Future use of the 470–694MHz band

Report for Abertis, Arqiva, BBC, BNE, EBU and TDF

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1 Summary of findings

The World Radiocommunication Conference in 2015 (WRC-15) will consider the award of co-primary status to mobile in the 470–694MHz band in Region 1. A consortium of Abertis, Arqiva, BBC, BNE, EBU and TDF has therefore requested Aetha to consider the economic benefits that would arise across the EU's 28 member states from mobile gaining access to the 470–694MHz band, compared to continued use for DTT and other existing uses.

We have considered a scenario in which DTT transmissions cease and consumers are required to migrate to alternative platforms (a mixture of satellite, cable and IPTV). All 224MHz of spectrum in the band then becomes available for mobile services. We have calculated the costs and benefits of this scenario over a 15-year period (2015 to 2029) and compared them to the costs and benefits of continued use of the spectrum for DTT and other existing uses (PMSE, radio astronomy and 'white spaces').

The benefits from making spectrum available for mobile are highly sensitive to forecast traffic levels. Therefore, we have considered a range of traffic forecasts, the highest of which is based on forecasts from the ITU and UMTS Forum.

The result of our economic assessment is provided in Figure 1-1below.

Figure 1-1: Results of our economic assessment across the EU [Source: Aetha]

	EUR billion
Cost of consumer equipment	19.7
Cost to set up new free-to-view platform	10.8
Cost of reduction in TV platform competition	14.2
Net avoided cost of operating DTT network	(6.2)
Total cost of DTT migration	**38.5**
Value of spectrum to mobile	**0–10.3 (depending on traffic forecast)**

Our results show that even in the most aggressive mobile traffic forecast, the **costs of clearing DTT from the spectrum (EUR38.5bn) significantly outweigh the potential value of using the spectrum for mobile (EUR10.3bn) by a factor of almost four.** When a less aggressive traffic forecast is used, the costs of clearing DTT are unchanged but the value of using the spectrum for mobile would be near to zero.

It is clear that the economic benefits for the EU are maximised if the 470–694MHz band continues to be used for DTT for at least the next 15 years – **there is clearly no economic case for switching-off existing DTT networks across Europe** on the grounds of spectral efficiency.

Further, the introduction of a co-primary allocation to mobile at WRC-15 **would have considerable negative impacts on DTT.** Given the history of DTT spectrum being awarded co-primary status for mobile and that then leading to the spectrum being cleared for mobile, granting a co-primary allocation to mobile in the 470–694MHz band would **undermine investor confidence in the future of the platform**. This would lead to the DTT platform falling behind other television platforms and even unnecessarily risk its viability, with little benefit to be derived.

2 Executive summary

This report has been prepared by Aetha Consulting Limited (Aetha) for a consortium of organisations comprising Abertis Telecom Terrestre, Arqiva Limited, British Broadcasting Corporation, Broadcast Networks Europe, European Broadcasting Union and TDF SAS. It provides a summary of our assessment of alternative uses of the 470–694MHz band across the European Union.

2.1 Background

World Radiocommunication Conference 2015 (WRC-15) will consider motions to award co-primary status to mobile services in the 470–694MHz band in Region 1, which is currently used for the provision of Digital Terrestrial Television (DTT) services across the European Union (EU). Adoption of similar motions relating to adjacent frequencies in the UHF band in previous World Radiocommunication Conferences (WRCs) have led to the creation of the 800MHz band for mobile broadband services across Europe and interest in the creation of a 700MHz band. Given a move could then lead to pressure for the release of spectrum in the 470–694MHz band for mobile broadband services, the above consortium of organisations has requested Aetha to consider this alternative future use of the 470–694MHz band and estimate the economic benefits arising for EU citizens relative to the benefits that accrue from continued use of the band for DTT and other existing uses, such as Programme Making and Special Events (PMSE), radio astronomy and ‘white space’ applications.

Our research has indicated that the reception of linear television continues to be of importance to European households. Whilst there has been significant increases in the amount of viewing of audio-visual content over the Internet (e.g. catch-up services and viewing of content from aggregators such as Netflix), viewing of linear television has remained relatively constant. Instead, it appears that the consumption of content over the Internet is largely substituting home-recorded content or content on physical formats such as DVDs and Blu-Rays. Additionally, the rapid growth in adoption of social media may further support the continuation of viewing of linear broadcasts – e.g. tweets regarding a particular television programme are mostly of interest to others viewing the same programme at the same time.

Given the current importance of linear television viewing, which is likely to remain for the foreseeable future given current trends, an assessment of alternative uses of the 470–694MHz band must consider alternative means of delivering linear television to those European households that currently depend on the DTT platform for either their main television set (‘primary set’) or other televisions in the household (‘secondary sets’).

2.2 Economic assessment of alternative use of the 470–694MHz band

In developing our economic assessment, we have considered two scenarios for the future use of the 470–694MHz band as follows:

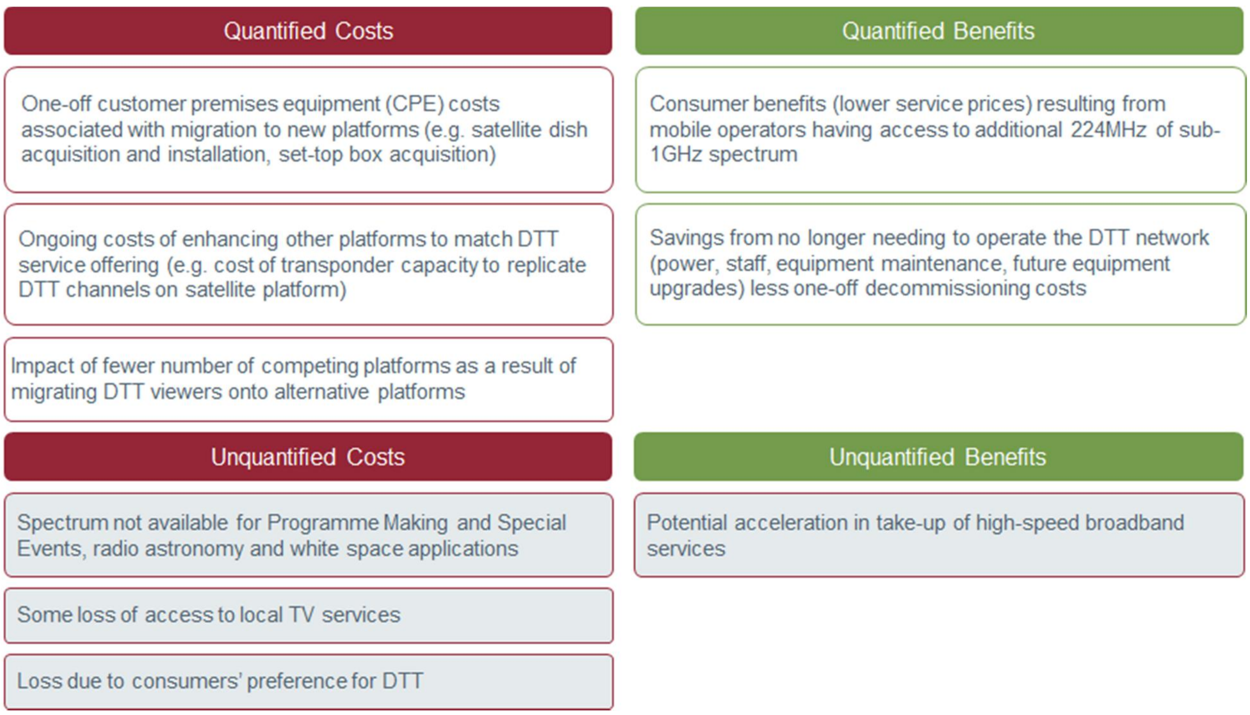
Scenario 1) The whole band continues to be used for the provision of DTT. No spectrum in the band becomes available for mobile services.

Scenario 2) DTT transmissions cease and consumers are migrated to alternative platforms (a mixture of satellite, cable and IPTV). All 224MHz of spectrum in the band becomes available for mobile services.

Note that in this study we have not considered options for part re-allocation of 470–694MHz to mobile services, for example a new '600MHz band'. This is because we do not detect that there is any appetite for further 'salami slicing' of the UHF band, given the amount of time and effort that is required to enable this to occur in terms of the international coordination process as well as the cost of migrating DTT transmitter sites onto new frequencies, which would be required on a widespread basis across the EU. Additionally the creation of 32MHz of spectrum in a new mobile sub-band (which is the approximate amount that could be made available if DTT operated with one fewer multiplex) is unlikely to be sufficient in terms of the amount of spectrum that the mobile industry would be interested in given the intensity of work required to internationally harmonise the band. Additionally it would reduce the number of DTT channels which could be offered, thereby detrimentally affecting the attractiveness of the platform. Further, the inclusion of 72MHz (plus a duplex gap) of spectrum in a mobile sub-band (the minimum amount that is likely to be of interest to the mobile industry) would result in the loss of approximately two or three multiplexes on the DTT platform which would, in many countries, substantially reduce platform capacity. This would make the DTT platform no longer viable in respect of there being a minimum amount of content available for it to be considered as a valid alternative to satellite and cable.

Our economic assessment thus aims to quantify the incremental costs and benefits arising under Scenario 2, when compared to Scenario 1. The incremental costs and benefits that arise under Scenario 2 are summarised in the diagram below. In particular, we have quantified those costs and benefits that are highlighted in white boxes. It can be seen that these comprise only some of the costs but the majority of the benefits. For this reason, our assessment should be considered as a lower bound estimate of the incremental costs associated with making the band available for mobile broadband.

Figure 2-1: Incremental costs and benefits associated with Scenario 2 (migration to alternative platforms) when compared to Scenario 1 (continued use of the whole band for DTT)



Our economic assessment is undertaken over a 15-year period – namely from 2015 to 2029 inclusive. We calculate the net present value (NPV) of all costs and benefits over this period using a social discount rate of 3.5%.

Our calculation of the costs and benefits associated with the migration of the DTT platform to alternative platforms has shown that there can be significant variations between countries due to specific circumstances – for example current levels of adoption of existing television platforms. Consequently we have selected eight case study countries (France, Germany, Italy, Poland, Romania, Spain, Sweden, UK), which represent a range of differing circumstances, and model the cost/benefits of platform migration in detail in each of these countries. We then calculate the total values for the EU by mapping each of the remaining 20 member states to one of the case study countries and scale the results with population. We note that 76% of the EU's population lies within our case study countries and therefore the majority of value is likely to be represented by our case study countries alone. The assignment of the remaining 20 EU member states is shown in Figure 2-2 below.

Figure 2-2: Assignment of remaining EU member states to case studies [Source: Aetha]

France	Germany	Italy	Poland	Romania	Spain	Sweden	UK
	Austria Belgium Luxembourg Netherlands	Croatia Greece	Slovakia	Bulgaria Estonia Hungary Slovenia		Denmark Finland Latvia Lithuania Malta Portugal	Cyprus Czech Rep Ireland

For calculating the benefits of making additional spectrum available for mobile broadband services, we consider a hypothetical country with a population of 50 million and then scale with population to obtain a total for the EU as a whole. Such an approach is possible since the differences in mobile markets across the EU are less pronounced than the differences in the television markets. Aetha has previously utilised a similar approach for the calculation of the economic benefits arising from making the 2.7–2.9GHz band available in Europe on behalf of the GSM Association[1]. The economic benefits from making spectrum available for mobile broadband services are highly sensitive to forecast traffic levels – consequently in addition to the forecast based on ITU/UMTS Forum projections utilised in our study for the GSM Association, we have also calculated the economic benefits using a second forecast adjusted from the UK forecast used by Ofcom in its recent consultation on the future use of the 700MHz band[2].

We have assumed that as much high-frequency spectrum as is required to provide sufficient capacity on mobile networks is made available, since the opportunity cost of making this spectrum available for mobile services is likely to be considerably lower than that of the 470–694MHz band. Nonetheless there will be elements of the traffic demand (for example in rural areas or deep indoors) that cannot economically be met using high frequencies. This is where the economic benefit of making the 470–694MHz band available for mobile broadband services arises. This benefit would arise in the form of costs savings for network operators from not having to deploy new base station sites to make more intensive use of other low-frequency spectrum (for example in the 900MHz, 800MHz and 700MHz bands). In our assessment we assume that 100% of these cost savings gained by the mobile network operators are passed on to consumers in the form of lower prices, This essentially assumes a perfectly competitive market – in reality we note that this may not necessarily be the case and therefore our assessment of the economic benefits resulting from the use of the band for mobile are likely to be overstated.

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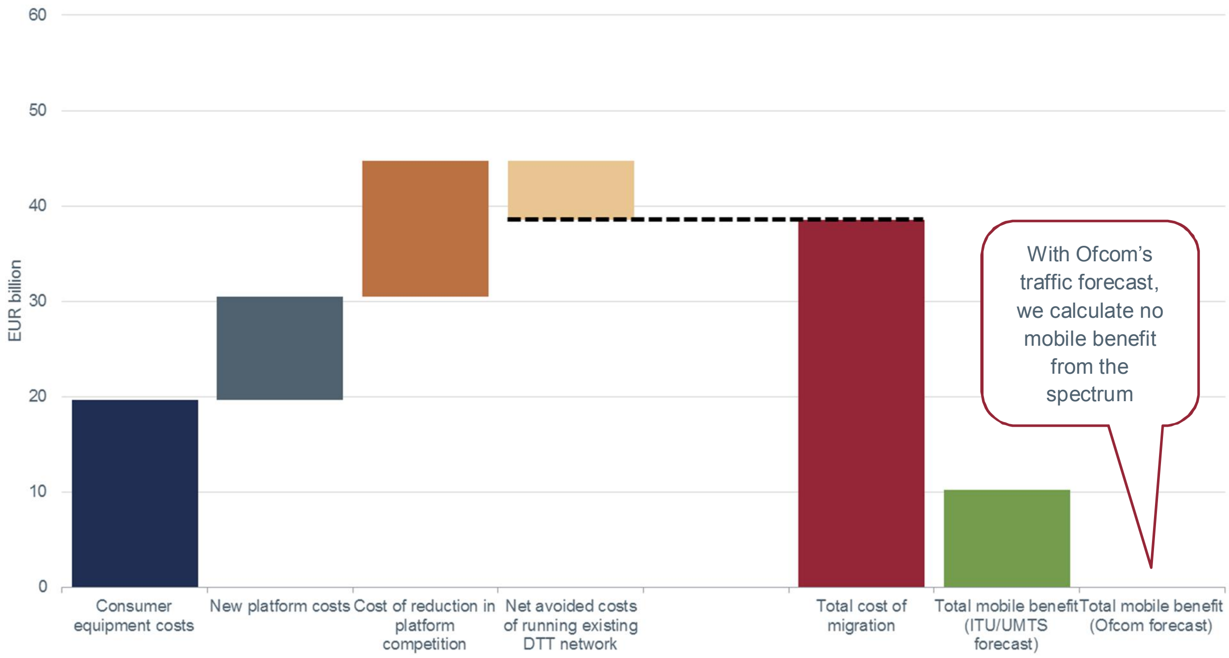
1 Aetha Consulting report for the GSM Association, 'Economic benefits from making the 2.7–2.9GHz band available for mobile broadband services in Western Europe', June 2013.

2 Ofcom, 'Consultation on future use of the 700MHz band – cost-benefit analysis of changing its use to mobile services', 28 May 2014.

2.3 Results of our quantitative assessment

In comparing the cost of migrating DTT viewers to alternative platforms with the benefits arising from clearing the entire 470–694MHz band for mobile services, we note that the **costs outweigh the benefits by a factor of almost four** (when using the ITU/UMTS-based traffic forecast), as shown in Figure 2-3 below.

Figure 2-3: Comparison of costs of migration of DTT to alternative platforms with benefits of making the 470–694MHz band available for mobile broadband [Source: Aetha]



It is clear that the economic benefits for the EU are maximised if the 470–694MHz band continues to be used for DTT for at least 15 years – on the grounds of spectral efficiency, **there is clearly no economic case for switching-off existing DTT networks across Europe**. Furthermore, as indicated earlier, the costs of DTT migration are likely to be an underestimate of the true costs, as our assessment does not consider the value lost from displacing other users of the band such as PMSE, radio astronomy and 'white space' applications.

2.4 Conclusions and recommendations

Our assessment has clearly demonstrated that, on current trends, the economic benefits are maximised for EU citizens if the 470–694MHz band continues to be used for DTT (as well as compatible uses such as PMSE, radio astronomy and white space applications) over the next 15 years. The costs associated with providing linear broadcast television services to all EU households in the absence of the DTT platform are many multiples of the benefits that would arise from making the 470–694MHz band available for mobile services. In summary, the digital terrestrial platform remains key for the cost effective delivery of linear broadcast content to EU consumers and use of the 470–694MHz band is a critical element of the platform.

Whilst Aetha normally encourages the removal of any unnecessary technology and service restrictions applying to spectrum, in this particular instance we are concerned that the introduction of a co-primary allocation for 470–694MHz spectrum to mobile at WRC-15 (in ITU Region 1) could risk undermining investor confidence in the future of the DTT platform, particularly in view of the history of previous allocations in the UHF band. Specifically, the historic re-purposing of DTT spectrum for mobile use following co-primary allocations being made to mobile at WRC-07 and WRC-12 could raise expectations that 470–694MHz spectrum could be taken away from DTT in the event that a co-primary allocation is made at WRC-15. This would be an inappropriate message to send to both the investment community and wider public at a time when investment in the next generation of digital broadcast technology (for example in DVB-T2 technology) by both network operators and consumers needs to be encouraged. As such, a co-primary allocation to mobile at WRC-15 would have considerable negative impacts on DTT. This would lead to the DTT platform falling behind other television platforms and even unnecessarily risk its viability, with little or no benefit to be derived. Consequently we recommend that European national administrations do not support making a co-primary allocation to mobile at WRC-15.

