telecommunications Commission (CRTC) commissioned OMDIA to produce a report published in 2020 that proposed legislation be updated to permit CRTC to use new adaptable and innovative approaches to regulation based on how the TV market is evolving.[310] The report not only examines how new legislation can assist the development of online BDUs, but it also examines how other countries are adjusting to the audience shift to online distribution.

The OMDIA report also records by 2020 “a clear shift underway with households migrating from pay TV to OTT video.”[311]

Figure 98 is from a 2023 CRTC report, that shows the gradual shift from Pay TV and satellite BDUs to DMBUs.

[309] Digital TV Research. (2018). Number of TV households in Canada from 2017 to 2023, by platform (in 1,000s). Statista. Statista Inc.. Accessed: March 27, 2024. https://www.statista.com/statistics/827719/canada-number-of-tv-households-platform/

[310] Informa Tech. Canadian Radio-television and Telecommunications Commission (2020) Harnessing TV Distribution for Canadians in the Digital Age) https://crtc.gc.ca/eng/publications/reports/omd20.htm (last accessed May 13th 2024)

[311] Ibid

Figure 98: Canadian viewing for all delivery TV delivery methods 2014-2022[312]

	Canadians watching television on any platforms (%)	Household BDU subscription rate (%)	Canadians watching television exclusively online (%)
2014	94.0%	79.8%	8.0%
2015	96.0%	78.6%	8.0%
2016	95.0%	76.4%	10.0%
2017	94.0%	74.2%	9.0%
2018	96.0%	68.7%	14.0%
2019	97.0%	66.2%	16.0%
2020	97.0%	63.5%	20.0%
2021	97.0%	61.0%	20.0%
2022	97.0%	58.6%	18.0%

"Watching television exclusively online" refers to those who do not watch live TV at home and choose to watch television exclusively online via various streaming websites and services.

"Watching television on any platform" refers to any form of television viewership, regardless of the chosen television medium. This includes, but is not restricted to, BDU-subscribed television, private conventional television, and Internet-based television services. The content can be viewed on any platform device.

Although CRTRC is not engaged in state intervention to assist the move from DTT to IPTV, it is responding to the consumer move online with proposed regulation to ensure streaming services register, supply more information and contribute to the Canadian broadcast landscape, partially driven by the increasing number of global SVOD platforms and their entrance into the Canadian market.[313] In 2023 the Canadian Broadcasting Corporation (CBC) declared their eventual intention to move solely online, transitioning from DTT to IPTV. CBC CEO Catherine Tait said: "We don't want to drag Canadians to digital. They are dragging us", although CBC has not yet indicated a probable timeline.[314] Reformed legislation that followed the 2020 OMDIA report is detailed at the CRTC website.[315]

4.5 Conclusion

The data presented here indicates that key competing factors on DTT usage and the paced transition to IPTV in other territories are the size of nation, size of language specific audience, multiple languages within one country, the strength/legitimacy of PSM, infrastructure (DTT vs cable/satellite, plus high-speed broadband) as well as cultures of viewing and cultural attitudes to TV. With major variances between these factors across all territories – there are no direct equivalents to the UK, although

[312] Government of Canada. Broadcasting Distribution Sector (2022) https://open.canada.ca/data/en/dataset/58e91edf-409e-464b-ab6c-092125abeea1 (last accessed May 13th 2024)

[313] Canadian Radio-television and Telecommunications Commission. *Regulatory plan to modernize Canada's broadcasting framework* (2024) https://crtc.gc.ca/eng/industr/modern/plan.htm (last accessed May 13th 2024)

[314] Marie Woolf. *CBC signals plans to go full streaming, ending traditional TV and radio broadcasts* (2023) https://www.theglobeandmail.com/politics/article-cbc-digital-streaming/ (last accessed May 13th 2024)

[315] Canadian Radio-television and Telecommunications Commission. Broadcasting Regulatory Policy CRTC 2023-331 and Broadcasting Order CRTC 2023-332 (2023) https://crtc.gc.ca/eng/archive/2023/2023-331.htm (last accessed May 13th 2024)

there is high DTT usage comparable to the UK in France, Italy and Spain. Where countries are more advanced in their transition away from DTT than the UK, this is not necessarily indicative of a move towards IPTV. Legacy infrastructure in some territories means that audiences are also migrating to satellite and cable alongside IPTV.

5 Spectrum Use

This section presents the status of the demand from other sectors for the spectrum currently allocated to DTT. As described in the Technology and International Comparisons sections of the report, the frequency range 470-694 MHz is allocated to broadcasting services on a primary[316] basis in ITU Region 1, consisting of Europe, including the UK, Africa and Russia. There has been a growing demand for this spectrum from the mobile sector to extend its coverage in rural areas. For instance, 700[317] and 800[318] MHz bands, currently used by mobile services were previously allocated to broadcast services and reallocated to mobile due to the high demand for mobile services over the last few decades. The mobile sector currently seeks further use of terrestrial frequencies allocated to TV Broadcasting around the 600[319] MHz spectrum band.

Some channels within the spectrum used by DTT are also used by Programme Making and Special Events (PMSE), i.e. devices such as wireless microphones with relatively low power that do not cause harmful interference. The demand for PMSE use of spectrum is also growing.

The Radio Spectrum Policy Group (RSPG) opinion[320] recommends that broadcast and PMSE be given priority in the UHF Band until at least 2030. Under Article 4 Decision (EU) 2017/899,[321] the European Council and European Parliament are providing legal certainty at least until 2030 to terrestrial broadcasting and PMSE, based on national needs, in the frequency band 470-694 MHz. RSPG finds the socio-economic benefits of broadcast and PMSE in the UHF band to outweigh those of potential alternative uses at this time.

5.1 World Radio Conference-23 (WRC-23) developments

The decisions related to the frequency allocation for different services are taken at the World Radio Conferences (WRCs). The WRC-23, which ended in December 2023, reviewed the spectrum use and spectrum needs of existing services in the frequency band 470-960 MHz in Region 1.

At the European level, CEPT (Conference of European Posts and Telecommunications administrations) coordinates the frequency usage and cooperates in the ITU policy-making process. CEPT has a wide membership

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316 Services with the primary allocation have priority use of the band. Other services allocated on a secondary basis may operate in the same band as long as it does not interfere with 'primary' services

317 700 MHz band (known as n28 band in 3GPP): 703 - 803 MHz

318 800 MHz band (known as n20 in 3GPP): 791-862 MHz

319 614 – 698 MHz

320 RADIO SPECTRUM POLICY GROUP *Opinion on Strategy on the future use of the frequency band 470-694 MHz beyond 2030 in the EU*, https://radio-spectrum-policy-group.ec.europa.eu/document/download/6cb17632-9aba-4a15-aee9-28b9d272d9ed_en?filename=RSPG23-035final-RSPG_Opinion_on_UHF_beyond_2030.pdf (last accessed Nov 6th 2024)

321 Decision (EU) 2017/899: https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32017D0899 (last accessed Nov 6th 2024)

covering 48 European countries[322] stretching from Ireland to Russia. Considering the interest for the mobile services in this band, CEPT countries, including the UK, supported a secondary allocation[323] to land mobile service in the frequency band 470-694 MHz to be made at WRC-23, with a future agenda item for WRC-31 to consider a possible upgrade to a primary allocation. The outcome of the WRC-23 was that broadcasting will remain the only primary service in the frequency band 470–694 MHz in ITU Region 1. According to CEPT, sharing studies indicate that due care will be required in introducing new mobile service applications in the band. Many countries including the Member States of the Inter-American Telecommunication Commission (CITEL) stated that any changes made under WRC-23 must not impact the existing allocations and identifications for Region 2.[324]

Interestingly 10 countries[325] from the Arab Spectrum Management Group (ASMG) agreed to allocate 614-694 MHz band for mobile service on a primary basis at WRC-23.