Whilst it is true that there is a lead-time between spectrum being identified for mobile services at a WRC and the spectrum becoming available for use, a delay in considering a co-primary allocation for mobile in the 470-694MHz band to a subsequent WRC is likely to be compatible with the timescale over which the spectrum might yield material economic benefits. As such, we would agree with the Lamy recommendation for a review by 2025, as proposed in his report to the European Commission regarding the results of the work of the High Level Group on the future use of the UHF band[3].

[3] Pascal Lamy, Report to the European Commission, 'Results of the work of the High Level Group on the future use of the UHF band (470–790 MHz), 1 September 2014.

3 Introduction

This report, commissioned by a consortium of organisations from the Digital Terrestrial Television (DTT) sector – consisting of Abertis Telecom Terrestre, Arqiva Limited, British Broadcasting Corporation, Broadcast Networks Europe, European Broadcasting Union and TDF SAS – examines options for the future use of 470–694MHz spectrum in Europe and assesses which option maximises the economic and social value over a 15-year timeframe. Based on this analysis, this report also discusses whether granting co-primary status to mobile in this band at the next World Radiocommunication Conference, WRC-15, is warranted.

3.1 Background

The switchover to digital television in the European Union (EU) has been a huge success – in particular the DTT platform has provided European viewers with a significantly improved service in respect of a substantial increase in the content (number and types of television channels available) and improved reception/signal quality.

All this has been achieved at the same time that some of the frequencies previously used for the transmission of analogue television services have been made available for the deployment of mobile broadband technologies. Specifically the 800MHz band (790–862MHz) is enabling the cost-efficient deployment of LTE technology in rural areas, as well as providing deep indoor coverage.

This 'win, win' situation was possible as a result of the significant spectral efficiency benefits from moving from analogue to digital terrestrial television – typically 8–12 television channels (standard definition) are carried digitally utilising the spectrum previously required for just one analogue television channel. However, we are now in a situation where there is further demand for more low-frequency spectrum by the mobile industry. Although DTT technology continues to evolve, it is unlikely that a similar step-change in spectral efficiency, as occurred during the digital switchover, will arise again. Consequently, governments and regulators need to make decisions on whether or not to remove capacity from the DTT service in favour of making additional spectrum available for the mobile service.

WRC-12 resulted in a decision to grant a co-primary allocation to mobile in the 700MHz band (694–790MHz), although this will not come into effect until after WRC-15. As a consequence of this decision, a number of European countries, including Finland, France, Germany, the Netherlands, Portugal, Sweden, and the UK, have announced that they plan to/are likely to make this band available for mobile services in the latter part of this decade.

There is increasing interest from the mobile industry in making additional spectrum, including even more low-frequency spectrum (i.e. below 1GHz), available for mobile services. As a consequence, there is a proposal for WRC-15 to consider giving mobile co-primary status in the 470–694MHz range. Given past developments, there is a possibility that this could eventually lead to governments/regulators re-allocating spectrum in this range from DTT to mobile.

The loss of any additional spectrum is likely to substantially impact the services that are available on the DTT platform. Given that in several countries the platform already operates at a capacity disadvantage to rival platforms, including satellite and cable, this could undermine the DTT platform's entire viability.

Additionally, the DTT platform may require additional spectrum in order to evolve (for example, to support Ultra High Definition services). The European Commission's spectrum inventory[4] identified that demand for future spectrum usage was at the same level for both the broadcast industry and the mobile industry in the short-term, medium-term and long-term.

DTT is not the only user of spectrum in the 470–694MHz range:

- The Programme Makers and Special Events (PMSE) community use this spectrum for applications such as radio microphones, talkback, in-ear monitors and other audio links, which are a critical element of television productions, theatre productions, outside broadcasts, and major concerts and sporting events. Today, devices are only available for these applications in 470–694MHz. Therefore, if this spectrum was awarded to mobile, there is currently no alternative solution available.
- White Space Devices (WSD) proponents, a new application that could provide a range of potential services, are preparing to use this spectrum.
- The radio astronomy community uses this spectrum for the study of celestial objects at radio frequencies.
- Each of these services uses the interleaved spectrum between DTT transmissions. Therefore, any decision to allocate 470–694MHz spectrum to mobile services would have substantial impacts on these services as well as DTT.

3.2 Objectives of this report

The objectives of this report are as follows:

- To investigate the socio-economic benefits and costs of migrating DTT viewers to alternative broadcast platforms and using 470–694 MHz spectrum for mobile over the period 2015 to 2029 in comparison to the continued use of this spectrum for DTT (and the other existing services)
- Based on the results of this analysis, to investigate the implications if mobile was given co-primary status in the 470–694MHz band at WRC-15, and conclude whether this is warranted.

The intention is that the report's results and conclusions will be used to inform the debate that is occurring both at the European level and in several individual member states on the future use of spectrum in the 470–694MHz range and the nature of broadcast television delivery.

3.3 Structure of this report

The remainder of this report is structured as follows:

- Section 4 discusses the relevance of linear television in the 'internet age'
- Section 5 introduces scenarios of alternative uses of the 470–694MHz band in the future
- Section 6 summarises the approach and results of our calculated cost of migration (a more detailed explanation can be found in Annex A)

4 European Commission, 'Report from the Commission to the European Parliament and the Council on the Radio Spectrum Inventory: COM(2014) 536 final', 1 September 2014.

- Section 7 summarises the approach and results of our calculated economic benefit of the spectrum for mobile (a more detailed explanation can be found in Annex B)
- Section 8 presents the overall results of our economic assessment
- Section 9 discusses the implications of making a co-primary allocation to mobile at WRC-15
- Section 10 presents the overall conclusions of our study.

4 The relevance of linear television

Despite the growth of on-demand viewing in recent years, linear television in the EU has maintained strong viewership and remains the clear primary means of viewing audio-visual content. This is shown in Section 4.1. In Section 4.2 we then explain why this position will be maintained over the period being considered by this study, and in Section 4.3, why linear television is most efficiently delivered by broadcasting means. We then explain in Section 4.4, the implications of these findings with regards to the relevance of broadcast television.

For the avoidance of doubt, we define linear television as any programming content that is transmitted one-to-many (broadcast), such that households receive it simultaneously. Live television is any content that is transmitted at the same time as the content is produced – but not necessarily linearly. This is an important distinction since linear television is of importance to both live and non-live content.

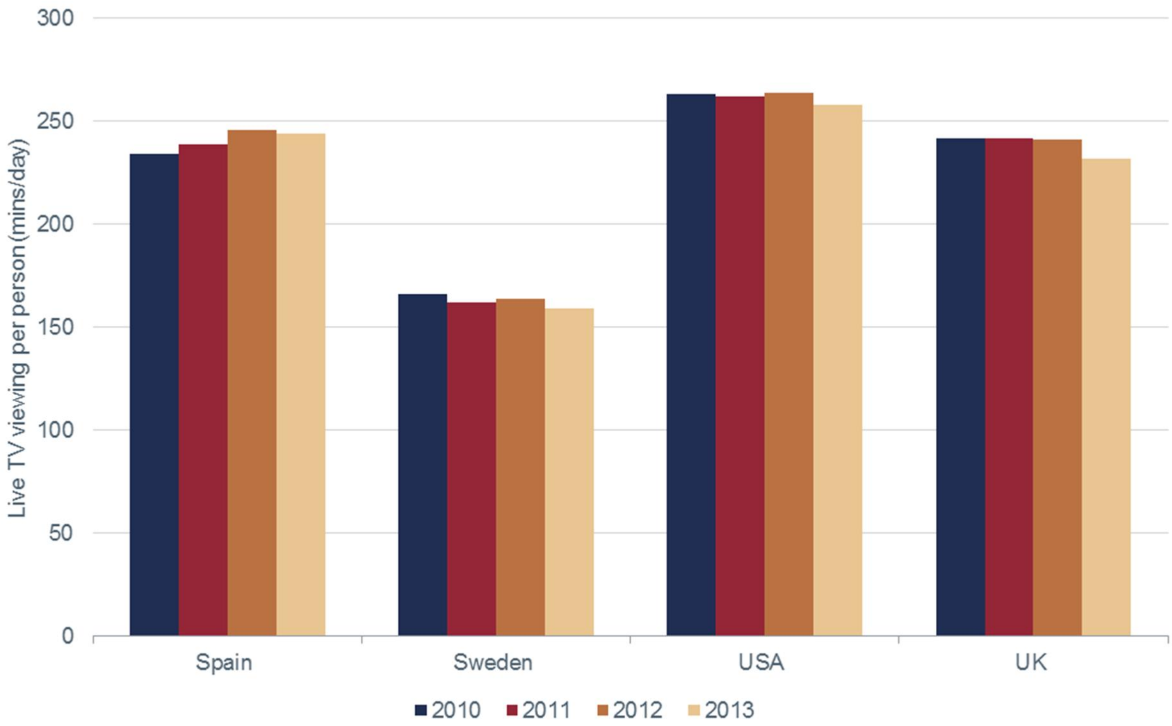
4.1 Trends in linear television viewing

In this section, we firstly show that despite the growth of on-demand services, the viewing figures for linear television have remained stable over recent years. Rather than substituting their linear viewing, consumers are instead supplementing it. In fact, the rise of on-demand services has instead served as an alternative to traditional pre-recorded formats such as DVDs.

4.1.1 The role of on-demand viewing

There is a misconception that the rise of on-demand content has been accompanied by a decline in linear television viewing, however the evidence does not support this. Viewing figures for linear television have remained relatively stable over recent years – with some markets such as Spain even registering an overall increase in viewing over the period as a whole, as shown in Figure 4-1 below.

Figure 4-1: Average linear television daily viewing per person [Source: Barlovento Comunicacion (Spain), MMS (Sweden), Ofcom (UK), Nielsen (USA)]



In a report by the UK regulator Ofcom published in 2013[5], 10 of the 15 countries in its study showed year-on-year increases in daily viewing minutes per person, with a total average of 222 minutes in 2012. Whilst viewing figures in 2012 may have been boosted by events such as the Olympic Games, it is clear that there is no strong decline in linear television viewing as has been suggested by some commentators in public meetings, conferences and industry workshops.

Linear television viewing in the EU does not seem to have been materially affected by the rise of on-demand services. In fact, linear television accounts for as much as 90% of overall viewing in the UK according to a recent survey conducted by Thinkbox[6]. In the same survey, it was found that even among the heavy on-demand viewers in the research sample, 60% typically checked what was on the linear television schedule first before considering other options. The fact that so many people choose to watch linear television in spite of the ever increasing alternatives, implies an inherent value to be gained from the availability of pre-scheduled content.

Linear television remains the staple of consumers' viewing habits, whilst on-demand complements this consumption. This is demonstrated clearly in Figure 4-2 below – since 2005, non-linear television viewing has grown on top of a stable base of linear viewing, which continues to constitute the vast majority of viewing. We note that this trend is also discussed in the Lamy report[3].

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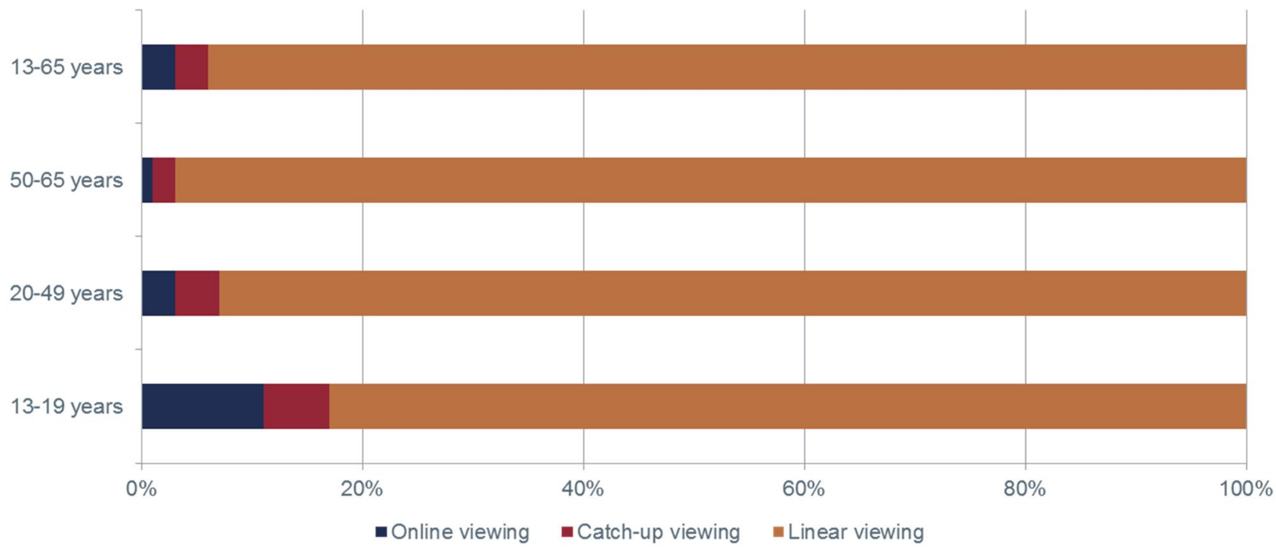
[5] Ofcom, 'International Communications Report', December 2013; countries in the study included UK, France, Germany, Italy, US, Canada, Australia, Spain, Netherlands, Sweden, Ireland, Poland, Brazil, Russia and China.

[6] Thinkbox, 'Screen Life: TV in Demand', 2013.

Figure 4-2: Evolution of linear and non-linear television viewing as an average of consumption in the EU 'Big 5' (France, Germany, Italy, Spain and the United Kingdom) [Source: IHS – ScreenDigest: Cross-platform television viewing time FY 2012]

Even for younger audiences, for whom on-demand and time-shifted viewing is highest, linear television dominates, as illustrated in Figure 4-3 below.

Figure 4-3: Online, catch-up and linear television viewing as a proportion of total viewing [Source: EBU BroadThinking 2013]

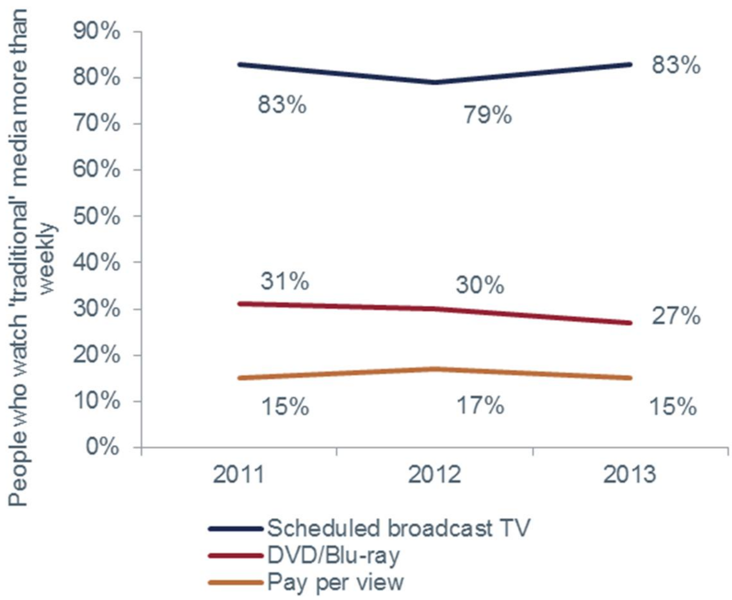


4.1.2 The decline of pre-recorded formats

As we have shown so far, the rise of on-demand services has not cannibalised linear viewing but complemented it. Instead, the evidence shows that the popularity of traditional pre-recorded formats has decreased due to the success of on-demand services.

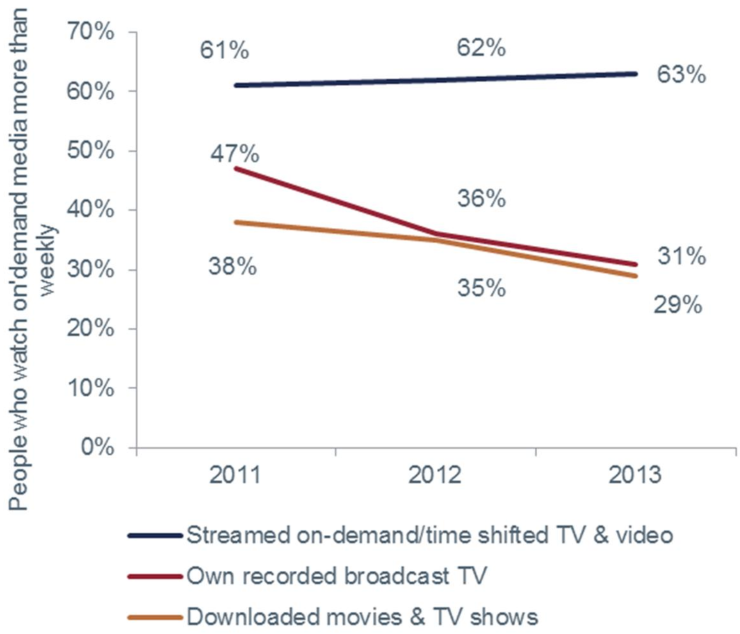
The two charts below illustrate the results of research undertaken by Ericsson.[7] They show that over the last two years both own-recorded television viewing and DVD/Blu-ray consumption has declined considerably, whilst scheduled linear television viewing has held steady.

Figure 4-4: Viewing habits of people who watch 'traditional' media more than weekly [Source: Ericsson ConsumerLab TV and Media study 2013 Base: US, UK, Germany, Sweden, Spain, Taiwan, China, South Korea and Brazil]



[7] Ericsson, 'ConsumerLab TV and Media Study', August 2013.