Any changes to the use of this spectrum band due to the changes in national demand will be subject to effective cross-border coordination between existing services and various alternative services/applications wishing to access the spectrum, including mobile services. This cross-border coordination agreement must comply with the requirements of the Geneva 2006 Regional Agreement for digital television broadcasting, known as the GE06 agreement.[326] CEPT supported the primary allocation of the 470-862 MHz band to the broadcasting service in Region 1 to enable the protection and development of incumbent usage of broadcasting services. CEPT also supports the continuation and development of the incumbent usage by PMSE. Further, CEPT supports protecting the radioastronomy service within the frequency band 606-614 MHz, where required, to ensure its continued operation.

5.2 UHF band's unique characteristics

UHF spectrum is globally harmonised and used for TV transmission due to the requirements of TV systems. TV reception usually requires an almost universal coverage. The propagation characteristics of this spectrum band enable a near universal coverage with acceptable sized antennas. These two reasons, i.e. global harmonisation and propagation characteristics, make the UHF band the most attractive spectrum band for TV transmission.

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322 https://www.upu.int/en/Universal-Postal-Union/About-UPU/Restricted-Unions/CEPT

323 Services with secondary allocation can operate without introducing harmful interference to primary services.

324 ITU Region 2 comprises the North and South America.

325 Saudi Arabia, Bahrain, Egypt, the United Arab Emirates, Iraq, Jordan, Kuwait, Oman, Palestine*, Qatar and the Syrian Arab Republic,

326 GE06 overview of the second session (RRC-06) and the main features for broadcasters https://tech.ebu.ch/docs/techreview/trev_308-rrc-06.pdf (last accessed Nov 6th 2024)

UHF spectrum also has the following special properties that are useful for wireless communications systems, such as mobile service:

- The propagation characteristics of the UHF band will be beneficial in:
    - extending coverage as it propagates further and deeper into buildings. e.g. users at the cell edge are likely to be covered only by sub 1 GHz spectrum when deep indoors (unless offloading onto Wi-Fi). The speed and capacity of the service available to them may, therefore, be limited by the amount of sub 1 GHz spectrum available.[327]
    - boosting performance in hard-to-cover areas. Users at the edge of the cell and some users in urban and suburban locations, less densely populated and unpopulated areas, will require fewer sites to cover the same area. Similar coverage could be provided using higher frequencies, but at greater cost to mobile operators.
    - enabling the provision of a ubiquitous coverage layer for machine-to-machine communications.
- When a user terminal (i.e. mobile device) is close to the human body, it generates an additional loss due to signal blocking and absorption, known as body loss. Body loss increases with higher frequencies.[328] For instance, body loss of 6.9 dB at 550 MHz increases to 9.7 dB at 854 MHz.[329]
- In addition to the propagation characteristics, the value of the spectrum depends on international harmonisation. This impact is not limited to the use of the spectrum in Europe but extends internationally.

The propagation properties of UHF are illustrated in figure 96, which shows the percentage of the UK population who would receive a service giving single user throughput of 2 Mbps deep indoors using a macrocell network consisting of 18,000 sites using 4G technology in 2x10 MHz spectrum[330].

However, the mobile device antenna gain is one counterbalancing factor to these advantages. Given the small size of mobile devices, their antenna size is limited, and this reduces this benefit for mobile services as frequency is reduced. This ratio limits the efficiency of a small antenna, so there could be limitations at the lower end of the

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[327] "Ofcom consultation on Mobile Data Strategy'', Ofcom, 21 November 2013, http://stakeholders.ofcom.org.uk/binaries/consultations/mobile-data-strategy/summary/MDS_Condoc.pdf (last accessed Nov 6th 2024)

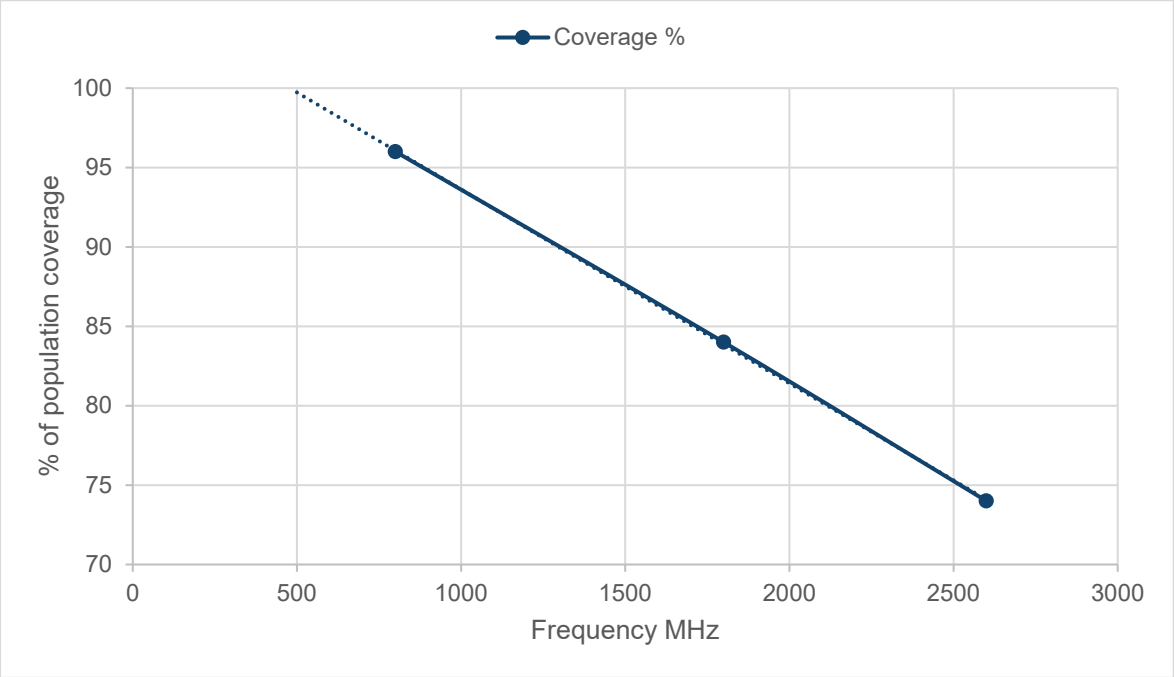
[328] CEPT Report 22: "Technical Feasibility of Harmonising a Sub-band of Bands IV and V for Fixed/Mobile Applications (including uplinks), minimising the Impact on GE06''
ECC CEPT, 6 July 2007, http://www.erodocdb.dk/docs/doc98/official/pdf/CEPTRep022.pdf (last accessed Nov 6th 2024)

[329] Nokia, "Handheld Devices and Preferred Spectrum", Multi-radio Multimedia Conference, Berlin January 2005

[330] Ofcom consultation on Mobile Data Strategy, 21 November 2013, https://www.ofcom.org.uk/__data/assets/pdf_file/0021/59151/Mobile-Data-Strategy.pdf (last accessed Nov 6th 2024)

UHF range to its attractiveness for small mobile devices.[331] There is about 4 dB reduction in the antenna gain at 470 MHz compared to 694 MHz. The increase in the propagation loss with the increase in frequency from 470 MHz to 694 MHz is approximately 3.4 dB.[332]

Figure 99: Impact of frequency on % of mobile population coverage for a network of a fixed size



5.3 Demand from the other sectors

The growing pressure from mobile operators around the world in the UHF band is highlighted by Agenda Item 1.5 of WRC-2023 where many countries had a significant interest on the progress of discussions related to this frequency band.

The '600 MHz band' (614-694 MHz) is being promoted by some in the mobile industry as a means to improve coverage in rural areas due to the lower propagation losses and building penetration losses compared to mid and higher frequency bands.

Development of the 600 MHz band began in the US and Canada,[333] while Asia is considering complementary alternatives to maximise the 600 MHz band in the APT Wireless Group (AWG).