Figure 4-5: Viewing habits of people who watch on-demand media more than weekly [Source: Ericsson ConsumerLab TV and Media study 2013 Base: US, UK, Germany, Sweden, Spain, Taiwan, China, South Korea and Brazil]



In essence, on-demand services such as Netflix and various catch-up services have had the greatest impact on video/DVD viewing, rather than on linear television viewing. These physical formats, which allow the consumer to view content in their homes and according to their own schedule, have thus been superseded by downloadable and streamable alternatives, which have enabled more immediate access to a huge library of content.

Notably, however, whilst online video platforms such as Amazon and Netflix are now beginning to invest in their own original series, the majority of content that is viewed on their services continues to comprise shows first popularised on *linear television*.

4.2 The future of linear television

In this section we demonstrate why it is likely that linear television will continue to remain the predominant means of viewing in years to come.

4.2.1 Linear television and live content

Content such as sports and news is inherently live, such that much of its value is derived from being able to view it in real-time. By definition, such content is therefore necessarily viewed simultaneously by many viewers – this lends itself to linear transmission.

Such live content forms a significant proportion of linear programming, and furthermore proves to be very popular. As shown in the table below, all 10 of the most-watched programmes in 2012[8] in the UK were live, and six out of 10 in 2013[9]. Notably, entertainment and sport (particularly given the timing of the London Olympic Games and the EURO 2012 football championship) feature prominently in this list.

[8] Ofcom, 'The Communications Market 2013', Chapter 2 ('Television and audio-visual'), 1 August 2013.

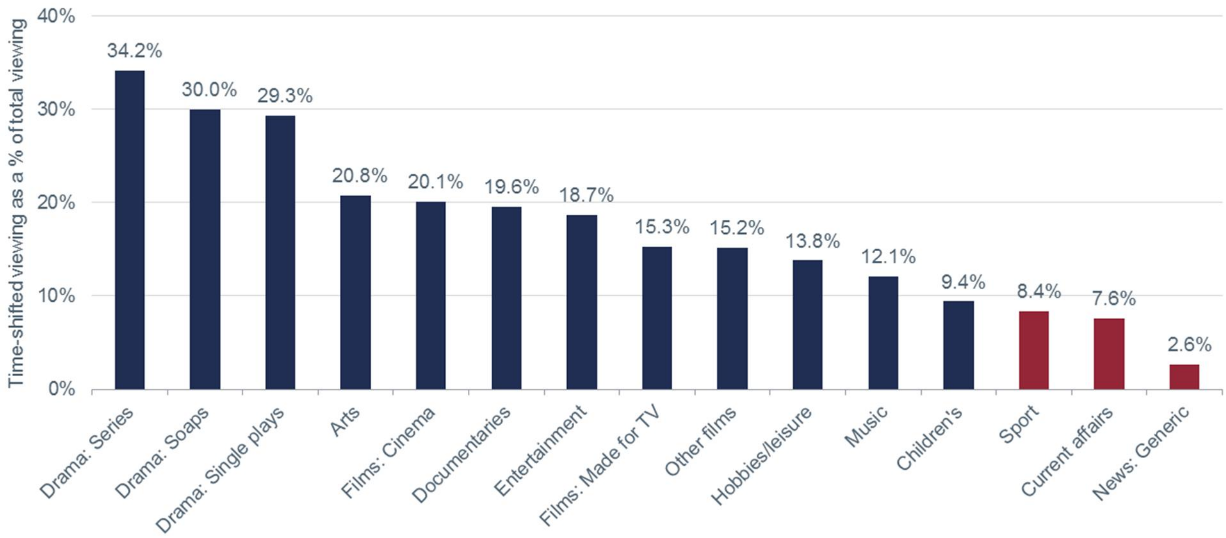
[9] Ofcom, 'The Communications Market 2014', Chapter 2 ('Television and audio-visual'), 7 August 2014.

Figure 4-6: Most-watched programmes in 2012 and 2013 in the UK [Source: BARB/InfoSys+]

	2012 Programme title	Genre	Delivery	Audience (millions)
1	OLYMPICS 2012: CLOSING CEREMONY	Sport	Live	24.5
2	OLYMPICS 2012: OPENING CEREMONY	Sport	Live	24.2
3	EURO 2012: ENG V ITA	Sport	Live	20.3
4	OLYMPICS 2012: MEN'S 100M FINAL	Sport	Live	17.3
5	EURO 2012: ENG V UKR	Sport	Live	16.2
6	THE DIAMOND JUBILEE CONCERT	Music	Live	15.3
7	EURO 2012: SWE V ENG	Sport	Live	14.3
8	OLYMPICS 2012: ATHLETICS (INC. MEN'S 100M SEMI-F)	Sport	Live	13.6
9	STRICTLY COME DANCING: FINAL	Entertainment	Live	13.4
10	STRICTLY COME DANCING: THE RESULTS	Entertainment	Live	13.4
	2013 Programme title	**Genre**	**Delivery**	**Audience (millions)**
1	NEW YEAR'S EVE FIREWORKS	Entertainment	Live	13.5
2	I'M A CELEBRITY GET ME OUT OF HERE!	Entertainment	Live	13.0
3	DOCTOR WHO	Drama	Pre-recorded	12.8
4	STRICTLY COME DANCING: THE RESULTS	Entertainment	Live	12.8
5	STRICTLY COME DANCING	Entertainment	Live	12.4
6	WIMBLEDON 2013: MEN'S FINAL	Sport	Live	12.3
7	STILL OPEN ALL HOURS	Entertainment	Pre-recorded	12.2
8	BRITAIN'S GOT TALENT	Entertainment	Live	12.2
9	DOWNTON ABBEY	Drama	Pre-recorded	11.7
10	MRS BROWN'S BOYS	Entertainment	Pre-recorded	11.5

Despite the prominence of sport on linear platforms in 2012, the genre features only once in the top 10 iPlayer catch-up programmes of that year.[10] Sport is thus an example of an extremely popular content genre that is predominantly watched live – just 8.4% of sport viewing by UK individuals aged 4+ and owning a digital video recorder (DVR) was time-shifted in 2012. Indeed only current affairs and news surpass sport in this measure, as shown in Figure 4-7 below.

Figure 4-7: Proportion of time-shifted viewing, by programme genre [Source: BARB/InfoSys+]



[10] TV Licensing, 'Telescope – A look at the nation's changing viewing habits from TV Licensing', 2013.

Entertainment shows have increasingly made use of live broadcasts with viewer participation becoming a key element of the show (for example viewers voting for their favourite contestant). Such direct viewer involvement in determining the content of the show (for example the Eurovision Song Contest concludes with a second performance by the winner of the contest, with voting taking place during the show) can only occur if viewers are watching the show at the same time.

The continued prominence and value of live content is demonstrated by the increasing sums of money that broadcasters are willing to invest in sports content (56% of total UK multichannel content investment in 2012 was by sports channels), entertainment (25%) and news (9%).

Live content therefore forms not only a significant proportion of television programming in terms of hours, but also in terms of commercial value. For such high-value content which is necessarily viewed simultaneously, linear television presents an efficient means of delivery.

4.2.2 Linear television and social viewing

Even for content that is not live, viewers derive a social benefit from the simultaneous viewing that is afforded by linear television. Indeed, as shown in Figure 4-6, pre-recorded programmes, and in particular drama series such as Downton Abbey prove hugely popular on linear platforms. Historically, a variety of shows (drama, soap operas and other forms of entertainment) have created a 'social buzz' around the show. Typically such discussions took place both at home and in the workplace ('water cooler' discussions), but more recently the growth of social media has made this effect stronger, as viewers are able to extend this shared viewing experience outside of their living rooms and workplaces.

Linear television creates shared viewing experiences

Social media and linear television generate mutual benefits. Whilst social viewing is not exclusive to social media, the rise of such communications has increased the importance of linear viewing, since social media discussions are dependent upon simultaneity. In turn, social media has helped to increase the degree of immediacy for popular television shows, since to participate in the discussion one must be watching at the same time as other people.

In fact, this has been somewhat *strengthened* by on-demand content. Previously, programmes involving long, multi-year story arcs would suffer from diminishing audiences where those who missed out could not easily catch up with those viewing the initial broadcasts. With the content available on-demand, viewers can now catch up and in the process re-join the live viewers and the social benefits this may confer.[11]

This is supported by recent evidence suggesting that young people are more than happy to wait, in order to share their viewing experiences with others – in a UK survey by Thinkbox[6], 28% of viewers aged 18–24 said their viewing was in order to connect with other people – almost double the average from the wider research sample. Furthermore, when given a choice between having the option to download a new series they liked in one go or waiting to watch it week by week on linear television, 73% of 18–24 year olds said they would prefer to wait, compared to 57% for the older audience of 35–55. It was also found that 54% of linear television was watched with another person, compared to 30% for video-on-demand.

This shared viewing has been acknowledged by shows that have moved from online platforms to television networks. The producer of Recipe Rehab, which moved from YouTube to a syndicated spot on ABC in the

[11] Reuters Institute for the Study of Journalism, Joshua Gans, 'Television Wants to be Shared', September 2013.

USA, recently quoted the reasons for this move, to "aggregate the biggest audiences possible, (...) and allow marketers to communicate with them".[12] Content providers therefore seek a collective experience with their public that no number of individual 'views' can replace.

Multi-screen activity facilitates social viewing

Mobiles, tablets and laptops are now becoming part of the home television setup, since they not only allow social interaction through discussion of television content, but also enable internet multitasking whilst viewing. Social networking sites and forums are used on a weekly basis by 59% of people while watching television, while almost one in three will discuss what they are currently viewing over social networks or chats.[13] The second screen therefore serves to amplify rather than distract from the viewing experience.

Interestingly, therefore, as multi-screening activities becomes more prevalent, the triggers to linear viewing actually become more compelling. In particular, this is driven by individuals not wishing to miss out on the social buzz around linear content.

4.2.3 Linear television and advertising

Television is still the dominant advertising medium, attracting 40% of global advertising spend in 2013, nearly double that of the Internet (21%). Furthermore, television advertising spend is also forecast to grow by 5.2% in 2014, up from 4.4% in 2013.[14] This suggests that linear television continues to provide an effective means of reaching mass audiences.

4.3 Means of delivering simultaneous content

Linear television continues to be the most effective means of delivering simultaneous content. It is costly and impractical to expect many viewers to stream a programme simultaneously online, as bandwidth can still be constrained.

Telecoms networks are not currently designed to cope with the simultaneous demand that comes with major television events – as demonstrated by a number of high-profile failures of streaming services such as Sky's Now TV, which crashed in response to the huge demand generated by the Game of Thrones Season Four opener[15], as well as ITV Player's live coverage of the World Cup, which saw the service crash during the showing of the tournament's opening match between Brazil and Croatia[16].

4.4 Implications

In this section, we have shown that despite the growth of on-demand viewing, linear television viewing levels have remained steady over recent years. Whilst replacing traditional pre-recorded formats such as DVDs, on-demand viewing has therefore acted as a supplement, rather than a substitute, to linear viewing.

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12 Huffington Post, 'TV Is Dead: Long Live TV', July 2013.

13 Thinkbox, 'Screen Life: The View from the Sofa', 2013.

14 Advertising Expenditure Forecasts, ZenithOptimedia, September 2013.

15 Cnet, 'Game of Thrones fans fuming again as another streaming service crashes', 8 April 2014.

16 The Guardian, 'ITV Player problems hit World Cup opening match coverage', 13 June 2014.

Furthermore, we expect the importance of linear television to continue in the future due to two main reasons. Firstly, a significant proportion of content such as sport and news is inherently live and therefore lends itself to linear distribution. Secondly, the simultaneity of viewing has become an integral part of the new socially integrated consumption of shows (live and non-live) which necessitates linearity for social media discussions. As such, we are seeing an increased appeal for linear content, resulting from the increasing numbers of people using 'second screens' to partake in the 'social buzz' surrounding programs they are viewing on their main television sets.

We therefore conclude that linear television will continue to play a relevant role in the continually evolving television market for many years to come. There are of course many ways to deliver linear television, including by both broadcasting and streaming platforms. However, it is clear that due to the capacity limitations of streaming platforms, broadcasting platforms (DTT, satellite and cable) will continue to be the most appropriate means of delivery for at least the next 10–15 years. Therefore the relevant questions that policy makers should be considering are:

1) Which are the appropriate broadcast platforms for providing linear television?
2) What benefits does continuing with the DTT platform bring over and above the others?

These are questions that the remainder of this report will seek to answer.

5 Alternative scenario for future use of 470–694MHz spectrum

In Section 5.1, we define our alternative scenario for the future use of the 470–694MHz band which forms the basis of our economic assessment. In Section 5.2, we then consider the benefits and costs that would apply relative to the continued use of the 470–694MHz band for DTT.

5.1 Alternative scenario for the delivery of broadcast television

As discussed in Section 4, we expect the demand for linear television to remain strong for (at least) the next 10–15 years. A key consideration therefore, is determining the most efficient means of delivering this content to consumers. In particular, if the 470–694MHz spectrum was made available for use for mobile broadband services and therefore not for the delivery of linear content via the DTT network, by what other means would linear television be delivered? Furthermore, we aim to consider how much such an alternative approach would cost compared to the current cost of operating, maintaining and upgrading existing DTT networks.

In alignment with the views of members of the High Level Group, as discussed in the Lamy report[17], we believe that the principal future scenario is based on platform co-existence, rather than a converged broadcast-broadband platform. As such, we have identified the migration of DTT viewers to alternative platforms as the main alternative scenario for the future delivery of linear broadcast services in the event that the 470–694MHz band was no longer available to support DTT networks. In this scenario, linear television is delivered to households through alternative existing platforms including satellite, cable television and, increasingly over time, IPTV. As much of DTT viewing is provided on a free-to-view basis, households currently receiving DTT services need to continue to be able to receive linear television on a free-to-view basis over these alternative platforms. Whilst we expect that the vast majority of existing services (national television programmes, regional television programmes) could be made available to households on these alternative platforms, it is possible that, without some form of intervention, it may not be economically viable to fully replicate all content (for example it may not be cost-effective to replicate local television content on a free-to-view satellite platform) so there could be some loss of consumer benefits. Additionally under this scenario, the broadcast industry has lost an entire delivery platform and the ensuing reduction in platform competition could result in the wholesale prices for delivery of broadcast content increasing. For example, in some locations, satellite would become the only broadcast delivery platform and this may provide an opportunity for the operators of the satellite platform to exercise less price discipline than was previously the case.

Note that in this study we have not considered options for part re-allocation of 470–694MHz to mobile, for example a new '600MHz band'. This is because we do not detect that there is any appetite for further 'salami slicing' of the UHF band, given the amount of time and effort that is required to enable this to occur (both from a political/negotiating perspective in respect of the extensive international co-ordination that would be required and also in relation to the costs and time it would take to migrate individual DTT transmitter sites onto new frequencies, which would be required on a widespread basis across the EU in order to ensure a fair distribution of the available spectrum across the member states). Furthermore:

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17 Pascal Lamy, Report to the European Commission, 'Results of the work of the High Level Group on the future use of the UHF band (470–790 MHz)', 1 September 2014.

- The creation of 32MHz of spectrum in a new mobile sub-band (which is the approximate amount that could be made available if DTT services operated with one fewer multiplex) is unlikely to be sufficient in terms of the amount of spectrum or in relation to the value of economic benefits that would arise, for the mobile industry to be interested in given the intensity of work required to internationally harmonise the band. It would however reduce the number of DTT channels which could be offered, thereby detrimentally affecting the attractiveness of the platform.

- The inclusion of 72MHz (plus a duplex gap) of spectrum in a mobile sub-band (the minimum amount that is likely to be of interest to the mobile industry) plus required guard bands would result in the loss of approximately two or three multiplexes on the DTT platform. This would, in many countries, result in a substantial reduction in the platform capacity and the number of television channels that could be supported. This would mean that the DTT platform is no longer viable in respect of there being a minimum amount of content available for it to be considered as a credible alternative to satellite and cable by consumers.

Under this alternative scenario, the DTT platform therefore would no longer exist and the entire 470–694MHz band would become available for use for mobile services.

5.2 Benefits and costs under alternative scenario

The potential costs associated with migrating DTT viewing to alternative platforms are as follows:

- **One-off customer premises equipment (CPE) costs** faced by consumers in migrating to alternative platforms. Such costs would include satellite dish and set-top box purchases and installation.

- **Upfront and on-going costs of providing content on alternative platforms**. This includes the cost of satellite transponders to carry the free-to-view channels currently available on the DTT platform.

- **Competitive impact of fewer competing platforms**. DTT viewers are migrated to alternative platforms and the DTT network shut down, which, as discussed earlier, could lead to less competitive pressure in the wholesale market for broadcast content distribution and a potential increase in these costs to broadcast organisations.

- **Spectrum not available for Programme Making and Special Events users**. In the event of the DTT platform being decommissioned, interleaved spectrum would no longer be available for PMSE use. It is not clear which frequencies PMSE users would migrate to and consequently we have not sought to quantify this cost in this study, although we note that this cost of migration is unlikely to be trivial.

- **Spectrum not available for white space applications**. As is the case with PMSE, this application is dependent on the availability of interleaved spectrum. Consequently the shutting down of the DTT network would result in a loss of white spaces. It is possible that alternative frequency bands could be found for these applications. However since details of alternative frequency bands are not known and the benefits of white space applications are highly uncertain at this time, we conclude that it is impractical to quantify this loss in this study.

- **Spectrum not available for radio astronomy**. Radio astronomy currently uses certain frequencies within the 470–694MHz band (e.g. Channel 38 in the United Kingdom). The loss of this spectrum could therefore be harmful to this area of research. It is not however practical to quantify this loss.

- **Loss of access to local television services**. We believe it is likely to be uneconomic to replicate local television services on satellite and cable platforms. This would mean that households lose the benefits they currently gain from this service being available on the DTT platform. We note that in many EU member states, DTT is the sole platform for providing such local television content[18], thus the loss of the platform could represent a sizeable loss in television advertising revenues in countries such as Spain and Italy with a high proportion of local channels. We have not sought to quantify this cost given that the loss of benefits from local television is very uncertain.

- **Losses due to consumers' preference for DTT**. Despite the assumption that the viewing experience will be replicated, some consumers may have a personal preference for DTT over alternative platforms such as satellite – e.g. consumers who may dislike having a satellite dish on their homes for aesthetic reasons. The cash cost of such consumers acquiring satellite dishes is considered in our quantitative assessment, however the cost associated with the reduction in utility for these consumers is excluded from our quantitative analysis as the extent of this is highly uncertain.

- **Damage to social inclusion and universal access**. The loss of the DTT platform could potentially result in a reduction in social inclusion and universal access in the event that free-to-view services would not be available to all households. We assess the cost of replicating both the DTT service offering and its coverage. Consequently we assume any damage to social inclusion and universal access is limited and thus do not consider further costs related to it in our quantitative assessment.

- **Reduction in free-to-view television's ability to constrain pay-television prices**. The absence or reduction in the capability of free-to-view television services could provide pay-television providers with an opportunity to increase prices. However, we consider the cost of replicating existing free-to-view services and therefore the offering to consumers is largely unchanged at the retail level (with the possible exception of availability of local television channels). Consequently, such price increase opportunities should generally not arise. Therefore, we do not consider this issue further in our quantitative assessment.

The potential benefits arising from making 470–694MHz spectrum available for alternative uses including mobile include:

- **Consumer benefits from mobile operators having access to all spectrum in the 470–694MHz band** for the provision of mobile broadband. In the event that traffic growth on mobile networks is high, mobile operators would benefit from having access to additional sub-1GHz spectrum. This would allow them to provide additional capacity on existing base station sites rather than having to deploy incremental sites, which is extremely costly. In a competitive market, these cost savings should be passed onto consumers in the form of lower prices, which in turn could lead to increase take-up and usage of the services.

- **Spectrum available for other mobile broadband uses e.g. Public Protection and Disaster Relief (PPDR).** The released spectrum in the 470–694MHz range could be used for other mobile broadband applications, such as for PPDR. However, our current understanding is that the requirements of the PPDR community are either likely to be met using spectrum from within the 400MHz and/or 700MHz ranges or alternatively through the acquisition of services from commercial mobile network operators. Consequently, we do not consider this benefit further in this study.

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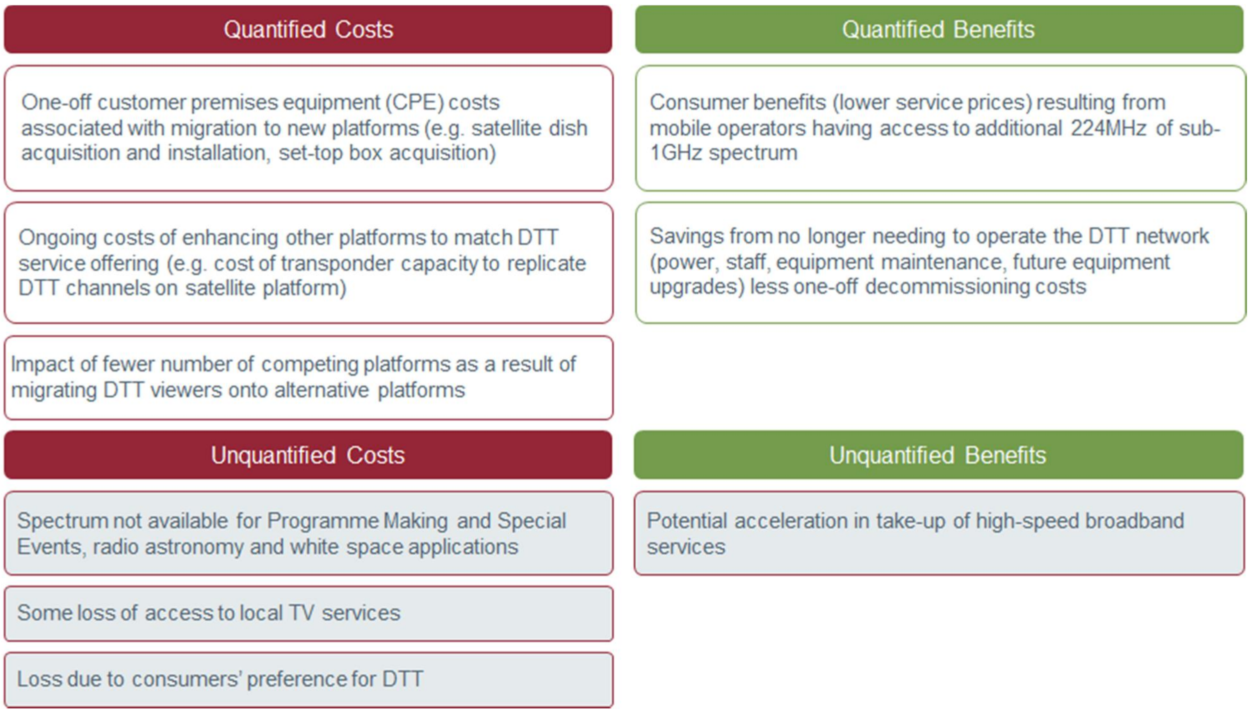
[18] European Commission Press Release, '2010 a milestone year for DTT in Europe', October 2010.

- **Savings from no longer needing to operate DTT networks less one-off decommissioning costs**. DTT networks across Europe will no longer need to be operated, resulting in on-going savings in power, staff costs, maintenance and future planned network enhancements. However some one-off costs would be incurred in decommissioning the existing infrastructure where this is not used for the provision of other services (e.g. broadcast radio). We consider the net cost savings as part of our quantitative assessment.

- **Potential acceleration in take-up of high-speed broadband services**. The shutdown of the DTT platform could lead to some households choosing to obtain television services over a high-speed broadband platform (i.e. actively choose IPTV over other available alternatives such as satellite and cable) which in turn could mean that the adoption rates of high-speed broadband services could be higher than otherwise might have been the case. In our economic assessment we assume that migration from DTT will generally be to a free-to-view satellite platform as this is likely to be the least cost alternative to DTT in the event of a large scale migration[19].

A summary of the benefits and costs that we consider further in this study are shown in Figure 5-1 below. The figure also highlights those benefits and costs that we have quantified in this study.

Figure 5-1: Costs and benefits associated with migration of DTT viewers to alternative platforms



[19] We do however assume a certain proportion of households in each country will not be able to migrate to satellite (for example because they cannot receive a satellite signal) and in these cases assume that migration will be to either cable or IPTV. Further details of these assumptions can be found in Section 6.1.1.

6 Cost of migration of DTT to alternative platforms

In this section, we summarise our approach to the calculation of the costs of ceasing DTT transmissions and migrating viewers to alternative platforms. In Section 6.1, we discuss our overall approach and the components of our cost calculation. In Section 6.2 we then present a summary of the overall results for the EU-wide cost of migration. Note that this section provides only a summary of our approach and results – for a more detailed explanation of the inputs and methodology used in our calculation, see Annex A.

6.1 Approach

As detailed in Section 5, we have considered two scenarios for the future use of the 470–694MHz band as follows:

Scenario 1) The whole band continues to be used for the provision of DTT. No spectrum in the band becomes available for mobile services.

Scenario 2) DTT transmissions cease and consumers are migrated to alternative platforms (a mixture of satellite, cable and IPTV). All 224MHz of spectrum in the band becomes available for mobile services.

Our economic assessment thus aims to quantify the incremental costs and benefits arising under Scenario 2, when compared to Scenario 1. In doing so, we make a number of key assumptions. Firstly, we assume that all national and regional DTT services are fully replicated on the platforms to which consumers are migrated, such that there is no change in the services offered to viewers[20] and no change in the current obligations of broadcasters in respect of content creation and funding. This is an important assumption, as we do not then consider effects resulting from impacts on the European content production industry, nor any losses in terms of the social benefits currently provided by the DTT platform.

Our modelling is based on calculating the net present value (NPV) in 2015 of the various benefits and costs over a 15-year period (2015–2029), utilising a social discount rate of 3.5%[21]. By considering a net present value of the total incremental benefits and costs we can ascertain whether a migration to alternative platforms or the continued use of the whole band for DTT is likely to result in more economically efficient use of 470–694MHz spectrum. In a case where the benefits outweigh the costs, this means that the migration represents a more efficient solution than continuing with DTT; whereas in a case where the costs outweigh the benefits, continued use of the 470–694MHz band for DTT is the most economically advantageous approach.

Our initial investigations revealed that the additional costs of migrating to alternative platforms outweighed the benefits of using the 470–694MHz band for mobile services. In order to ensure this outcome was ‘robust’ under a range of assumptions, we have sought to make assumptions that will tend to underestimate the costs of migration whilst possibly overestimating the benefits of making spectrum available for mobile broadband use. Our calculation of benefits is therefore deliberately an upper bound estimate, whilst the calculation of costs should be considered to be a lower bound.

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20 With the exception of local TV channels.

21 D. Evans, ‘Social discount rates for the European Union’, 31 October 2006.

As an example of this, we have assumed that the 470–694MHz band could be made available for new uses from 2018 across Europe at the same time as the 700MHz band (which also aligns with the earliest date of 2020±2 for the clearance of the 700MHz band proposed in the Lamy report[3]). However, in reality, neither the 700MHz band or the 470–694MHz band are likely to be cleared as early as 2018 across Europe and therefore our modelling should be viewed as an overestimate of the true economic benefits for mobile.

The benefits/costs of using the spectrum for DTT vary widely across the EU due to country specific circumstances – e.g. DTT penetration, the availability of other platforms. To capture these variations, we consider eight detailed case studies, to which we assign each of the remaining 20 EU member states, scaled by their respective populations. The sum then constitutes our total cost of migration for the EU. Our eight chosen case studies and their assignments are as follows:

Figure 6-1: Case studies and assignment of remaining EU member states [Source: Aetha]

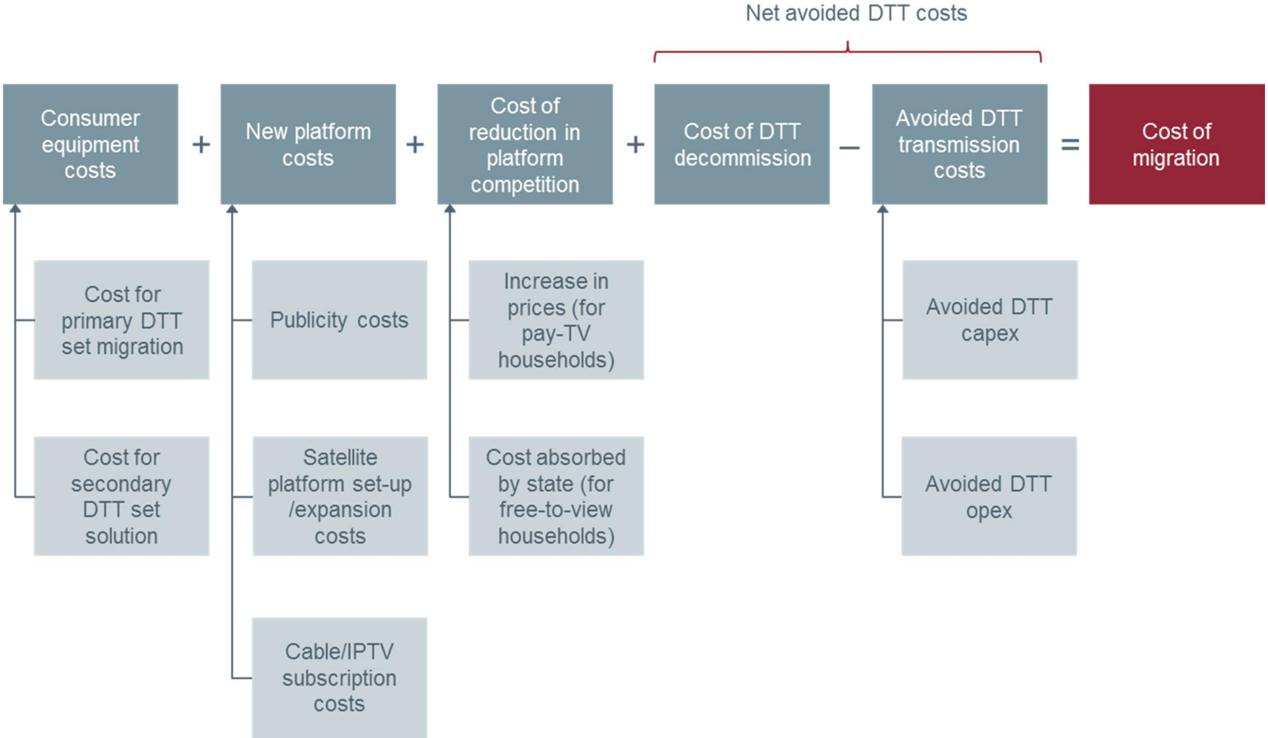
France	Germany	Italy	Poland	Romania	Spain	Sweden	UK
	Austria Belgium Luxembourg Netherlands	Croatia Greece	Slovakia	Bulgaria Estonia Hungary Slovenia		Denmark Finland Latvia Lithuania Malta Portugal	Cyprus Czech Rep Ireland

Those countries assigned to Germany are largely low DTT and high cable usage countries, whilst those assigned to Italy are high DTT penetration markets. Poland and Slovakia both have satellite as the leading platform, followed by cable and then DTT. Those assigned to Romania are eastern European countries with high cable usage, whilst those assigned to Sweden share a high usage of cable, but also a relatively low usage of satellite. UK assigned countries have strong DTT and satellite markets.

We note that 76% of the EU population reside within these case study countries, such that the majority of the cost of migration is likely to be captured by our case study countries alone.

In evaluating this overall cost, we consider a number of cost components to the calculation, which are summarised below in Figure 6-2, and in the remainder of this section. For a more detailed explanation of the inputs and methodology behind the calculation of each component, see Annex A.

Figure 6-2: High-level components to the calculation of the cost of migration [Source: Aetha]



The sum of these components provides an overall cost of migration, which in turn implies an overall value of 470–694MHz spectrum to DTT services. We then compare this to the economic benefit generated from the accompanying release of the 470–694MHz band for mobile services under this scenario, as calculated in Section 7.

6.1.1 Consumer premises equipment (CPE) costs

Before transmissions can be switched off, DTT viewers must first have the necessary equipment to receive their television via alternative platforms in order to prevent any discontinuity of services. This represents a significant cost (e.g. satellite dishes, set-top boxes, installation costs).

In many cases however, households with multiple television sets may use multiple platforms for their viewing. We therefore distinguish between those households that use the DTT platform as their primary means of television reception, and those households that do not use DTT on their primary sets, but may use it for secondary sets – e.g. in bedrooms.

We assume that all primary DTT households are actively migrated to the satellite, cable or IPTV platforms. For primary DTT households also using DTT on secondary sets, we implicitly assume that in such a scenario where large numbers of European households require a solution for secondary sets, a reasonably priced wireless solution is likely to be made available (e.g. using a technology such as Wi-Fi). For the remaining non-primary DTT households (i.e. those who do not use DTT on primary sets but may do so on secondary sets), we have assumed a secondary set-top box to allow the connection of a secondary set to the primary means of reception.

We assume a migration to the satellite platform for the majority of viewers, since it is for most countries the only platform, other than DTT, with near universal coverage. Inevitably however, there may be a small proportion of households that are unable to receive a satellite signal. For such households we assume that they would instead be migrated to cable or IPTV and model the on-going subscription costs of such a service. In highly cable-penetrated countries we also assume that there may be some customers who have a preference for migrating to cable, despite being able to receive a satellite television, and factor this into our costs.

6.1.2 New platform costs

In addition to the CPE costs necessary for households to receive television via the alternative platform, there are further costs associated with providing the platform to which the consumers are migrated.

We consider these new platform costs to comprise the following components:

- Publicity costs – i.e. for promoting awareness of the platform switchover
- Platform costs of migration to satellite
  - cost of incremental transponder capacity
  - Electronic Programming Guide (EPG) set-up costs for new service
- Platform costs of migration to cable/IPTV
  - subscription cost of cable/IPTV service for households unable to receive a satellite signal, or with a preference for a migration to cable.

The cost of incremental transponder capacity depends on two main variables – the number of channels on the DTT platform, and the number of those channels already replicated on a free-to-view satellite service. For example in some countries (France, Germany and the UK), a comprehensive free-to-view satellite service already exists and offers all/most DTT channels.

In addition to the cost of acquiring the broadcasting capacity needed to host the migrated channels, we also include EPG setup and publicity costs (i.e. for promoting awareness of the platform switchover). We do not include costs to purchase the satellite, cable or IPTV rights of current DTT content. We therefore assume that the rights follow the content providers onto the new platform.

6.1.3 Economic impact of reduction in platform competition

The loss of the DTT platform would mean that there is one fewer nationwide television distribution platform in each country. This would inevitably lead to a reduction in competition in the television distribution market for each country. Therefore, in addition to the CPE and platform costs of migration, we also consider the economic impact resulting from the reduction in platform competition. The impact of the increase in market concentration for broadcasting capacity, due to the loss of a platform, may manifest itself in one or both of two ways:

- An increase in the price of broadcasting capacity (i.e. broadcaster distribution costs)
- A reduction in innovation.

For simplicity, we assume the reduction in competition purely manifests itself in price increases, as the reduction in innovation is difficult to quantify.