[331] "A Near Field Propagation Law & A Novel Fundamental Limit to Antenna Gain Versus Size'', H.G Schantz, IEEE APS conference July 2005 ,
[332] "Free space path loss: details, formula, calculator'', Ian Poole, Radio-Electronics.com http://www.radio-electronics.com/info/propagation/path-loss/free-space-formula-equation.php (last accessed Nov 6th 2024)
[333] GSMA note on The GSMA WRC Series Low-Band Capacity, https://www.gsma.com/spectrum/wp-content/uploads/2021/04/WRC-23-Low-Band-Capacity.pdf (last accessed Nov 6th 2024)

A study[334] on the future use of UHF spectrum in ITU Region 1 identified increasing demand for spectrum from the mobile industry against a slowly declining use by television broadcasting. It showed that this is not a uniform trend across all countries in Region 1, and some countries rely more on DTT than others. The study concludes that the bands 470 – 694 MHz should be allocated on a co-primary basis to DTT and mobile, with regulators coordinating between themselves to ensure that any impacts of cross-border interference are minimised. The study also recommended that regulators consider the requirements for all users of the UHF spectrum in their country and use geographic or other sharing methods to accommodate demand.

There are a few sub-1 GHz band categories specified by the 3rd Generation Partnership Project (3GPP)[335] for mobile service in the 614–960 MHz range:[336]

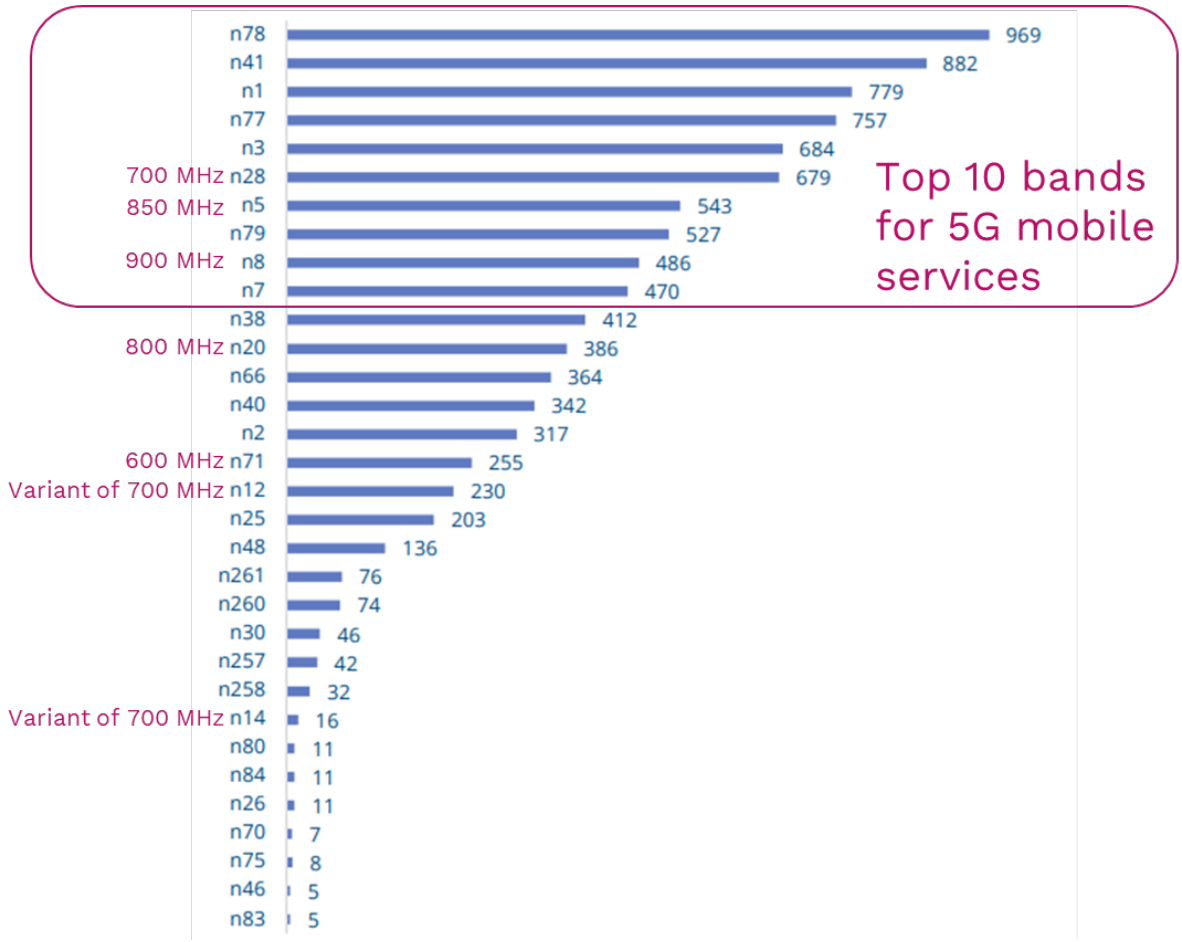
- 700 MHz band (n28): 703 - 803 MHz
- 850 MHz (n5): 824- 894 MHz
- 900 MHz (n8)880-960 MHz
- 800 MHz band (n20): 791-862 MHz
- 600 MHz band (n71): 617 - 698 MHz
- Variant of 700 MHz band (n12) 699-746 MHz
- Variant of 700 MHz band (n14) 758-798 MHz

There are other variants defined in 3GPP. We present the top 7 popular bands for device availability. Depending on the region and country, between 180 and 210 MHz of sub-1 GHz spectrum has been identified for IMT.[337]

An overview of the availability of devices supporting the 5G mobile spectrum bands is shown in figure 97. The device availability indicates the popularity of the band for mobile services. It shows that three sub 1 GHz bands (700, 850 and 900 MHz bands are among the top 10 bands for 5G device availability.

[334] The future use of UHF spectrum in ITU Region 1, https://gsacom.com/paper/the-future-use-of-uhf-spectrum-in-itu-region-1/ (last accessed Nov 6th 2024)
[335] 3GPP unites seven telecommunications standard development organisations, providing their members with a stable environment to produce the Reports and Specifications that define mobile technologies such as 4G and 5G.
[336] 3GPP TS 38.101-1 V18.4.0 (2023-12), https://www.3gpp.org/ftp/Specs/archive/38_series/38.101- (last accessed Nov 6th 2024)
[337] International Mobile Telecommunications (IMT) is the term used in the ITU for mobile communications technologies such as 4G, 5G etc.

Figure 100: Availability of devices supporting the 5G mobile spectrum bands



Source : Global mobile Suppliers Association[338]

According to figure 100, the device ecosystem for the 600 MHz band is not too far behind (16th place), showing the demand for the 600 MHz band for mobile service. Further, the move by the 10 ASMG countries to make mobile allocation on a primary basis indicates that mobile sector demand for this band is likely to increase in the coming years.

5.3.1 Demand from the PMSE sector

Programme Making and Special Events (PMSE) consists of all types of wireless production tools for broadcast production and programme making, such as professional wireless microphone systems (PWMS), In-Ear Monitor systems (IEM), wireless video cameras and other wireless video links, audio links, conference systems, etc. Wireless audio PMSE technologies help improve security and safety levels within the entertainment industry and other sectors. Their benefits include:[339]

- Improving the management of electrical safety.

[338] https://gsacom.com/

[339] The British Entertainment Industry Radio Group (BEIRG) website, https://www.beirg.org/consultations (last accessed Nov 6th 2024)

- Reducing noise levels.
- Developing safety in communications and reducing trip hazards.
- Providing an essential tool for security-orientated services.

The PMSE sector plays a vital role in developing original content for UK media. In its plan of work for 2022/23,[340] Ofcom highlights the importance of UK media to ensure audiences can continue enjoying a range of "original content" representing the people and communities in all parts of the UK.

PMSE currently has access to the UHF band on a secondary basis to broadcasting. The operation of PMSE equipment relies on interference-free access to spectrum on an opportunistic basis – when the frequency is needed, it has to be available free of interference. Interference from TV in the UHF bands is predictable and can be accounted for as part of PMSE's sharing of interleaved spectrum with DTT.

A survey[341] carried out within the European Union Member States showed that approximately 50% of Member States 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 current technologies, 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).'

The British Entertainment Industry Radio Group (BEIRG) states that the PMSE sector has grown from theatre shows and large-scale events into an entire ecosystem that affects everyone in some form. During the last 10 years, the PMSE sector has faced two significant changes in the UK resulting in a reduction of nearly 50% of the spectrum available to PMSE use. Although mitigated by the UK Government funding scheme, the impact of these changes was significant to many in the industry. According to the BEIRG,[342] further reduction in spectrum access will have a critical effect on the industry's ability to deliver daily events of all sizes and scales. It is also important to add that while financial support packages help, these will only work if sufficient existing spectrum is maintained or new technically viable spectrum is made available to the PMSE sector. The PMSE sector believes that it is

[340] Statement: Ofcom's plan of work 2022/23, https://www.ofcom.org.uk/consultations-and-statements/category-2/plan-of-work-2022-23#:~:text=Ofcom's%20themes%20for%202022%2F23&text=We%20will%20support%20continued%20investment,left%20behind%20as%20services%20evolve. (last accessed Nov 6th 2024)
[341] Study on the use of the sub-700 MHz band (470-694 MHz), https://op.europa.eu/en/publication-detail/-/publication/8c6755a1-4f55-11ed-92ed-01aa75ed71a1/language-en/format-PDF/source-search (last accessed Nov 6th 2024)
[342] Consultation responses by BEIRG, https://www.beirg.org/consultations (last accessed Nov 6th 2024)

vital that regulators recognise this and prioritise policies to maintain and protect accessible spectrum for PMSE use in the long term.

If the 600 MHz band is allocated to mobile services, the PMSE sector will also lose access, leaving the PMSE with only 470 MHz to 600 MHz in the UHF spectrum.

Most wireless microphones (mostly audio and data applications) use interleaved spectrum throughout the UHF TV spectrum 470-862 MHz. Cordless cameras and video links use a variety of frequencies outside the UHF bands (typically above 2 GHz and 3.4-3.6 MHz). Currently, no technically viable alternative bands are identified for these PMSE audio applications.[343] Wireless Microphones and In-Ear Monitors in the UK are generally available at VHF (170 - 210 MHz) and UHF (470 - 790 MHz).

According to the BEIRG, only a limited pool of PMSE equipment operates outside the UHF spectrum; the UHF bands offer the largest quantity of contiguous, good quality spectrum required for large professional events. Due to the relatively limited tuning ranges of PMSE equipment, access to contiguous bands of spectrum is considered important for the flexibility and quality of PMSE. Regional variations in spectrum use causes changing requirements for PMSE.

The government Spectrum statement[344] stated that any future policy decision on spectrum availability for DTT must consider numerous factors, including the importance of PMSE for the UK's vibrant media and cultural sectors. 'Regardless of changes to viewing habits, there will be an ongoing requirement for spectrum for PMSE, which uses, among other bands, spectrum in the 470-694 MHz band'. However, currently there are no firm policy proposals from the government or Ofcom regarding the alternative bands into which PMSE could migrate.

[343] ''*The value of Digital Terrestrial Television in an era of increasing demand for spectrum''*, R. Kenny, R. Foster & T. Suter, January 2014, http://www.digitag.org/The_Value_of_DTT_in_an_era_of_increasing_demand_for_spectrum_20-1-14.pdf (last accessed Nov 6th 2024)

[344] Policy paper Spectrum statement, Published 11 April 2023, https://www.gov.uk/government/publications/spectrum-statement/spectrum-statement (last accessed Nov 6th 2024)

6 Market Impact

As discussed in the Audience Analysis section, viewing habits are changing significantly, with an ongoing shift towards video viewing via online delivery mechanisms rather than broadcast technology. This change in viewing and device preferences have implications for commercial revenues for traditional TV distribution, because users can subscribe to different (or incremental) video services (e.g. Netflix, Disney+, Amazon Prime) and the ability for advertising sales platforms to monetise their inventory is influenced by the size and demographic composition of audiences.

- Era of online subscription video services: With the rise of streaming services like Netflix, Amazon Prime Video, and Disney+, viewers have more options for subscription content at a lower price without having to commit to long-term fixed contracts.
- Fragmentation of audiences undermines traditional ad sales: one of the key strengths of commercial TV was its ability to offer advertisers large, captive audiences through a small number of major channels. However, with the proliferation of streaming services, and online video platforms, audiences are becoming more fragmented. This makes it harder for advertisers to reach their target demographics effectively, leading to a decrease in the value of advertising slots on traditional TV.
- Broadcast audiences continue to skew older: Broadcast TV viewing fell 11% from 2021 to 2022, with younger audiences increasingly moving to other forms of viewing. In 2022, 16-24 year olds watched 39 minutes of broadcast TV each day, vs. 5 hours and a half for those over 75+. Typically, younger audiences especially aged 16-34 command a commercial premium for advertising. As audiences for broadcast TV age, it will be more difficult to generate the same levels of commercial return from advertising for these audiences.
- Connected TV user interfaces favour new players: The shift to IP-based viewing moves control of the viewing experience away from the content players who have traditionally dominated the linear grid, particularly the PSBs, and towards IP-based platforms and services. IP platforms like Amazon and Samsung and services like Netflix present increasingly personalised, algorithmically-driven UIs designed to capture the audience and promote their own content. This can lead to dramatic shifts in viewing behaviour when viewers shift from traditional linear-led UIs to devices that focus primarily on OTT services.

The proliferation of SVOD makes the Pay TV landscape significantly more competitive, since subscribers can switch in and out of competing services with much greater ease than they can with traditional linear Pay TV. This in turn drives greater returns to scale, so revenue is funnelled away from local players towards global services like Netflix and Amazon who have the financial resources to build a

substantial library of material and a constantly renewed pipeline of new content to reduce their churn rates relative to smaller competitors.

As online streaming services increasingly offer advertising-supported services to bring in more cost-conscious customers, this significantly increases the supply of tier 1 advertising inventory, which further increases the pressure on traditional broadcast advertisers.

Overall, the shift in viewing habits towards digital platforms is challenging the traditional TV advertising model, leading to a decline in broadcast advertising revenues and new global SVOD players taking share of subscription revenue.

Figure 101: Ofcom exhibit on total TV revenue by source.