We use an oligopoly model to predict the price increase of distribution based on the change in the Herfindahl–Hirschman Index (HHI) calculated from the (primary set) platform shares for each country and our estimates for the current price. The price change leads to an increase in the cost of supply for television service providers for which we consider two separate impacts:

- For the pay-television market, these costs can be passed straight through to retail prices – we estimate the economic impact of this by calculation of the loss in consumer surplus.
- For the free-to-view market, we assume that the increased distribution costs are absorbed by the State as there is no scope for passing costs on to viewers. Note that this should be considered as a lower bound; should the costs instead be absorbed by the broadcasters, they may be forced to reduce investment in programming content which would have an even greater loss of economic value.

Since we assume a full replication of the DTT service on the satellite platform[22], there is no reduction in competition at the retail level – i.e. DTT households are migrated to a broadly identical service, and have the same number of services to choose from. There is for example, no reduction in free-to-view's ability to constrain pay-television prices. Our competition model considers only the reduction in competition resulting from the loss of the DTT platform *at a wholesale level* (i.e. the market for broadcasting distribution).

6.1.4 Net avoided costs of DTT transmissions

Despite the many costs associated with switching off DTT transmissions, we must also then consider the benefit of the *avoided* costs of running the DTT network – i.e. those costs which would otherwise be incurred given the continuation of the DTT platform, less any one-off infrastructure decommissioning costs.

In respect of the costs of running the DTT network, we only consider the marginal costs, without allowance for capital depreciation or other fixed costs that would have to be reallocated to other services.

The *avoided* DTT costs include:

- Network operating costs (opex)
- Business as usual capital expenditure (capex)
- Additional capex from expected upgrades to the network over the 15-year period.

For each of these costs, it is important that we consider only the specific costs associated with DTT transmissions, since other services such as radio also operate on the same tower footprint. The costs of radio to broadcast to consumers are effectively shared with DTT, therefore unless a decision were made to transition radio technologies as well, a proportion of the costs currently attributed to DTT would continue. We therefore assume that radio will continue to operate on the existing transmission infrastructure, whilst DTT will cease.

Using data provided by the broadcast network operators themselves in six of our case study countries (France, Germany, Italy, Spain, Sweden and the UK), we have estimated the annual avoided DTT opex and business as usual capex under the assumption that the 700MHz band has already been cleared prior to the DTT switch off, as envisaged under this modelling scenario. For the purpose of anonymising this commercially sensitive data, we have aggregated the total cost and distributed it over our case study countries by population and the number of multiplexes deployed.

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[22] With the exception that we assume that it will not be economical to replace local DTT channels on the satellite platform.

In addition to these costs, we also consider the avoided capex resulting from expected upgrades to the network, such as the introduction of next generation technologies. Note that this is largely dominated by the CPE costs of set top box upgrades for consumers.

However in order to obtain the above cost saving benefits from switching-off DTT transmissions, some one-off costs would be incurred for the decommissioning of DTT equipment on the network.

It is important to note that since other services such as radio also operate on the same tower network, we consider only the specific costs associated with DTT transmissions. We assume that radio will continue to operate on the transmission network, whilst DTT will cease. As a result only active equipment specific to DTT is decommissioned, including any repeaters not used for the transmission of radio.

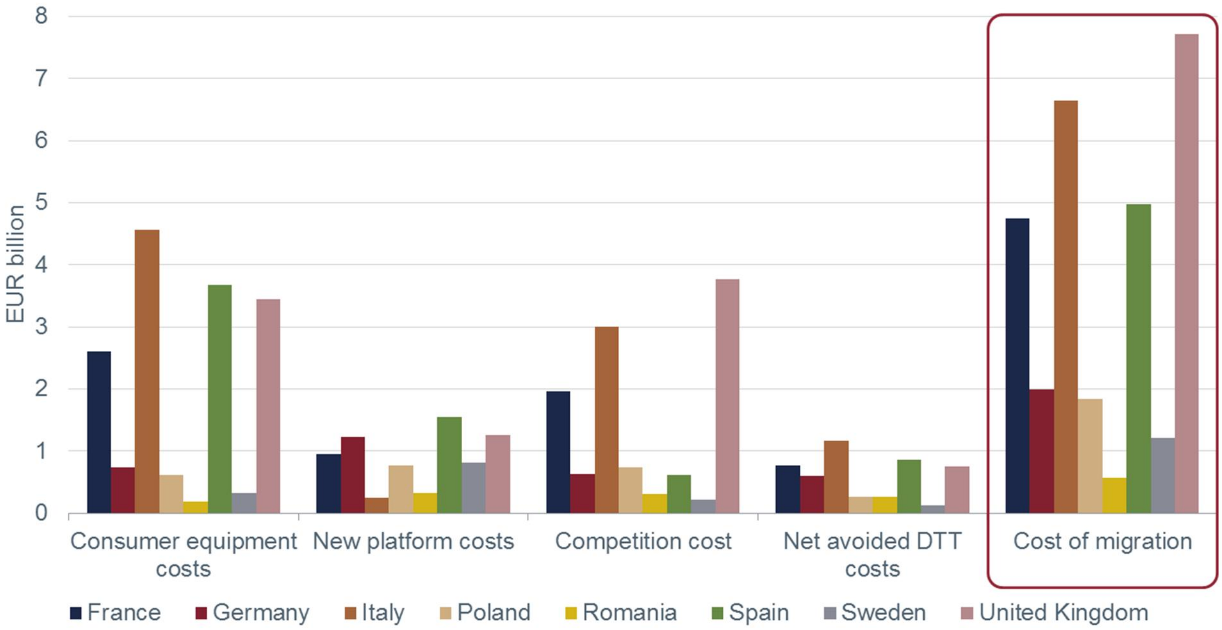
Indeed, the counterfactual scenario of decommissioning the entire network and ceasing radio transmission would represent an even greater cost. For universal coverage, radio requires a terrestrial platform. Therefore, the cessation of radio transmissions over the current high-power, high-tower network would require a migration onto an alternative terrestrial network in order to prevent the loss of services.

In our assessment, we do not account for the impact of amortising DTT equipment faster than was expected (i.e. writing-off network assets). This effect would have a negative impact on the profit and loss and balance sheets of the terrestrial broadcast network operators, but are sunk costs (since the equipment has already been deployed) and therefore cannot be avoided. Therefore, these costs are not included in our economic assessment as they are not relevant.

6.2 Results

Figure 6-3 summarises the results of our calculations for our eight case study countries.

Figure 6-3: High-level components to the calculation of the cost of migration [Source: Aetha]



As can be seen, there are significant variations in costs for our eight case study countries.

Particularly for the largest of our case study countries, we find that CPE costs make up a large proportion of the total cost of migration. This is because whilst CPE costs scale strongly with the number of DTT households, the new platform costs do not. This is evident in the case of Sweden. Italy notably has the highest consumer equipment costs due to the large number of DTT households. By contrast, Italy has the lowest new platform costs since free-to-view satellite services already exist in this market and the non-availability of cable TV means that consumers are not able to utilise this service as a preferred alternative.

The competition impact from the loss of DTT is also high in Italy, due to the minimal penetration of cable and IPTV services. Thus we find that the loss of the DTT platform reduces the market to a satellite monopoly in most areas of the country. In the UK, there is significant loss of competition in areas without cable coverage (about half of UK households), where the migration of DTT viewers onto satellite leads to a dominant market share over the sole alternative (IPTV). This, coupled with the high average expenditure per household on television services in the UK, results in it having the highest economic impact from the reduction in platform competition.

The avoided costs of DTT are greatest for Italy, due to the large number of multiplexes deployed. As expected, Poland, Romania and Sweden have lower costs given their much smaller populations. Notably however, Germany shows the smallest overall cost *per household* due to the smaller number of national coverage multiplexes deployed.

After the assignment of our remaining countries, we calculate the total cost of migration for the EU to be EUR38.5 billion, as shown in the figure below.

Figure 6-4: EU cost of migration to alternative platforms [Source: Aetha]

	EUR billion
Cost of consumer equipment	19.7
Cost to set up new free-to-view platform	10.8
Cost of reduction in TV platform competition	14.2
Net avoided cost of operating DTT network	(6.2)
Total cost of DTT migration	**38.5**

Note that there are a number of negative impacts from the loss of the platform which, though not included in our quantitative assessment, should be considered as further costs of migration. These are explained in detail in Section 5.2, and include the following:

- Spectrum not available for Programme Making and Special Events users
- Spectrum not available for white space applications
- Spectrum not available for radio astronomy
- Loss of access to local television services
- Losses due to consumers' preference for DTT.

As a result, our cost calculation should be considered as a lower bound.

7 Benefit of using the spectrum for mobile services

In this section, we consider the economic benefit of using all 470–694MHz spectrum for mobile services, as would be the case under Scenario 2 (where DTT transmissions cease and viewers are migrated to alternative platforms). Note that this section provides only a summary of our approach and results – for a more detailed explanation of the inputs and methodology used in our calculation, see Annex B.

7.1 Approach

If all 470–694MHz spectrum was allocated to mobile, the new spectrum could be used on existing sites – thus increasing the capacity per site and decreasing the number of new sites needed to meet traffic demand. The avoided building and operating costs of these sites, represents a network cost saving that leads to an increase in producer surplus – i.e. the profit earned by the network operators.

Our network cost calculations concern the cost of expansion for a generic mobile network operator (MNO) in a theoretical EU country, which we assume to have the following properties:

- a steady population of 50 million
- three MNOs, each with equal market share
- a current site grid of 10 000 sites for each operator, in order to provide sufficient coverage and carry current traffic levels.

In order to calculate the cost savings to the MNO, we consider the difference between the network costs with and without 470–694MHz spectrum (i.e. an additional 224MHz for mobile services). This allows us to compare the incremental benefit of making the 470–694MHz band available for mobile broadband services.

In a competitive market, the MNOs would lower their prices in line with the cost savings achieved from the new spectrum, in order to retain market share. Thus for each year of the modelling period, we transfer the gain in producer surplus to a gain in consumer surplus (i.e. the difference between consumers' willingness to pay for the service and the prices actually paid). The consumer surplus is calculated at a market level for our theoretical country and then scaled to the EU population. The difference in consumer surplus between the scenarios thus represents the total economic benefit to the EU in each year.

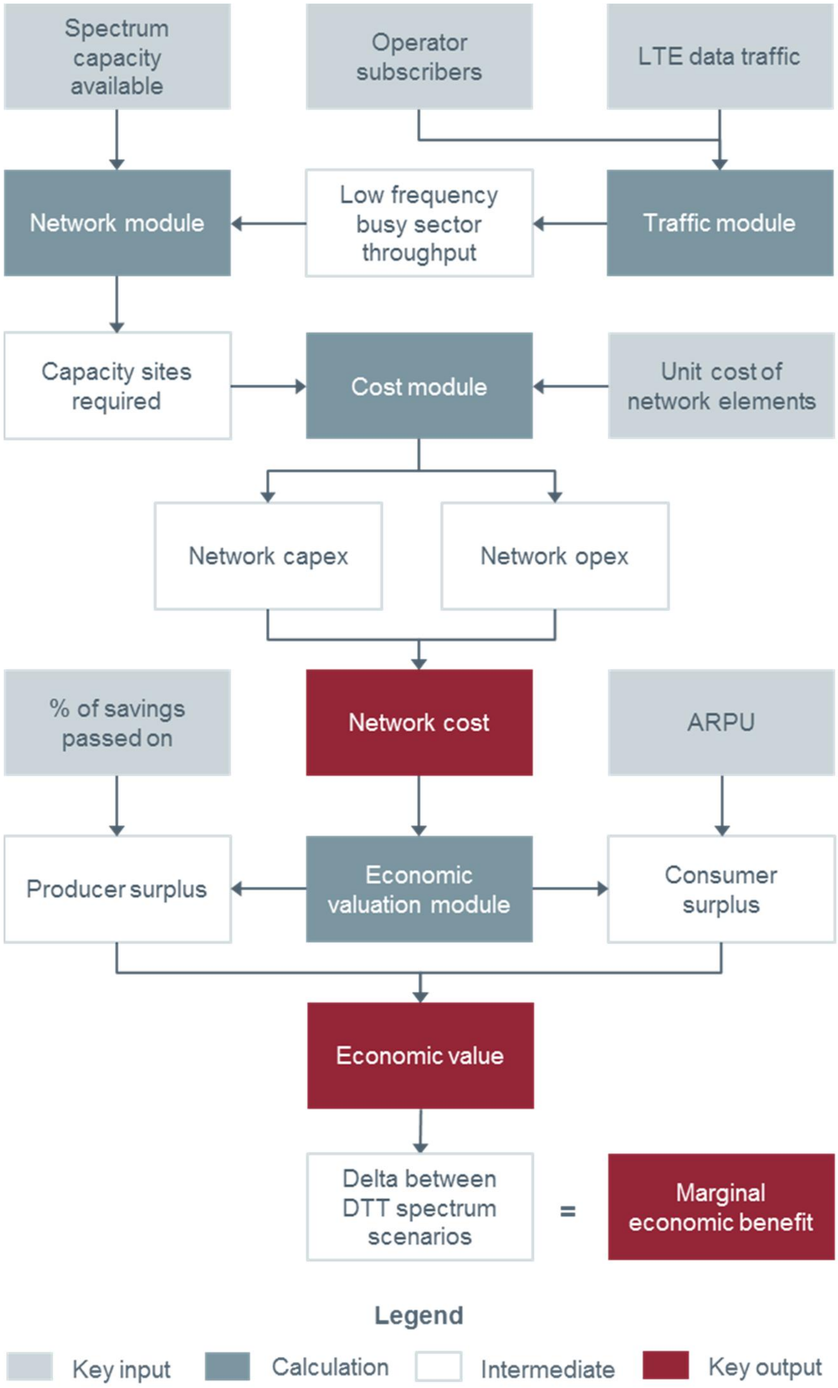
For the purpose of apportioning this total cost to our case study countries, we scale the mobile benefit by the GDP contribution of each country to the EU. This takes into account both the relative size and wealth of each country. Such an approach is possible since the differences in mobile markets across the EU are less pronounced than the differences in the television markets. Aetha has previously utilised a similar approach for the calculation of the economic benefits arising from making the 2.7-2.9GHz band available in Europe undertaken on behalf of the GSM Association[23]. Wherever possible we have sought to use the same approach and assumptions in this study.

The figure below provides an overview of our calculation methodology. From our traffic forecasts and the available capacity per site, we calculate the number of sites required to meet demand. From this we

[23] Aetha Consulting report for the GSM Association, 'Economic benefits from making the 2.7-2.9GHz band available for mobile broadband services in Western Europe', June 2013.

determine the network cost savings resulting from access to spectrum and subsequently passed on to consumers.

Figure 7-1: Calculation flow of methodology [Source: Aetha]



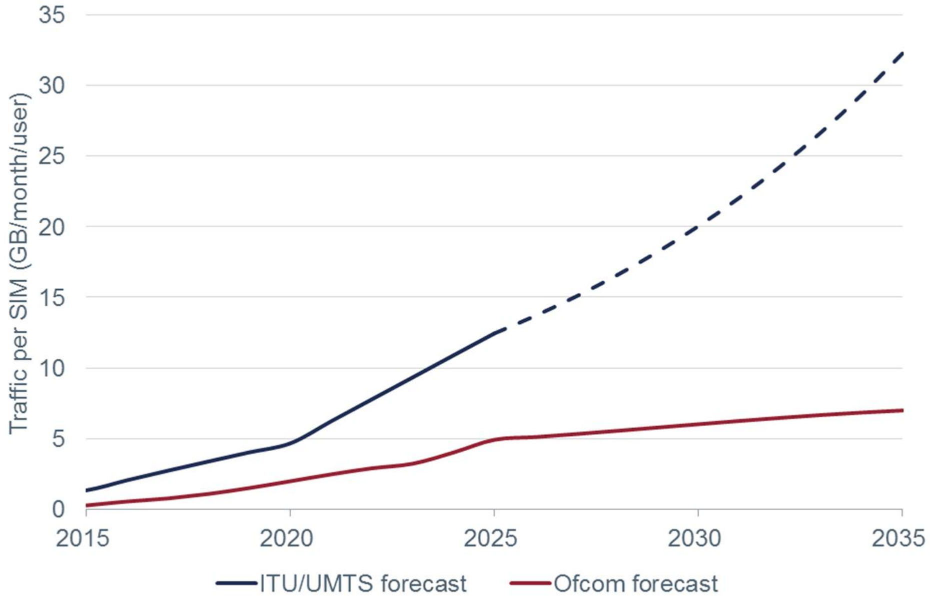
It is worth noting that in our calculation of the economic benefit:

- We have assumed that sufficient high-frequency spectrum will be made available for capacity purposes to meet the growth in mobile demand – i.e. supra-1GHz spectrum is not a limiting factor. As such, the use of 470–694MHz spectrum is assumed to be for additional capacity in areas out of reach of high-frequency spectrum, and not for increasing mobile coverage levels. Even in a scenario that there was a shortage of high-frequency spectrum to meet capacity demands – the opportunity cost of freeing spectrum at higher frequencies is much lower than for lower frequencies. Therefore it is not appropriate to consider capacity benefits from traffic that could be met by higher frequencies.

- We assume the best case in respect of the cost savings of the mobile operators being passed on to consumers *in full*. This would be the case for a perfectly competitive market, since the MNOs would lower their prices in line with the cost savings achieved from the new spectrum, in order to retain market share. In reality however, the market may not be perfectly competitive and the consumer surplus would be lower than predicted.

The economic benefits from making spectrum available for mobile broadband services are highly sensitive to forecast traffic levels – consequently in addition to the forecast based on ITU/UMTS Forum projections utilised in our study for the GSM Association, we have also calculated the economic benefits from the 470–694MHz band using a second forecast based on the UK traffic forecast used by Ofcom in its recent consultation on the future use of the 700MHz band[24].