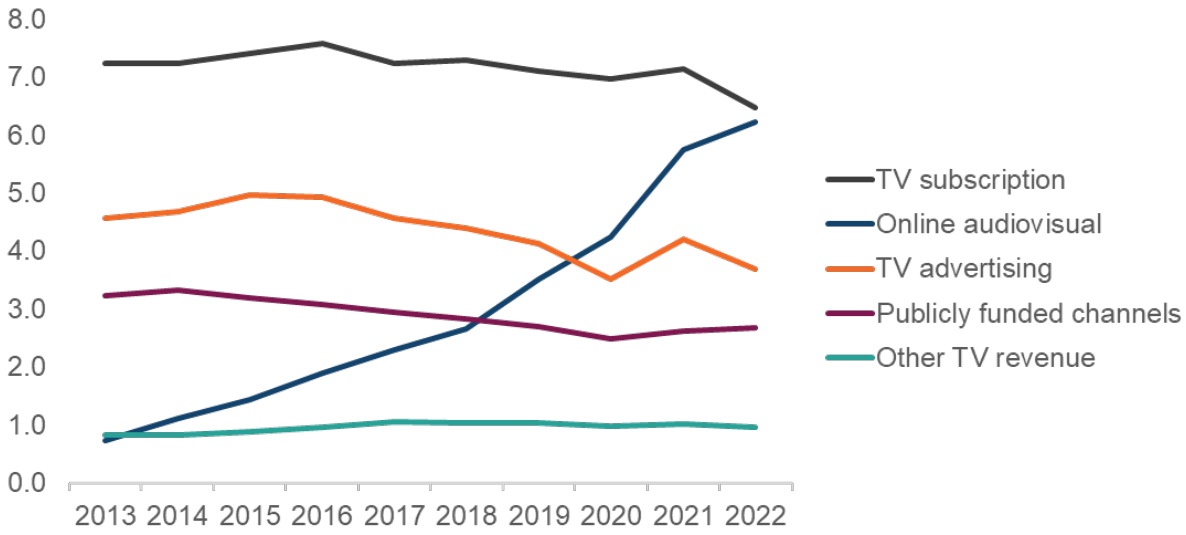
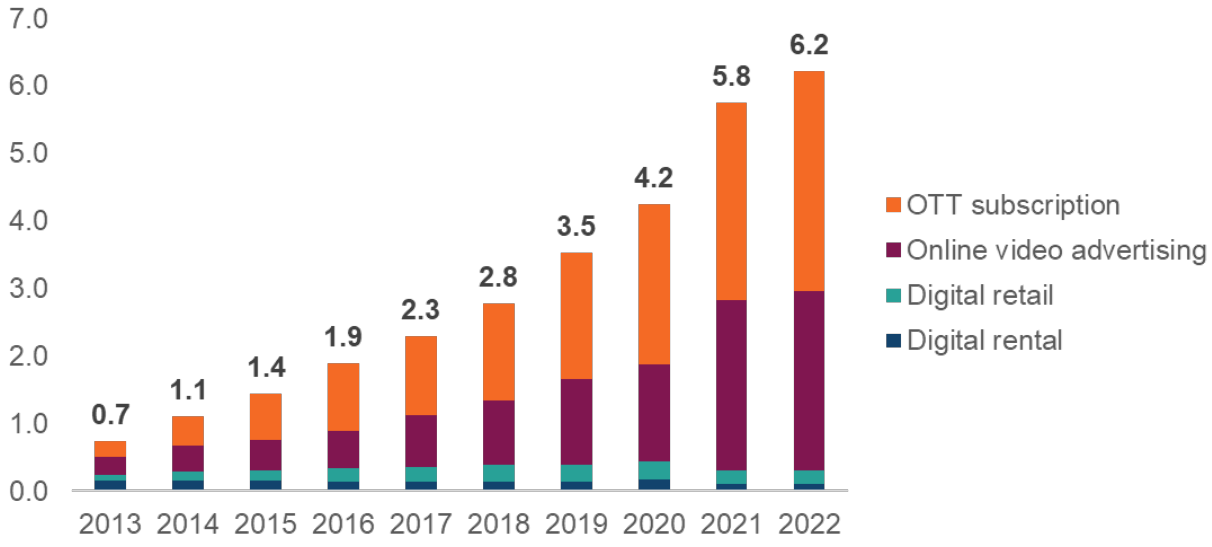


Figure 102: Ofcom exhibit on share of total online audio-visual revenue.



Implications for content production and creative industries

There are several implications for the content production industry:

- Revenue from traditional buyers is declining: in 2009, 63% of UK producer TV revenue was from four main PSBs vs. 39% in 2022 (source: Pact). As viewing migrates towards online services, the relative buying power of PSBs and UK multi-channels is declining. UK producers are adapting by attracting higher levels of international revenue: international digital revenue has increased from £280 million in 2018 to £696 million in 2022.
- Direct-to-consumer distribution vs. online syndication: theoretically, online video delivery gives production companies the opportunity to distribute their content directly to consumers without the need for intermediaries such as traditional broadcasters or cable networks. This DTC (direct-to-consumer) distribution model gives production companies greater control over their content and revenue streams. However, it is important to note that significant investment and risk is required to create an owned-and-operated platform. It is common for smaller production companies to seek a quasi-DTC approach by publishing on syndication platforms, such as YouTube, TikTok and other video-led online networks. In doing so, producers can benefit from some direct-to-consumer attributes (e.g. association with producers' brand, direct feedback from viewers, reduced time-to-market), without the expense and risk of creating their own DTC platform. In practice, the revenue per viewer generated by video publishing platforms like YouTube is relatively small and does not justify the investment required to produce original, premium long form programming for these platforms. They tend instead to provide monetisation for content that is either very cheap to make (e.g. user-generated content) or deep catalogue (i.e. older content which has already been well exploited on streaming services and linear channels).
- Global reach and accessibility: the growth of online video delivery, and specifically the emergence of global video providers such as Netflix and Amazon Prime Video, has meant that increasingly platforms offer global reach, allowing production companies to distribute their content to audiences worldwide with a single distribution partner, rather than doing multiple territory-by-territory deals with individual regional broadcasters.
- Demand for original and exclusive content: the rise of video on demand and online delivery has increased the demand for high-quality, exclusive video content. For subscription services, viewers often make the choice to subscribe based on the availability of headline films and TV shows. For advertising-funded broadcasters, high quality content is important to sustain large audiences. This creates a demand for original, high-quality content from production companies, driving investment in content creation and innovation within the creative industries.

6.1 Enablers and barriers to entry for online video vs. broadcast

The barriers and enablers to market entry for a new IPTV business significantly differ when compared to businesses that predominantly rely on broadcast technology for distribution. To enable the comparison, we will consider two types of organisations: an advertising-led company that produces or acquires content for its own branded channels (ad-funded broadcaster) and a subscription-led company that combines its own content or content it has acquired with channels from other providers (subscription-led Pay TV operator).

For an ad-funded broadcaster, the crucial difference in barriers to entry for online video delivery vs. broadcast technology is in upfront investment required to secure transmission capacity (via DTT or satellite for broadcast or via online mechanisms). MTM estimates that commercial satellite capacity requires c. £2 million per annum and commercial DTT capacity requires c. £4 million per annum, excluding media management and playout technology. For online video delivery via third party platforms, costs are more likely to scale with audiences, and some platforms (i.e. YouTube) allow ad-funded broadcasters to publish content for free in exchange for a share of the advertising revenue that is generated.

However, in the online domain, prominence and discovery is a challenge. Due to the low barriers to entry, an ad-funded broadcaster faces very significant competition from other providers and, depending on their choices for publishing, would be subject to the prominence rules and patterns of the platforms on which they are published (i.e. whether their content is shown on YouTube's home page or within their 'suggested videos' UI). This, combined with the flexibility connected TV UIs have to promote or demote content via algorithmic feeds, gives the device or UI platform very significant bargaining leverage in negotiation with content providers. UI platforms can determine what free content gets presented to the audience, and therefore its viewership and revenue potential. This allows UI platforms to demand a significant cut of advertising revenue, often 30% or more, for all but the largest and most established content providers.

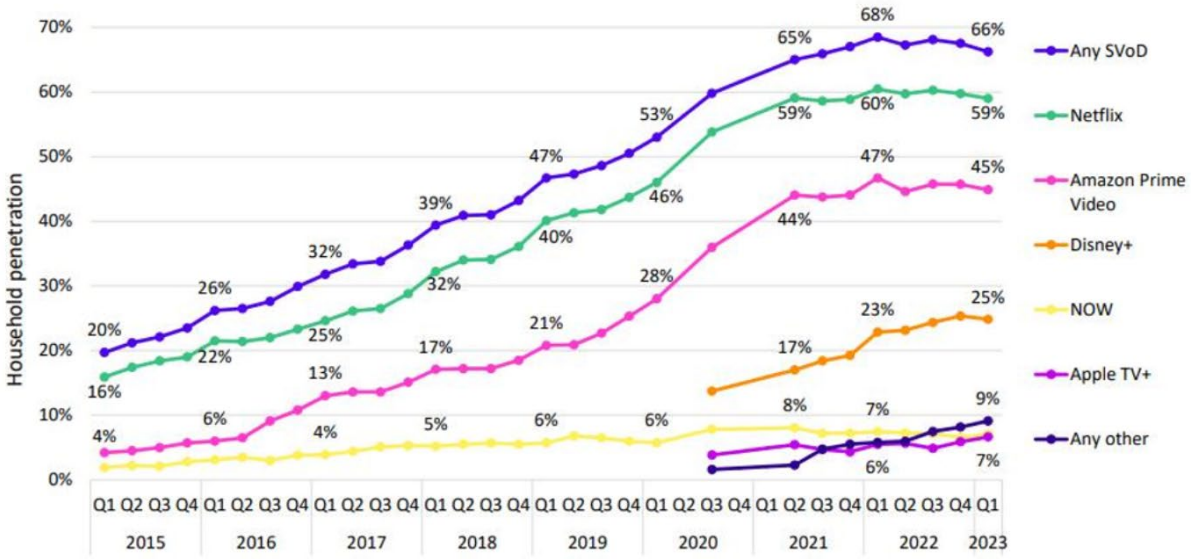
New entrants would face significant competition from existing ad-funded and free-to-air providers. The strength of the UK PSB ecosystem in the UK means that new entrants have to offer distinctive and compelling content on a consistent basis to attract viewers regardless of chosen delivery mechanism (broadcast or online).