Figure 7-2: Traffic forecasts used in mobile modelling [Source: Aetha]



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[24] Ofcom, 'Consultation on future use of the 700MHz band – cost-benefit analysis of changing its use to mobile services', 28 May 2014.

7.2 Results

As shown in Figure 7-3 below, there is no economic benefit generated from use of the 470–694MHz band for mobile broadband services under the input assumption based on Ofcom's traffic forecast. This is because demand can be met using other frequencies and without the need for additional sites. Under the higher ITU/UMTS-based traffic forecast however, there is a calculated economic benefit to the EU of EUR10.3 billion. The table below also shows the estimated benefit (EUR1.7 billion) using a forecast traffic level that is the average of the traffic forecasts based on the Ofcom and ITU/UMTS projections.

Figure 7-3: Economic benefit from the use of 470–694MHz spectrum for mobile services [Source: Aetha]

	Economic benefit (EUR billion)		
Country	Ofcom forecast	Average of Ofcom and ITU/UMTS forecasts	ITU/UMTS forecast
France	0.0	0.2	1.4
Germany	0.0	0.3	2.0
Italy	0.0	0.2	1.2
Poland	0.0	0.1	0.5
Romania	0.0	0.04	0.2
Spain	0.0	0.2	0.9
Sweden	0.0	0.04	0.2
United Kingdom	0.0	0.2	1.4
Rest of EU	0.0	0.4	2.3
EU	**0.0**	**1.7**	**10.3**

8 Results of our economic assessment

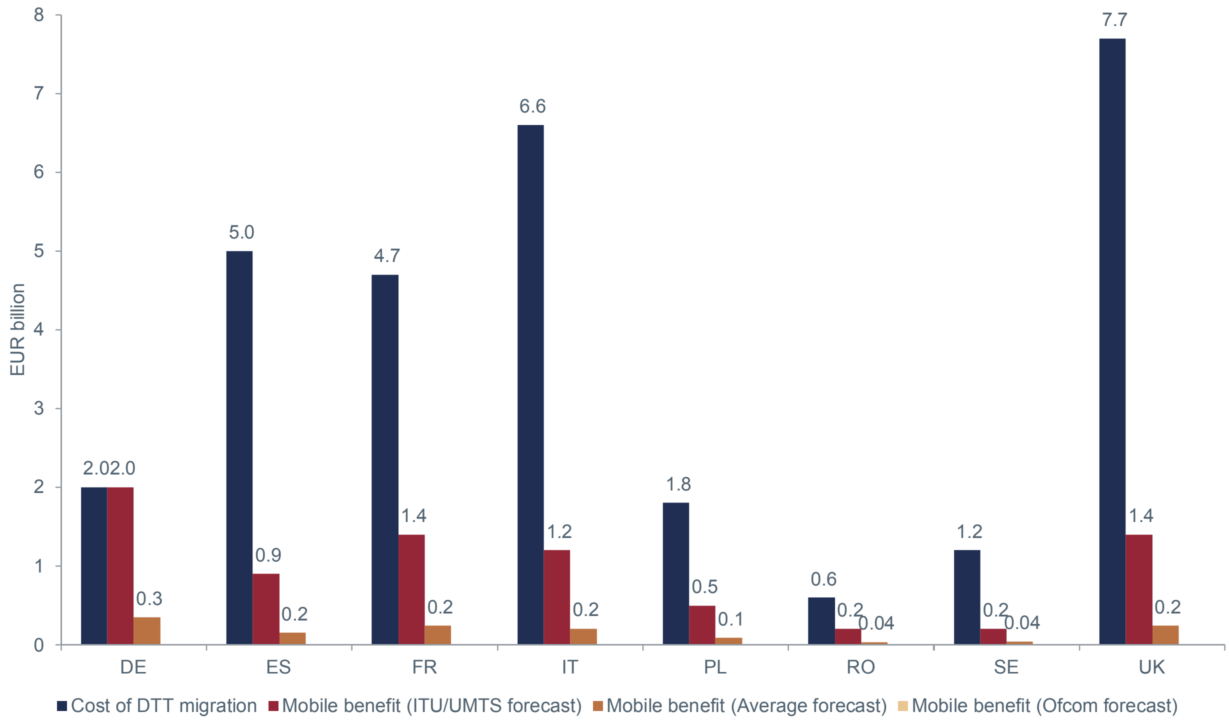
In this section, we first present the overall results of our economic assessment, for our case study countries and for the EU as a whole. In particular, we compare the economic cost of migrating DTT to the economic benefit generated from the subsequent availability of the 470–694 MHz band for mobile services.

Full breakdowns of the results for each of our case study countries can be seen in Annex D.

8.1 Migration of viewers to alternative platforms

For each country we take the cost of migration (CPE, new platform costs and the economic impact of the reduction in platform competition) and subtract the cost savings from switching off the DTT network (avoided DTT costs less decommissioning costs). From this we obtain a net cost of DTT migration, which we compare to the calculated mobile benefit from the spectrum under each of our traffic inputs. This is shown for each of our case study countries in the graph below.

Figure 8-1: Comparison of the cost of migrating DTT viewers to alternative platforms and the potential benefits of releasing the 470–694MHz band for mobile services [Source: Aetha]



In each of these countries there is a very clear case for the continued use of 470–694MHz spectrum for DTT, although, as expected, the cost of migration varies considerably from country to country. The only case where the economic model shows a balanced result is Germany, but only in the event that the mobile traffic levels in the ITU/UMTS-based forecast are realised. However, we note that using Ofcom's traffic forecast, the cost of migrating DTT in Germany considerably outweighs the potential benefits to mobile.

Furthermore, we note that even if the potential benefits to mobile in one country are greater than the cost of migrating all DTT viewers to alternative platforms, these benefits would only be realised if both suitable consumer equipment is available and if the band can be used for mobile services without harmful interference being caused to it from DTT transmission in neighbouring countries. This is only likely to occur in the event of a pan-European decision to make the 470–694MHz band available for mobile services, for which we have shown, there would be no economic benefit to such a decision for the EU as a whole, at least for the next 15 years.

After assigning the remaining EU member states to our case studies and scaling by population, we find that the total cost of migrating viewers to an alternative platform is **EUR38.5 billion**, whilst our upper-bound estimate of the value that could be generated by using the 470–694MHz band for mobile services is **EUR10.3 billion** based on the ITU/UMTS traffic forecast, and **EUR0** billion based on the Ofcom traffic forecast.

8.2 Summary of results for European Union

The table below summarises the overall results for our case study countries and for the EU as whole, following the assignment of the remaining 20 EU member states (as shown in Figure 6-1).

Figure 8-2: Overall results of economic assessment [Source: Aetha]

Country	Cost of DTT migration (EUR bn)	Mobile benefit (EUR bn)		
		Ofcom forecast	Average of Ofcom and ITU/UMTS forecasts	ITU/UMTS forecast
France	4.7	0.0	0.2	1.4
Germany	2.0	0.0	0.3	2.0
Italy	6.6	0.0	0.2	1.2
Poland	1.8	0.0	0.1	0.5
Romania	0.6	0.0	0.04	0.2
Spain	5.0	0.0	0.2	0.9
Sweden	1.2	0.0	0.04	0.2
United Kingdom	7.7	0.0	0.2	1.4
Rest of EU	8.8	0.0	0.4	2.3
EU	**38.5**	**0.0**	**1.7**	**10.3**

The costs incurred by switching off DTT across the EU exceed the benefits of using the 470–694MHz band for mobile services by a factor of almost four under the case where mobile traffic levels grew in line with the ITU/UMTS forecast. When a less aggressive traffic forecast is used, the costs of clearing DTT are unchanged but the value of using the spectrum for mobile would be near to zero.

9 Implications of a co-primary allocation at WRC-15

As part of Agenda Item 1.1, the topic of identifying additional spectrum to meet growing demand for mobile data will be discussed at WRC-15. One of the bands that has been identified in the preparations for the conference is 470–694MHz. There is a proposal originating from the mobile industry to consider giving mobile co-primary status in this range.

The basis of the mobile industry's proposal is broadly as follows:

- Demand for mobile data services has been growing quickly, and this growth is expected to continue for the foreseeable future.
- Additional spectrum is required to meet this demand, and particularly low-frequency spectrum (below 1GHz) due to its superior propagation characteristics, which enables cost-effective deployment of mobile services.
- Even if the 700MHz band is released for mobile services, more spectrum is likely to be required to meet forecast data growth.
- There are long lead-times from the allocation of a band for mobile use until it is available for mass market use. This is due to the standardisation process, equipment development and the timescale for devices to become commonplace amongst users. Therefore, it is important that mobile is given primary allocation status in the 470–694MHz band as soon as possible (i.e. at WRC-15) so that this process can commence and benefits of using this spectrum for mobile services are not delayed.
- There are no downsides from 470–694MHz having co-primary status with mobile. In the event that demand for mobile services is lower than expected, the spectrum could continue to be used for DTT and the other existing uses.
- Therefore, given there are no downsides yet likely potential upsides, granting co-primary status is an obvious decision.

In the previous section, we clearly demonstrated that between now and 2030 that the one-off and on-going costs of the displacement of DTT from 470–694MHz would significantly outweigh the benefits of using the spectrum for mobile services. Further, our estimate is likely to underestimate the losses from ceasing DTT transmission. This analysis nullifies one of the key arguments from the mobile industry, i.e. that the use of 470–694MHz for mobile services would generate a net economic benefit.

In this section, we challenge the two other elements of the mobile industry's argument:

- that there are no downsides from 470–694MHz having co-primary status with mobile
- that if 470–694MHz was to be given co-primary status for mobile (which is far from clear given the analysis presented in Section 8), this would need to happen at WRC-15.

9.1 The cost of a co-primary allocation

Superficially, it may appear that there are no costs associated with mobile having co-primary status in the 470–694MHz band. If demand does not materialise to justify the use of the spectrum for mobile services, then the spectrum could continue to be used for the existing uses – DTT, PMSE, radio astronomy and white space devices. This is an argument used by those that promote co-primary allocation as a principle.

However, if 470–694MHz was given co-primary status, there would be a series of costs that ensue for DTT, as well as other uses, having uncertainty regarding their tenure as the users of the spectrum.

This would not be the first time that broadcasting spectrum has been given co-primary status with mobile:

- At WRC-07, the 800MHz band (790–862MHz) was given co-primary status with mobile. This led to broadcasting being cleared from the band across Europe.
- At WRC-12, a decision was made to agree to grant mobile co-primary status in the 700MHz band (694–790MHz), although this does not come into effect until after WRC-15 in order to allow time for the appropriate technical studies to be completed. This was an unexpected decision, given that discussion of the 700MHz band had not been on the agenda (the proposal for co-primary status was only presented at the start of the conference by African and Arab countries), and there was no socio-economic case presented for use of the spectrum for mobile. Following this decision, a number of European countries, including Finland[25], France[26], Germany[27], Portugal[28], Sweden[29], and the UK[30], have announced plans to clear the 700MHz band of broadcasting use and award it for mobile use. The decision to adopt the 700MHz band for mobile has not been formally made in some of the above mentioned countries, and decisions are yet to be made in other European countries, but the decision at WRC-12 to grant mobile co-primary status was an important catalyst to this issue being raised across Europe.

Therefore, there is a history of mobile being given co-primary status with broadcasting in different parts of the UHF band and that leading to either the spectrum being cleared for mobile services or discussions about the spectrum being cleared. It is therefore inevitable that a co-primary allocation to mobile in the 470–694MHz band would lead to uncertainty regarding the future of DTT's use of this spectrum – and given that this is the only remaining spectrum that DTT uses for transmissions – uncertainty regarding the future of DTT as a television platform.

Such uncertainty would have a number of consequences:

- Firstly, incentives to invest in the DTT platform and the services it provides would be undermined. Historically, the DTT industry has made numerous investments to improve the efficiency of the platform and the quality of services that it offers. These have included the introduction of DVB-T2 transmissions and MPEG-4 compression technology in many European countries. Such investments typically have long payback periods (e.g. 10 years). If there is uncertainty regarding the future of the platform, similar future investments are unlikely to be made. This would lead to the DTT platform falling behind other television platforms, unnecessarily risking its viability.

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25 Ministry of Transport and Communications, 'Communications Policy Programme for Electronic Media', 2012.

26 Telegeography, 'France plans to allocate 700MHz band to telecoms in 2015', 26 June 2013.

27 BNetzA, 'Konsultationsentwurf zur Anordnung und Wahl des Verfahrens zur Vergabe von Fre-quenzen in den Bereichen 700 MHz, 900 MHz, 1800 MHz sowie im Bereich 1452 –1492 MHz für den drahtlosen Netzzugang', June 2013.

28 ANACOM, 'Consulta pública sobre o futuro da TDT', April 2014.

29 Regeringskansliet, 'Digital-tv får nu lämna frekvenser till mobilerna', 27 February 2014.

30 Ofcom, 'Future use of the 700MHz band', April 2013.

- Secondly, for the platform to thrive, consumers also need confidence in its future. If there is doubt then consumers are unlikely to purchase the next-generation of DTT equipment, instead preferring other platforms. Notably, migrations to new technologies can only be completed once all consumer equipment is switched to the new technology.

Therefore, there is a clear cost to a co-primary allocation to mobile at this time – it would inevitably lead to increased uncertainty regarding the future of the DTT platform, which would result in reduced incentives for both the DTT industry and consumers to invest in the platform. Potentially, this could lead to the DTT platform falling behind other television platforms and unnecessarily risk the viability of the platform.

9.2 The need for a co-primary allocation at WRC-15

In Section 8 we clearly demonstrate that, on the grounds of spectral efficiency, there is no economic case for switching the use of 470–694MHz from DTT to mobile between 2015 and 2029. There is therefore no immediate requirement to grant a co-primary allocation to mobile in the 470–694MHz band at WRC-15 and this issue could be considered again at a later WRC in the event that the economic case were to change.

The mobile industry is correct in its claims that there are long lead-times between a spectrum band being given primary allocation status for mobile services and the economic benefits being realised from it being widely used for that service. In the case of the 800MHz band, this period was in the order of six years. Mobile was given co-primary allocation status in the 790-862MHz band at WRC-07, which occurred in late 2007. The first instance of services being delivered using this band was by Vodafone in Germany in December 2010, just three years after the co-primary allocation. However, it took a few more years until the 800MHz band was widely available in devices and in the majority of European countries. Notably, the 800MHz band was only included in the iPhone 5S, which was launched in September 2013, nearly six years after the co-primary allocation was made. At the time of writing, approximately six and a half years after the co-primary allocation, the 800MHz band has been awarded in all but five of the 28 EU member states. The economic benefits of the 800MHz band are clearly now being widely experienced across Europe.

Not granting mobile co-primary status at WRC-15 and instead granting it at a later WRC could potentially delay the realisation of benefits, if they were to occur. However, as demonstrated by our analysis, a delay in making a decision on this matter to a subsequent WRC would be compatible with the timescale over which the spectrum might start to yield material economic benefits if it was made available for mobile services, and would also be concurrent with the proposal of the Lamy report[3] for a review by 2025. Furthermore Ofcom has stated in its Mobile Data Strategy[31] that, if made available for mobile services, the potential timing for release of the 470–694MHz band for such a use would unlikely to be relevant until beyond 2030.

In conclusion, there would be minimal loss of potential economic benefits if consideration to giving co-primary status to mobile in the 470–694MHz band in Region 1 was undertaken at a later WRC. Therefore, given the costs and implications associated with making such a decision prematurely, it would appear prudent to delay the decision to a later WRC. At that point, there would be more certainty regarding both the traffic levels on mobile networks and the availability of other bands for mobile services, such that a more informed decision could be made.

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[31] Ofcom, 'Mobile Data Strategy', 21 November 2013.

10 Conclusions

Our economic assessment has demonstrated the substantial value that is generated for EU citizens from continuing use of the 470–694MHz band for the provision of DTT. Specifically, over the next 15 years, the costs associated with providing broadcast television services to all EU households in the absence of the DTT platform are at least four times the value of benefits that would arise from making the 470–694MHz band available for mobile services. Furthermore, this quantitative assessment is likely to be a lower bound estimate of the true value of the existing use of the spectrum since:

- We have not accounted quantitatively for various benefits of the DTT platform, for example the preference of some consumers for DTT.
- We have not calculated the economic benefits arising from other existing uses of the spectrum – in particular for PMSE, radio astronomy and new 'white space' applications.
- Our estimate does not take account of the loss of the local television channels that exist in some EU member states and would not be economic to replicate on alternative platforms.

In contrast, our assessment of the economic benefits of making spectrum in the 470–694MHz band can be considered as an upper bound estimate. These benefits are highly dependent on future mobile traffic forecasts – and, for this reason, we have considered two forecasts of traffic. Under one of these traffic forecasts, we estimate that the benefits of using 470–694MHz spectrum for mobile broad services to be zero.

In summary, it is therefore important that an appropriate policy environment remains to facilitate the continued use of the 470–694MHz band for the provision of terrestrial broadcast television services in the coming 15-year period.

We note that the history of UHF spectrum previously used for broadcasting being given co-primary status by World Radiocommunication Conferences has directly led to the spectrum being cleared for mobile services or preparations for the spectrum being cleared. Consequently we are concerned that a co-primary allocation to mobile in the 470–694MHz band in Region 1 could lead to uncertainty regarding the future use of this spectrum for DTT – and therefore, since this is the only spectrum used by the DTT platform, uncertainty regarding the future of the platform as a whole which would be wholly unjustified based on the findings of this study.