For subscription-led Pay TV operators, an online-only distribution strategy means that operators can opt to forego the expense of providing customers with dedicated TV hardware to access their services, and instead offer an application or website. Pay TV operators using broadcast technology would often be required to invest heavily in consumer equipment and supply these as part of a long-term contract, whereas online-only operators are able to provide equivalent services without their own devices. There are disadvantages with an online-only distribution strategy, including potentially limited access to the default user interface on some devices, lack of control over quality of service and the requirement to invest in video applications to support a range of device specifications and models so an application

can work on as many devices as possible vs. a ‘one size’ approach for traditional Pay TV operators.

As with ad-funded models, subscription-led operators face significant barriers to entry due to the scale required to compete effectively within the subscription video arena and the broader subscription entertainment space. BARB’s reported household penetration indicates that the top 3 SVOD providers in the UK (Netflix, Amazon Prime Video and Disney+) account for ~90% of all SVOD subscriptions in the UK in Q1 2023, and the next 4 operators only account for ~10%, with a long tail of operators not reported. This suggest there is a huge barrier to entry to the subscription space: research shows that the average number of pay streaming services per household is only 2.2, and rising very slowly, so consumers’ appetite to add new paid subscriptions is heavily constrained.

Figure 103: SVoD penetration of UK households, by provider: Q1 2015 to Q1 2023

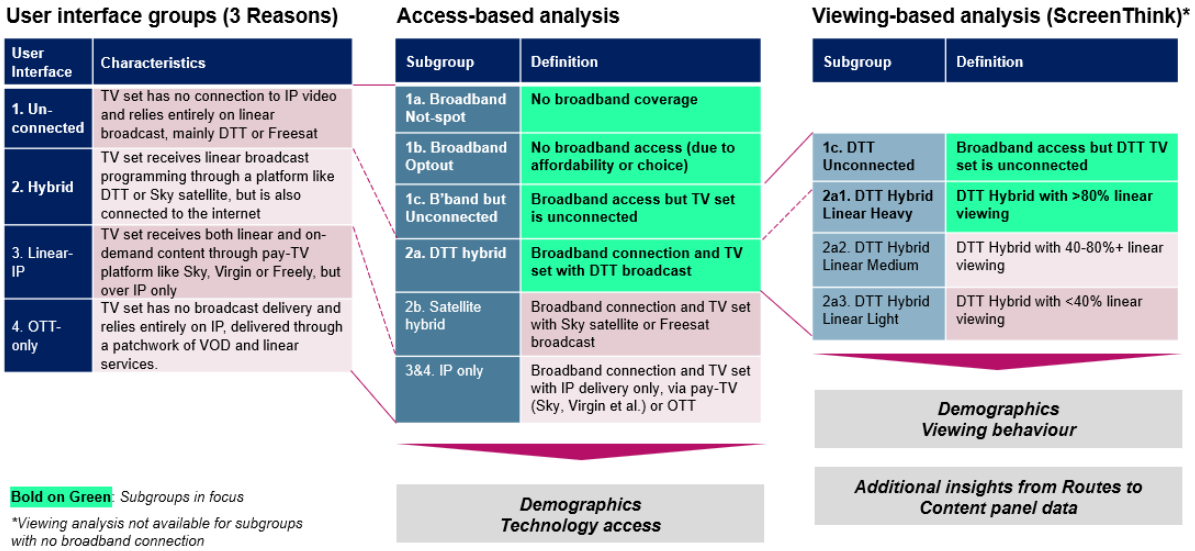


Source: Barb Establishment Survey. Includes paid-for subscriptions and free trials. No data for Q2 2020, Q4 2020, and Q1 2021 due to the suspension of fieldwork due to the Covid-19 pandemic. ‘Any other’ includes Hayu, Discovery+, Paramount+ and BritBox.

Appendix A. Analytical approach to key subgroups

In order to understand the groups who rely on DTT and remain unconnected to IP services, and those who tend to favour DTT linear broadcast despite having access to IP, we have structured our approach to incorporate both an *access-based* and a viewing-based analysis.

Figure 104: Unconnected TV and linear-heavy groups – analytical framework



Source: 3 Reasons

Starting with the 3 Reasons user interface segmentation, we have sub-segmented the Unconnected group (DTT or Freesat[345] homes with TVs unconnected to the internet) into three categories:

- Broadband Not-spot: DTT and Freesat homes in areas without any fixed-line broadband coverage or with broadband lines of less than 2 Mbps
- Broadband Optout: Homes without broadband access for reasons of affordability or choice
- Broadband but Unconnected TV: Homes that have broadband access, but where the primary TV set remains unconnected to the internet

We also identify a fourth relevant category, DTT Hybrid, which is part of 3 Reasons' Hybrid group. These are homes that use DTT broadcast and have primary TV sets connected to the internet. The rest of 3 Reasons' Hybrid group are homes that use Sky satellite, Freesat, or cable. We compare these to 3 Reasons' IP-connected Linear-IP and OTT-only groups, though these are not the main focus of our analysis.

[345] Unconnected group includes a small number of homes with Sky as their primary set platform.

For each of the groups in focus, we are able to create profiles of their demographic composition and their access to technology, using Barb Establishment Survey data and data from 3 Reasons.

To analyse these groups in more depth, we use data from ScreenThink, a syndicated viewer panel survey run by MTM. Here, we focus on the Unconnected TV group, i.e. homes with broadband but where the DTT set is unconnected to the internet, and on the DTT Hybrid group, which we divide into three subgroups:

- DTT Linear Heavy, where 80%+ of their TV viewing is linear. This group is the most likely to rely on traditional linear broadcast delivery
- DTT Linear Medium, where between 40% and 80% of TV viewing is linear
- DTT Linear Light, where less than 40% of TV viewing is linear.

(Note that as ScreenThink is an online panel, viewing behaviour data is not available for homes without a broadband connection).

We have also analysed data from the Routes to Content panel, which gives valuable further data about reported viewing by different segments. While audience groups in this dataset are not directly comparable to those in the other datasets we use, the analysis still yields useful insights about the attitudes of audiences who rely more heavily on linear broadcast DTT.

Appendix B. Analytical approach modelling unconnected group to 2040

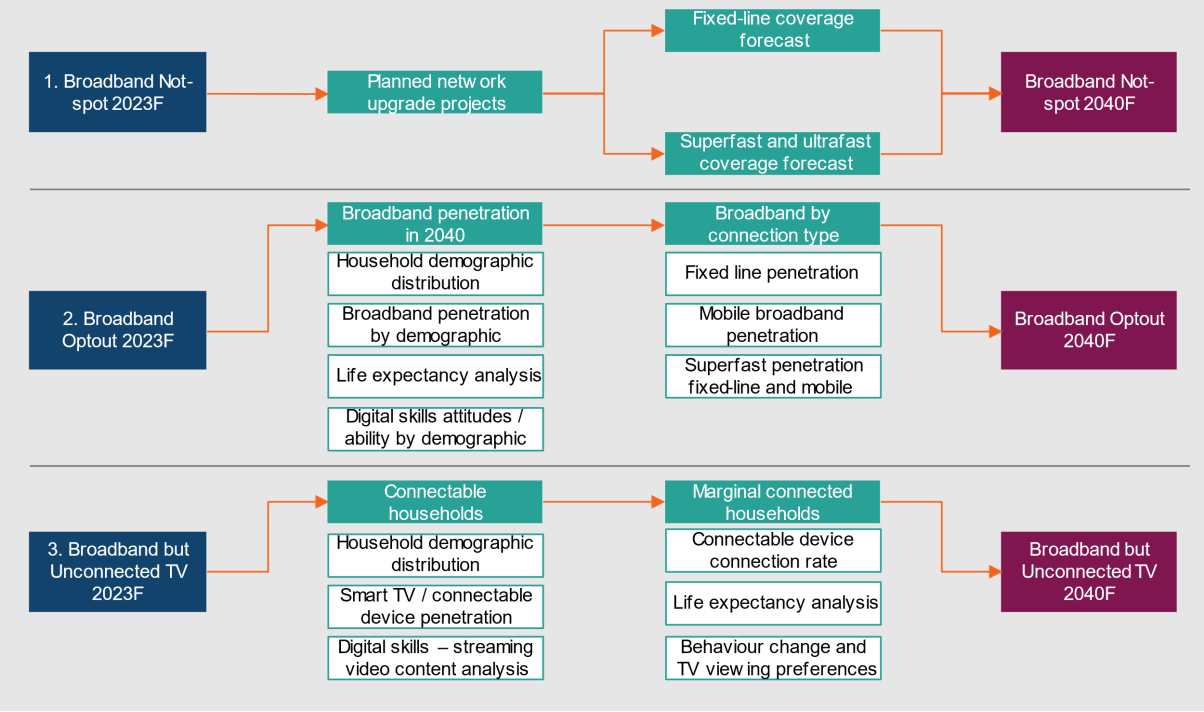
Assumptions

This section outlines our methodology, assumptions and sources for the unconnected groups forecast.

For Group 1 (Broadband Not-spot), we used forecasts for projected UK broadband coverage, and assumed that coverage would be universal by 2040.

For groups 2 and 3 (Broadband Optout and Broadband but Unconnected TV), our starting point was the 3 Reasons model data for 2023. The forecast is driven by a bottom-up approach which models individuals within each cohort up to 2040. This allows us to incorporate assumptions tailored to each demographic at a granular level. A simplified model schematic of our approach is shown in Figure 105.

Figure 105: Unconnected groups forecast framework



Source: MTM.

Group 1: Broadband Not-spot

To determine UK broadband coverage, we used Ofcom's data for fixed output areas.[346] We were able to map this observed broadband coverage to the Barb Establishment survey dataset which allowed us to analyse the demographic breakdown of this group.

[346] Ofcom, Data Downloads (2024) https://www.ofcom.org.uk/phones-and-broadband/coverage-and-speeds/connected-nations-2023/data-downloads/ (last accessed Nov 6th 2024)

Planned network upgrade projects – such as project Gigabit[347] – aim to provide broadband access to all of the UK by 2040, focused on providing hard-to-reach communities with gigabit capable broadband. We assume that this target will be met and eliminate the broadband Not-spot group in 2030. We estimate that superfast broadband will be available on all fixed line connections by 2030.

Group 2: Broadband Optout

As a first step, we analysed the 2023 demographic breakdown of homes without broadband connections, according to several key parameters:

- Age
- Region
- Gender
- Socioeconomic status

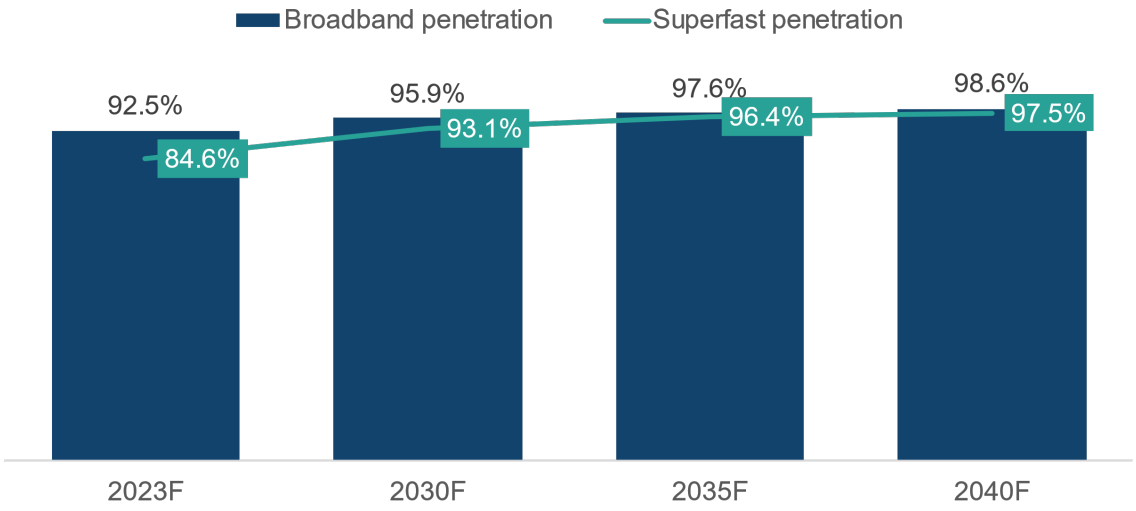
3 Reasons has used Barb Establishment Survey data to estimate broadband penetration for each of these demographics to determine current broadband take-up. We also accounted for the level of digital skills among each age cohort.

We then projected how this group evolves demographically up to 2040. It's important to note that our broadband penetration projections assume that propensity to use broadband is a more influenced by age cohort / generation, rather than age; for example, broadband penetration among 70-year olds in 2040 is likely to be significantly higher than among 70-year olds in 2024.

In terms of broadband speed, we assume that 100% of fixed-line connections will be superfast by 2030, and that a growing proportion of mobile broadband connections will be VOD-capable, growing to c. 81% by 2040. The chart below depicts our broadband penetration[348] and VOD-capable broadband[349] adoption forecast, as a percentage of all UK households.

[347] UK Government, Project Gigabit (Updated 2024) https://www.gov.uk/guidance/project-gigabit-uk-gigabit-programme (last accessed Nov 6th 2024)
[348] Includes fixed-line and mobile connections.
[349] Includes the proportion of fixed-line superfast (30Mbps) and VOD-capable mobile connections that are capable of streaming IP content at a quality considered adequate by industry consensus.

Figure 106: All homes broadband and superfast penetration, %, 2023F-40F



Source: 3 Reasons

Applying the evolution of the demographic-specific broadband forecasts to the Broadband Optout group yields a projection for the size of this group to 2040, declining from 1.7m to c. 0.4m.

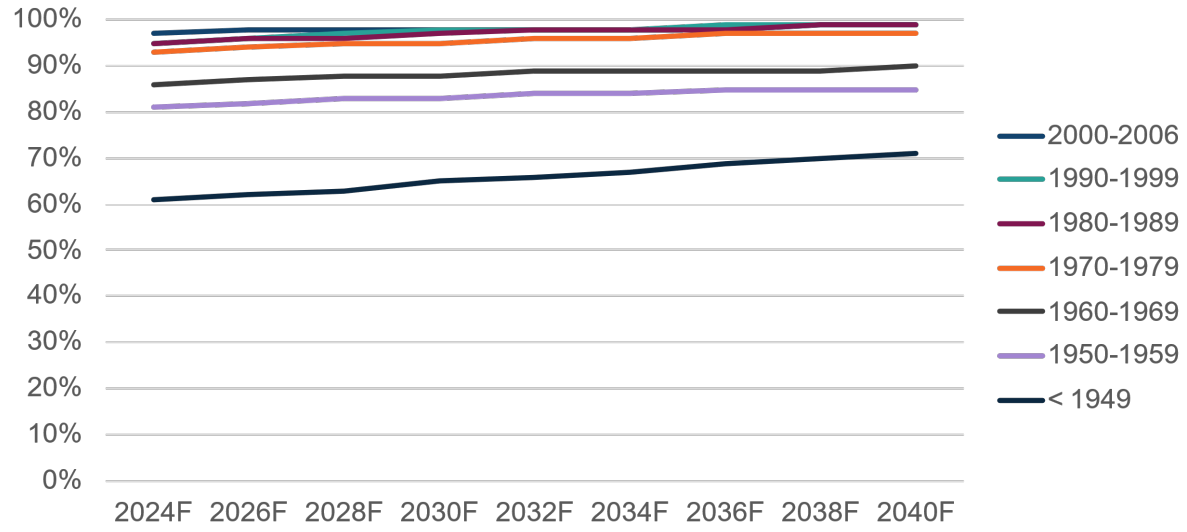
Group 3: Broadband but Unconnected TV

In our modelling, the Broadband but Unconnected TV group gains households transitioning from Group 2 (i.e., those who have adopted broadband), while simultaneously losing members to the Hybrid, Linear IP, and OTT-only groups, as individuals in broadband homes connect their primary TV sets.