Such uncertainty could have considerable negative impacts. Firstly, incentives to invest in the DTT platform would be undermined. This includes investments by the broadcast industry in both the underlying transmission technology (for example the migration from DVB-T to the more spectrally efficient DVB-T2) as well as in the associated consumer service platforms (for example in hybrid DTT/Internet platforms such as the YouView service in the UK). Additionally, investment by consumers would be threatened – consumers need confidence in the future of the platform to spend money on new customer premises equipment such as set-top boxes and televisions that are compatible with the latest DTT technologies. This could undermine broadcast network operators' plans for migrating to new spectrally efficient technologies. Worse still, this uncertainty could lead to the DTT platform falling behind other platforms unduly compromising its competitive impact and risking the viability of the platform.

For these reasons, whilst Aetha is normally a strong proponent of the removal of any unnecessary technology and service restrictions on individual spectrum bands, on this particular occasion we believe that granting a co-primary allocation to mobile in the 470–694MHz band in Region 1 at WRC-15 is not appropriate. Whilst it is possible that consumer trends may change in the longer term – for example mobile traffic could grow faster – such developments can be considered as they arise and the situation reviewed at future WRCs. Whilst it is true that there is a lead-time between a spectrum band being identified for mobile at a WRC and that spectrum becoming available for use, a delay in making a decision on this matter to a subsequent WRC would be compatible with the timescale over which the spectrum might yield material economic benefits. As such, we would agree with the Lamy recommendation for a review by 2025, as proposed in his report to the European Commission regarding the results of the work of the High Level Group on the future use of the UHF band[17].

Annex A Cost of migration to alternative platforms: detailed approach

This Annex discusses our detailed approach to the calculation of the cost of ceasing DTT transmissions and migrating viewers to alternative platforms. In evaluating this overall cost, we have considered a number of cost components to the calculation:

- Consumer premises equipment (CPE) costs
- New platform costs
- Economic impact of reduction in platform competition
- DTT decommissioning costs
- Avoided costs of DTT transmissions.

The sum of these components provides an overall cost of migration, which provides a lower bound estimate of the value of 470–694MHz spectrum to DTT services. Throughout the remainder of this section, we now describe the detailed inputs and assumptions used in the calculation of each cost components. Furthermore, we also present the results for each component for our eight case study countries.

A.1 Consumer equipment and new platform costs

Before DTT transmission can be switched off, viewers must first be migrated to alternative platforms in order to prevent any discontinuity of services. This represents a significant cost.

We assume a migration to the satellite platform for the majority of viewers, since it is for most countries the only platform, other than DTT, with near universal coverage. Inevitably however, there may be a small proportion of households that are unable to receive a satellite signal. For example, in some areas where there may be planning restrictions preventing the installation of dishes, or where there is a lack of free line of sight towards the satellite – i.e. shadowing by other buildings or where apartments are not facing in the right direction. In the UK for example, a study[32] found that satellite coverage assuming shadowing from terrain only is 99.99% whilst including building and vegetation blockage is 96% for residential addresses. For such households we assume that they would instead be migrated to cable or IPTV and model the on-going subscription costs of such a service. In highly cable-penetrated countries we also assume that there may be some customers in particular countries who have a preference for migrating to cable, despite being able to receive satellite services. This may be due to a preference for the cable offering a desire to avoid placing a satellite dish on the property or the accessibility of the existing cable infrastructure which may mean that many households are already capable of receiving cable television. For example, in Germany we assume that 23.5% of primary DTT households choose to migrate to cable. For the other case study countries, we then scale this factor in line with the adoption of cable television services.

We consider there to be two significant sources for the cost of migration:

- Customer premises equipment (CPE) costs (satellite dishes, set-top boxes, installation)
- New platform costs (costs of cable/IPTV subscriptions, costs of replicating DTT channels on the satellite platform – e.g. leasing transponder capacity, Electronic Programming Guide (EPG) set-up costs, publicity costs).

[32] John Biddiscombe, Rutherford Appleton Laboratory, 'UK Satellite Coverage Prediction Study'.

A.1.1 Consumer premises equipment (CPE) costs

For households using DTT, to receive their television via another means, they must first be provided with the necessary equipment to do so. In many cases however, households with multiple television sets may use multiple platforms for their viewing. We therefore distinguish between those households that use the DTT platform as their primary means of television reception, and those households that do not use DTT on their primary sets, but may use it for secondary sets – e.g. in bedrooms.

We assume that all primary DTT households are actively migrated to the satellite, cable or IPTV platforms. We assume that the CPE costs are incurred one year prior to the DTT switch-off in 2018. These costs include the cost of a satellite dish (EUR50), the cost of a set-top box (EUR70) and the cost of installing the equipment itself. Note that since the cost of installation varies between countries due to wealth differentials, we scale these values by GDP/capita – using EUR100 as inputs for France and Spain, we calculate implied costs for the other case study countries by scaling against the average GDP/capita of France and Spain. For households migrated to cable/IPTV, we assume the same set-top box cost, but a lower installation cost (80% of the satellite installation cost).

For primary DTT households also using DTT on secondary sets, we assume a cost of EUR50 to extend viewing from the primary set. We implicitly assume that in such a scenario where large numbers of European households require a solution for secondary sets, a reasonably priced wireless solution is likely to be made available (e.g. using a technology such as Wi-Fi). We have determined the number of such sets from the number of television sets per household and using the base assumption that households using DTT on a primary set will also use DTT on secondary sets.

For the remaining non-primary DTT households (i.e. those who do not use DTT on primary sets but may do so on secondary sets), we have assumed a secondary set-top box of EUR50 per television set to allow the connection of a secondary set to the primary means of reception.

Note that CPE costs may be underestimated due to the potential requirement of new communal aerial systems for blocks of flats (in the UK a large proportion of the 5.8 million flats would need significant upgrades to their communal systems)[33].

In order to quantify the total cost from our unit cost assumptions, we determine the number of households owning at least one television in each case study country. We use figures for the total number of households[34] and the penetration of television among all households[35]. Having determined the size of the market, we then determine the number of primary and secondary DTT sets. The penetration of the different distribution platforms among primary sets is provided by various subscriber data for each of our case study countries[36]. The number of households using DTT on secondary but not primary sets was provided by the European Broadcasting Union, and calculated by subtracting primary set platform penetration from overall household penetration. We assume that for primary DTT households, any secondary sets also use DTT.

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33 ManderCom Consultants, 'Communal Aerial Systems in Multiple Dwelling Units', March 2014.

34 European Commission, Eurostat 2012.

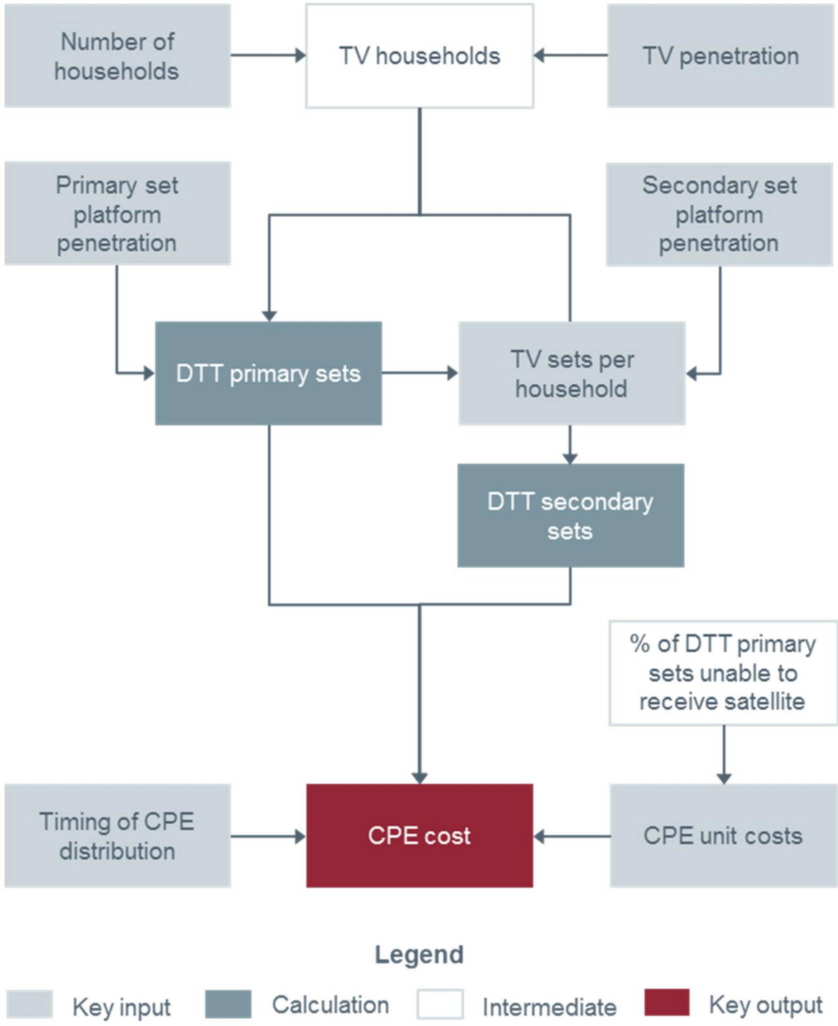
35 European Commission, 'E-Communications Household Survey', November 2013.

36 See Annex C for specific country inputs.

From the percentage of households with multiple sets[37] and the average number of televisions per household in each country we then determine the total number of secondary DTT sets.

The diagram below summarises the methodology and input assumptions used in the calculation of the CPE costs of migration.

Figure A-1: Calculation flow for CPE costs of migration [Source: Aetha]



A.1.2 New platform costs

In addition to the CPE costs necessary for households to receive television via the alternative platform, there are additional costs associated with providing the platform to which the consumers are migrated.

We consider these new platform costs to comprise the following components:

- Publicity costs – i.e. for promoting awareness of the platform switchover
- Platform costs of migration to satellite
  - cost of incremental transponder capacity
  - Electronic Programming Guide (EPG) set-up costs
- Platform costs of migration to cable/IPTV

[37] IP Deutschland, 'Television 2013 International Key Facts', 2013.

- subscription cost of cable/IPTV service for households unable to receive a satellite signal, or with a preference for a migration to cable.

The cost of incremental transponder capacity depends on two main variables – the number of channels on the DTT platform, and the number of those channels already replicated on a free-to-view satellite service. In some countries, a comprehensive free-to-view satellite service already exists and offers all/most DTT channels. Of our case study countries, this includes France, Germany and the UK. In Italy, a service exists, but replicates only free-to-view channels. We therefore assume the expansion of the platform to include the DTT subscription channels in our costs, since these also comprise a significant proportion of the Italian DTT channel offering. In Poland, Spain and Sweden no free-to-view satellite service exists, therefore we assume the creation of a new service. Notably, Romania has a 'Freesat' service, however whilst marketed as free-to-view, it does levy a EUR23 yearly service charge to its customers. We estimated that the cost of subsidising the service charge and expanding the service is more expensive than creating a new service. Therefore we assume a new service in our calculations.

In determining the satellite capacity required, we assume that one HD channel requires the same capacity as four SD channels, and that one satellite transponder (with a bandwidth of 36MHz) can carry nine SD channels – roughly equivalent to the capacity of one DTT multiplex. Transponders are typically leased at a cost of EUR4 million per year[38], therefore we do not directly consider the cost of launching and operating satellites etc. which we assume to be accounted for in the leasing cost. We assume the same leasing cost for all European broadcasters.

In addition to the cost of acquiring the broadcasting capacity needed to host the migrated channels, we also include EPG setup and publicity costs (i.e. for promoting awareness of the platform switchover). An EPG setup cost of EUR10 million is applied only in the cases where the creation of a new service is necessary. Publicity costs are applied to all countries, since the viewers must still be told to migrate, whether or not the service already exists. We assume for the UK, a cost comparable to that incurred during the digital switchover (EUR7.30 per household)[39], and apply this to each case study country. We do not include costs to purchase the satellite, cable or IPTV rights of current DTT content. We therefore assume that the rights follow the content providers onto the new platform.

For determining the subscription cost of cable/IPTV service for households unable to receive a satellite signal, or households with a preference for migration to cable, we assume a monthly cost of EUR12 per household in the UK for a basic service which includes all DTT channels. We then scale this by GDP/capita for our other countries. Note that we assume that wherever satellite is not available, cable/IPTV is available – i.e. in urban areas. This is a reasonable assumption, since it is mostly in urban areas where the reception issues would arise – e.g. due to lack of free line of sight towards the satellite (shadowing by other buildings or where apartments are not facing in the right direction).

The diagram below summarises the methodology and input assumptions used in the calculation of the new platform costs of migration.

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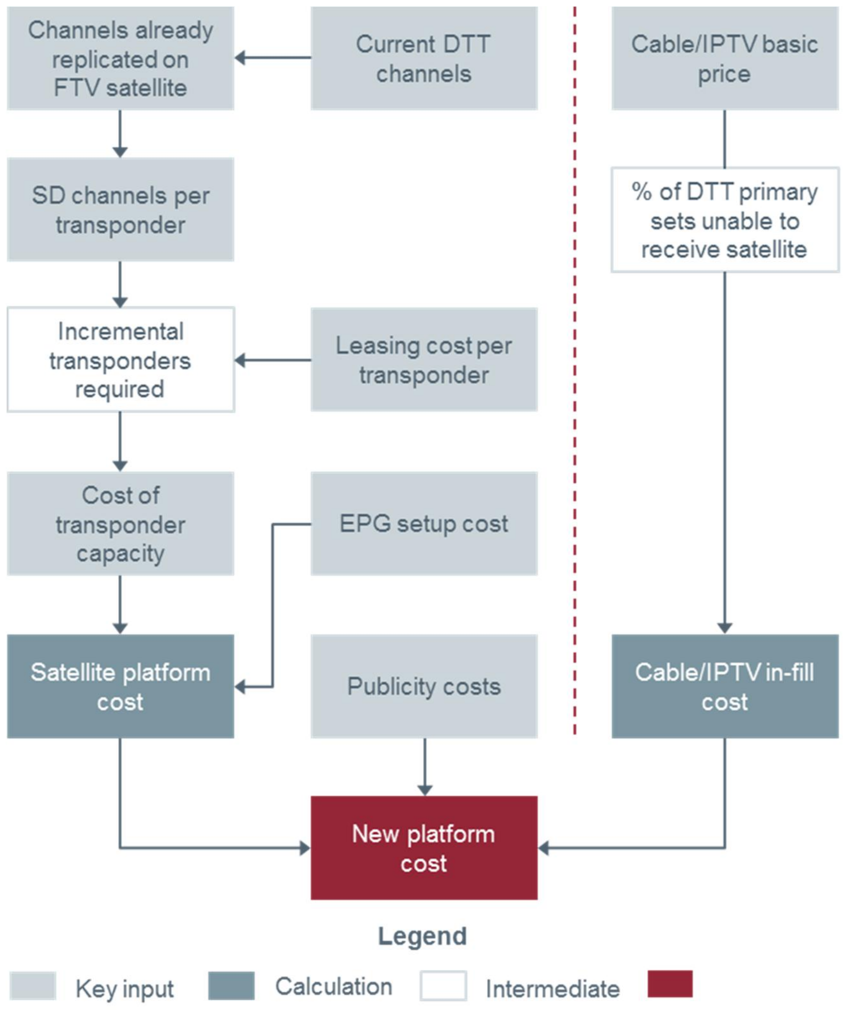
38 Comsys, 'Satellite capacity for *yes*', January 2013.

39 Digital UK.

Figure A-2: Calculation flow for new platform costs of migration [Source: Aetha]

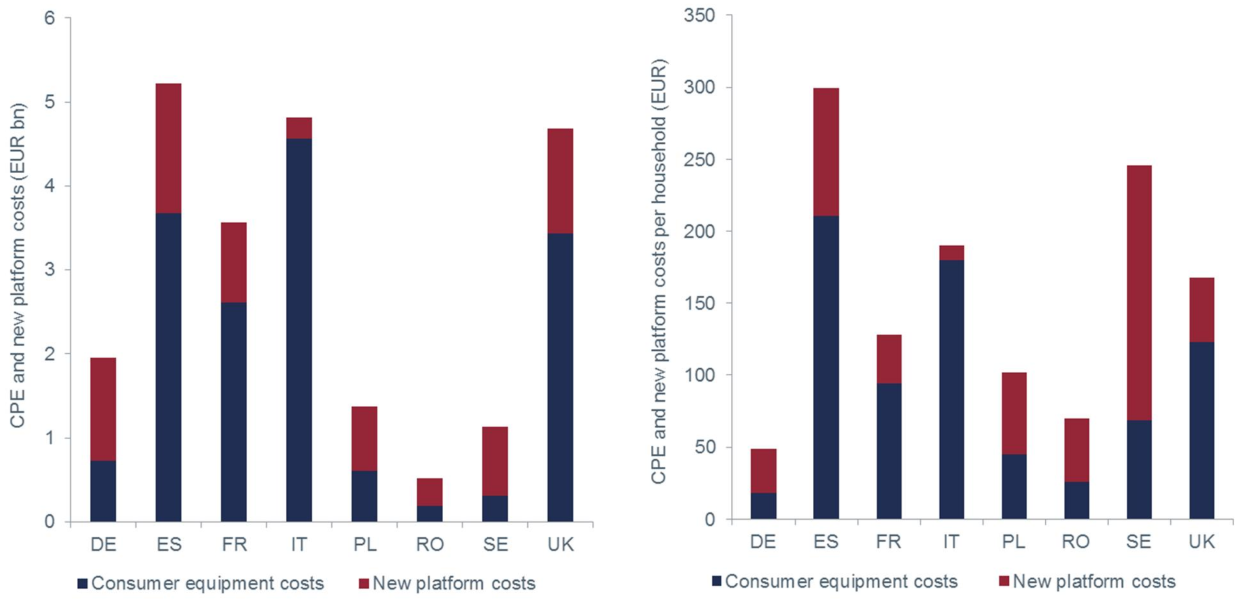


A.1.3 Results

Particularly for the largest of our case study countries, we find that the cost of migration is dominated by CPE costs. This is because whilst CPE costs scale strongly with the number of DTT households, the new platform costs do not. This is evident in the case of Sweden – as shown in the figure below, Sweden has the greatest new platform cost per household despite a comparable overall cost to the other countries.