3 Reasons has used Barb Establishment survey data and data on digital skills from Lloyd's Digital Skills Data Tables[350] to estimate the proportion of individuals in this group within each age cohort who own a smart TV or connectable device and who know how to use a smart TV, or are willing to learn. Projecting these forward, we arrive at a forecast, by age cohort, for what proportion will own a smart TV/device and what proportion will connect it to the internet.

[350] Lloyds, Essential Digital Skills Data Table (2023) https://www.lloydsbank.com/banking-with-us/whats-happening/consumer-digital-index/essential-digital-skills.html (last accessed Nov 6th)

Figure 107: % of each generation who know how to stream TV via the internet, %, 2024F-40F



Source: Lloyds Digital Skills Data Tables, 2023; MTM analysis.

Appendix C. Technical comparison between DVB-T and DVB-T2

A summary of technical comparison between DVB-T and DVB-T2 is shown in Figure 108.

Figure 108: Comparison of DVB-T and DVB-T2[351].[352]

Features	DVB-T	DVB-T2	Comments
Forward Error Correction (FEC) coding	Convolutional coding + Reed Solomon (RS): 1/2, 2/3, 3/4, 5/6, 7/8	Low Density Parity Check (LDPC)+ Bose-Chaudhuri-Hocquengham (BCH): 1/2, 3/5, 2/3, 3/4, 4/5, 5/6	New generation FEC (more complex than the previous ones) resulting in a capacity gain of 25-30% and higher-order constellations (e.g. 256 QAM) provides a higher spectral efficiency.
Modulation	QPSK, 16QAM, 64QAM	QPSK, 16QAM, 64QAM, 256QAM with constellation rotation	Rotated constellations to assist in the reception of higher code-rate signals in demanding transmission channels.
Guard interval (GI)	1/4, 1/8, 1/16, 1/32	1/4, 19/128, 1/8, 19/256, 1/16, 1/32, 1/128	New GI fractions: 1/128, 19/256, 19/128. Scattered pilot optimization according to the GI, continual pilot minimisation resulting in an overhead reduction of ~10%.
FFT Size	2K, 4K, 8K	1K, 2K, 4K, 8K, 16K, 32K	Increased symbol time by a factor two (16k FFT) and four (32k FFT)
Scattered pilots	8% of total	1%, 2%, 4%, 8% of total	Scattered pilot optimisation according to the guard interval (GI)
Continual Pilots	2.0% of total	0.4%-2.4%	Continual pilot minimization resulting in an overhead reduction of ~10%
Bandwidth	5, 6, 7, 8 MHz	1.7, 5, 6, 7, 8, 10 MHz	Bandwidth extension: e.g., for 8 MHz bandwidth, 7.77 MHz instead of 7.61 MHz (2% gain)
Typical data rate	24 Mbit/s	40 Mbit/s	A higher data rate using the same spectrum implies more efficient use of spectrum.
Max. data rate (@ 20dB C/N)	31.7 Mbit/s	45.5 Mbit/s	

[351] RF Wireless World, *Difference between DVB-T and DVB-T2 | DVB-T vs DVB-T2* https://www.rfwireless-world.com/Terminology/Difference-between-DVB-T-and-DVB-T2.html *T2* (last accessed Nov 6th 2024)

[352] Frequency and network planning aspect of DVB-T2, EBU Status report, Version 4.1.2, January 2020, https://tech.ebu.ch/docs/tech/tech3348.pdf *T2* (last accessed Nov 6th 2024)

Further benefits of DVB-T2 include[353]:

- The number of possible combinations of the available parameters increases significantly, resulting in a much higher potential efficiency of the standard, a much higher capacity to adapt to specific characteristics and constraints of the infrastructures in which it is used, but a much higher complexity in both transmitting and receiving sides.
- Extended interleaving including bit, cell, time and frequency interleaving allows multiple trade-offs in terms of time diversity, latency and power saving.[354]
- DVB-T2 offers greater multipath[355] and impulsive noise[356] interference tolerance than DVB-T.
- Multiple Physical Layer Pipes allow separate adjustments of the robustness of each delivered service within a channel to meet the required reception conditions (for example, in-door or roof-top antenna). It also allows receivers to save power by decoding only a single service rather than the whole multiplex of services.
- MISO (multiple input, single output) transmission mode using a modified form of Alamouti encoding that improves coverage in small-scale single-frequency networks.
- Future Extension Frames (FEF) allow the standard to be compatibly enhanced in the future.
- DVB-T2 also allows for three new signal bandwidths: 1.7 MHz (for use as a successor to DAB), 5 MHz and 10 MHz.

According to the DVB-T2 specification, the DVB organisation defined a set of commercial requirements which acted as a framework for the T2 developments[355]:

- T2 transmissions should be able to use existing domestic antenna installations and should be able to re-use existing transmitter infrastructures.

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[353] ETSI Technical Specification ETSI TS 102 831 V1.2.1 (2012-08), Digital Video Broadcasting (DVB);Implementation guidelines for a second generation digital terrestrial television broadcasting system (DVB-T2); https://www.etsi.org/deliver/etsi_ts/102800_102899/102831/01.02.01_60/ts_102831v010201p.pdf *T2* (last accessed Nov 6th 2024)

[354] K. Sambasivarao, N.V. Ramana and M. Venkata Manikanta, "Effect Of Time Interleaving Parameters in Mobile DVB-T2 Systems", International Journal Of Engineering Sciences & Research Technology, pp. 175-181, 2017.

[355] The transmitted signal can take various paths (known as multipath) of different lengths to reach the receiver, and at a particular instance, it will arrive at the receiver over a spread of time. These multiple signal components can cause problems with phase distortion and inter-symbol interference arriving at the receiver.

[356] Short power spikes have an approximately flat frequency response over the spectrum range of interest.

(This requirement ruled out the consideration of MIMO[357] techniques, which would involve both new receiving and transmitting antennas.)

- T2 should primarily target services to fixed and portable receivers.
- T2 should provide a minimum of a 30% capacity, typically a 50% increase over DVB-T, working within the same planning constraints and conditions as DVB-T.
- Click here to enter text.T2 should improve the performance when deployed in a single-frequency-network (SFN) mode compared with DVB-T.
- T2 should have a mechanism for providing service-specific robustness; i.e. it should be possible to give different levels of robustness to some services compared to others. For example, within a single 8 MHz channel, it should be possible to target some services for roof-top reception and other services for reception on portables.
- T2 should provide for bandwidth and frequency flexibility.
- There should be a mechanism defined, if possible, to reduce the peak-to-average-power ratio of the transmitted signal in order to reduce transmission costs.

[357] MIMO (multiple input, multiple output) is a technology for wireless communications in which multiple antennas are used at the transmitter and the receiver to minimise errors, increase data speed, and improve the capacity of radio transmissions by enabling data to travel over many signal paths at the same time and to combine at the receiver using multiple receiver antennas.