Italy notably has the highest consumer equipment costs due to the large number of DTT households. Italy also has the lowest new platform costs since free-to-view satellite services already exist in this market and the non-availability of cable TV means that consumers are not able to utilise this service as a preferred alternative, we assume no cable in-fill (given the lack of cable services available). The total CPE cost for the EU, after assigning the remaining countries to our case studies, is EUR19.7 billion, whilst the total new platform cost is EUR10.8 billion. This amounts to a combined cost of EUR30.5 billion.

Figure A-3: CPE and new platform costs of migration to alternative platforms, both as country totals and per household (not just migrated households) [Source: Aetha]



A.2 Economic impact from reduction in platform competition

The loss of the DTT platform would mean that there is one fewer nationwide television distribution platform in each country. This would inevitably lead to a reduction in competition in the television distribution of each country. Therefore, in addition to the CPE and platform costs of migration, we also consider the economic impact resulting from the reduction in platform competition. The impact of the increase in market concentration for broadcasting capacity, due to the loss of a platform, may manifest itself in one or both of two ways:

- An increase in the price of broadcasting capacity (i.e. broadcaster distribution costs)
- A reduction in innovation.

For simplicity, we assume the reduction in competition purely manifests itself in price increases, as the reduction in innovation is difficult to quantify.

We use an oligopoly model to predict the price increase of distribution based on the change in the Herfindahl–Hirschman Index (HHI) calculated from the (primary set) platform shares for each country and our estimates for the current price. The price change leads to an increase in the cost of supply for television service providers for which we consider two separate impacts:

- For the pay-television market, these costs can be passed straight through to retail prices – we estimate the economic impact of this by calculation of the loss in consumer surplus.

- For the free-to-view market, we assume that the increased distribution costs are absorbed by the State as there is no scope for passing costs on to viewers. Note that this should be considered as a lower bound; should the costs instead be absorbed by the broadcasters, they may be forced to reduce investment in programming content which would have an even greater loss of economic value.

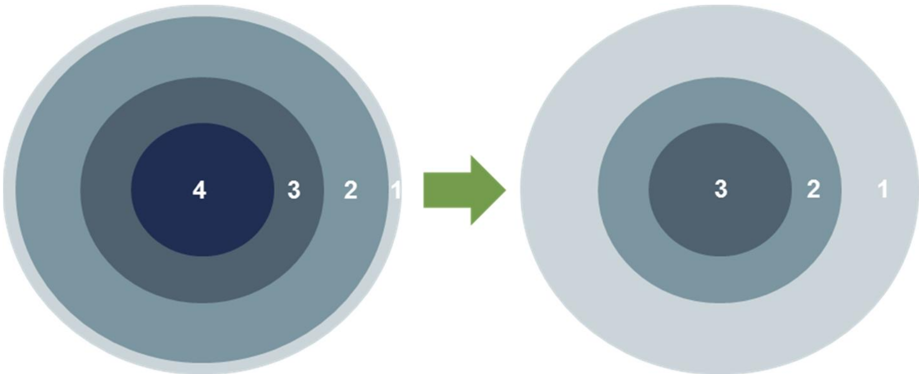
Since we assume a full replication of the DTT service on the satellite platform[40], there is no reduction in competition at the retail level – i.e. DTT households are migrated to a broadly identical service, and have the same number of services to choose from. There is for example, no reduction in free-to-view's ability to constrain pay-television prices. Our competition model considers only the reduction in competition resulting from the loss of the DTT platform *at a wholesale level* (i.e. the market for broadcasting distribution).

A.2.1 Oligopoly model

The function of the oligopoly model is to predict the rise in distribution prices resulting from the increase in market concentration, due to the loss of the DTT platform.

Using platform coverage data (taken from the European Commission's Broadband coverage report[41] and Aetha estimates), we first divide each country into 'geographic zones' by the number of available platforms. We make the assumption that coverage is purely concentric as shown in the figure below:

Figure A-4: Representation of impact of the loss of DTT on the number of available platforms [Source: Aetha]



Applying the migration scenario to our platform market shares, we then calculate the development of the market concentration using the Herfindahl–Hirschman Index (HHI) for each of these zones (assuming the same ratio of uptake between different platforms as the national shares).

To this we apply a *Cournot competition model,* but interpolate the expected market price as a function of HHI, rather than purely the number of competitors. The interpolation is calculated from a trend line based on points which assume equal market shares for all operators in an *n* operator market – a basic assumption of the Cournot model.[42]

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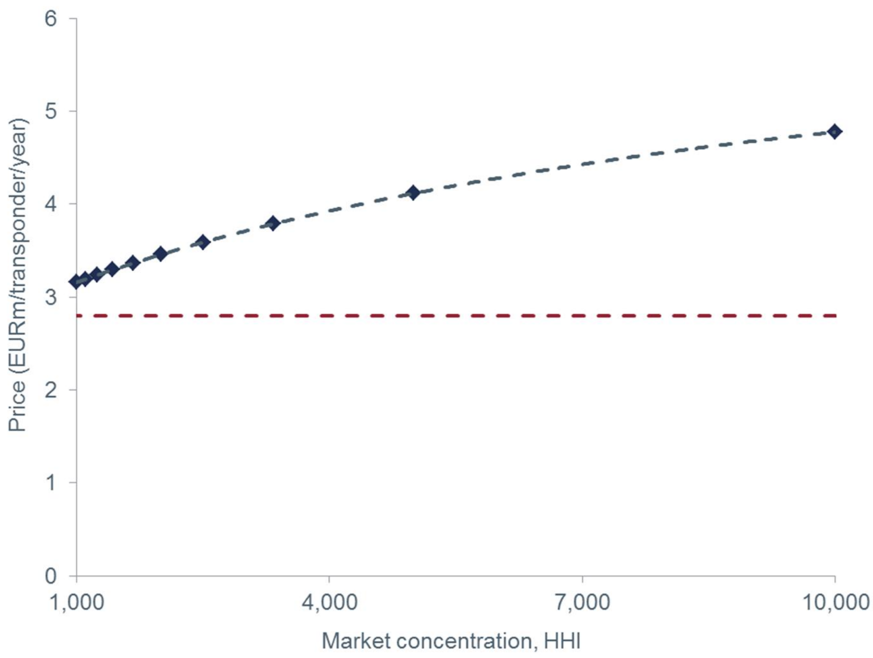
40 With the exception that local DTT channels will not be replicated on satellite.

41 Point Topic report for the European Commission, 'Broadband coverage in Europe in 2012', 2012.

42 Balkenborg, 'Cournot Oligopoly with n firms'.

Figure A-5: Graph of 2015 price as a function of HHI [Source: Aetha]



The model parameters are calibrated to produce the estimated price in 2015 given the current average HHI value across Europe (~4400). We assume, for the satellite transponder market, a choke price (i.e. the theoretical maximum price, at which there would be no subscribers) of EUR6.75 million per year and a cost of supply of EUR2.80 million per year. The calculated percentage increase in price is then used as an input to our supply and demand analysis. Note that the percentage change we obtain is a re-blended national figure, weighted by the number of households within each geographic zone.

A.2.2 Economic impact model

For the pay-television market, we determine the absolute increase in the cost of supply from the predicted percentage price change, in conjunction with the assumption that distribution costs comprise 11% of revenues[43]. We then calculate the economic impact from passing on these additional costs to consumers. We achieve this through a supply and demand analysis, for which we make certain assumptions to define the market.

The demand curve is derived from the expenditure per user[43] forecast and subscriber numbers, along with a price elasticity of demand (i.e. how the subscriber numbers would react to a change in the price of the service). We assume the price elasticity to be -0.55, which is a 'symbolic average' of estimates from a variety of studies, as is suggested by a recent survey by Benzoni & Deffains[44]. Note that for simplicity, we conservatively assume the demand curve to be linear. This is likely to underestimate the size of the consumer surplus as the gradient of the curve is likely to be steeper at higher prices.

From the linear demand curve for 2015 we infer a choke price. Demand curves for the years following 2015 are then based on a forecast of the choke price, which we have assumed to follow the same trend as

43 Ofcom, 'Pay TV market investigation', February 2008.

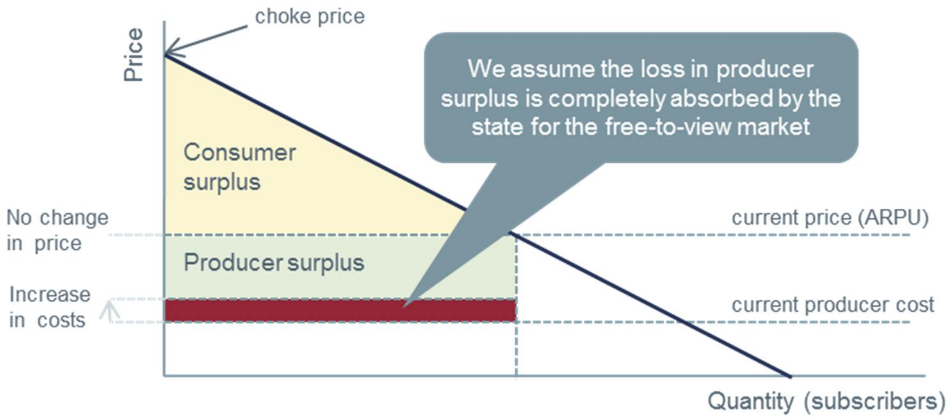
44 L. Benzoni & B. Deffains, 'Market Homogenisation or Regulation Harmonisation? The Welfare Cost of a European Mobile Market without the Later Entrant Operators', 2012.

the expenditure per user (yearly decrease of 1%), in part to reflect the decreasing value of the service as it increases in age and substitute services appear.

From the demand curve, predicted price impact and marginal cost (assumed to be 50%) we can then calculate the producer and consumer surpluses.

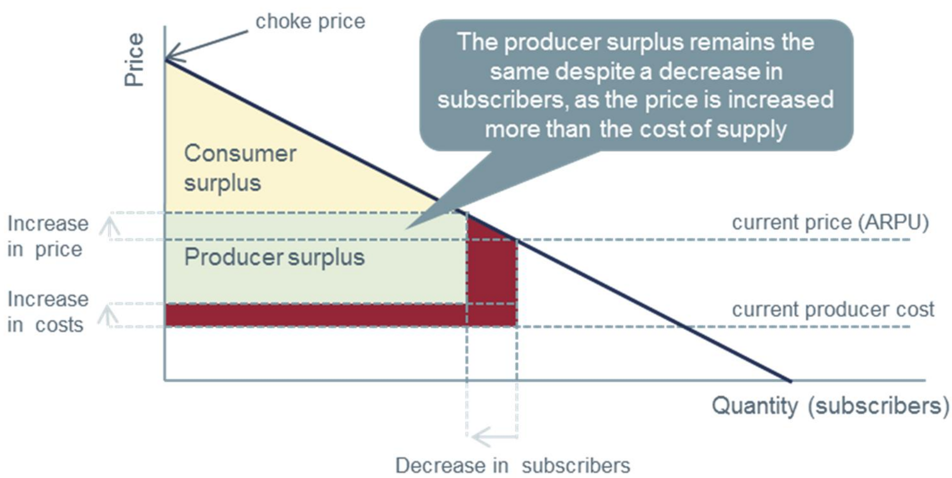
For the free-to view market, we assume the loss in producer surplus is completely absorbed by the State, as a *lower bound* to the economic impact. There is thus no change in consumer prices – i.e. consumer surplus remains constant.

Figure A-6: Illustration of the competition impact on the free-to-view market [Source: Aetha]



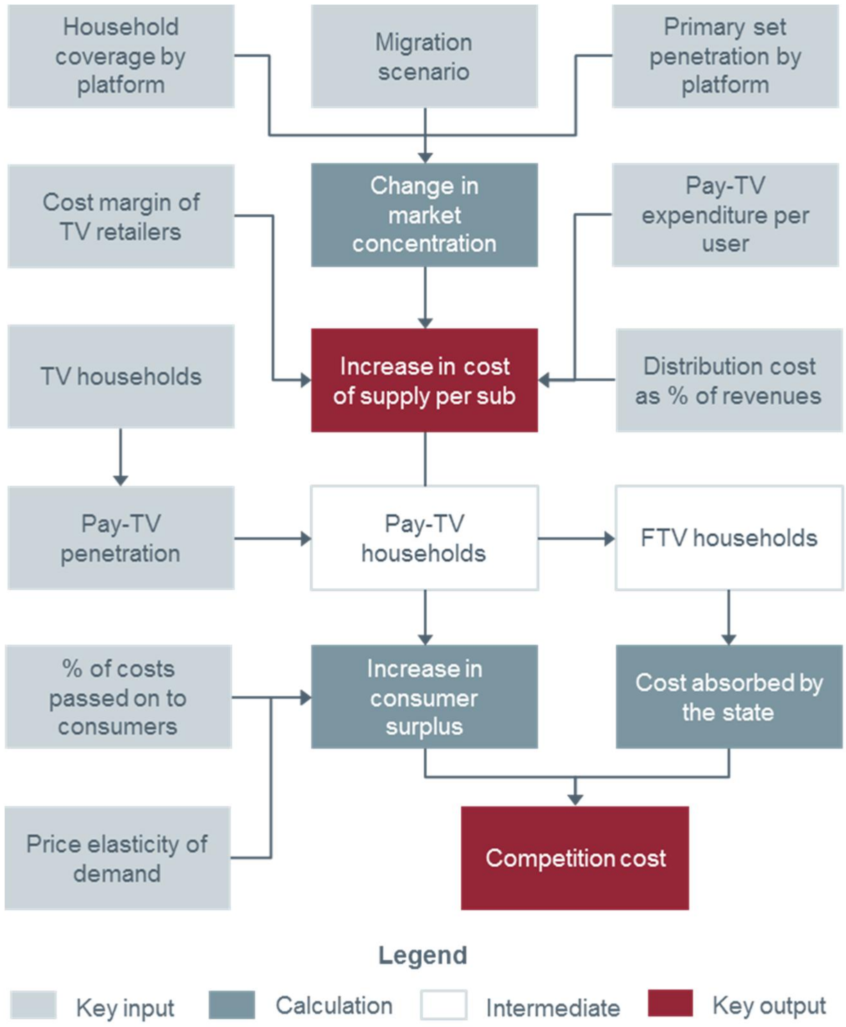
In the pay-television market however, we assume that 100% of the costs are passed on to consumers, such that the producer surplus remains constant, whilst consumer surplus is reduced. This occurs in spite of a decrease in the number of subscribers, as the price is increased more than the cost of supply.

Figure A-7: Illustration of the competition impact on the pay-television market [Source: Aetha]



The diagram below details the full methodology and inputs used in our competition cost calculation.

Figure A-8: Calculation flow for the economic impact from the reduction in platform competition [Source: Aetha]

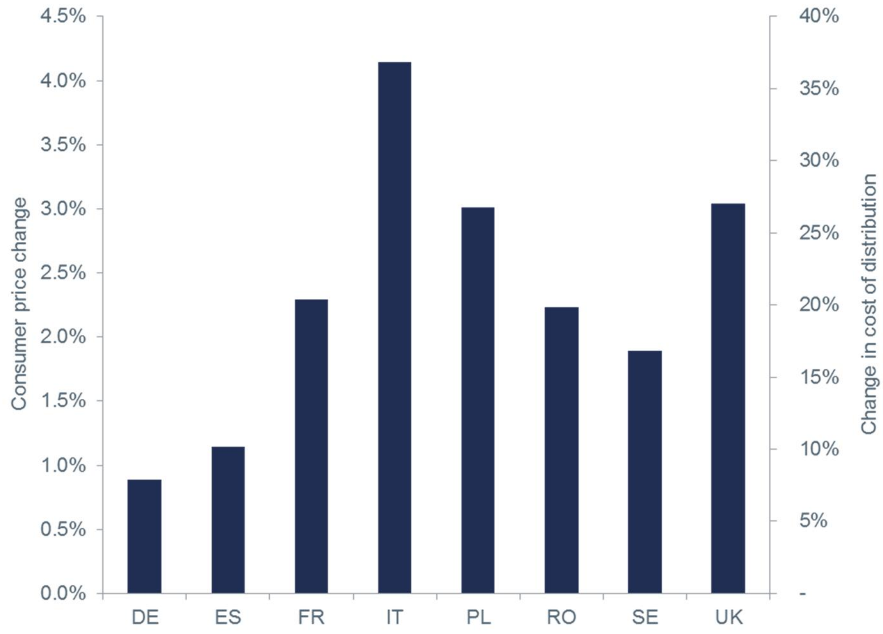


The sum of impacts to the pay-television and free-to-view markets constitutes the overall economic impact of the reduction in platform competition. Naturally, the relative magnitude of these two components varies significantly with pay-television penetration.

A.2.3 Results

As expected, the reduction in platform competition between each of the case study markets varies considerably. This can be seen in the figure below.

Figure A-9: Results of Cournot competition model [Source: Aetha]



The competition impact from the loss of DTT is greatest in Italy, as there is minimal penetration of cable and IPTV services. Thus we find that the loss of the DTT platform reduces the market to a satellite monopoly in most areas of the country. Similarly in France, for those households without cable or IPTV coverage, satellite becomes the only available platform. In the UK, there is significant loss of competition in areas without cable coverage (about half of UK households), where the migration of DTT viewers onto satellite leads to a dominant market share over the sole alternative (IPTV).

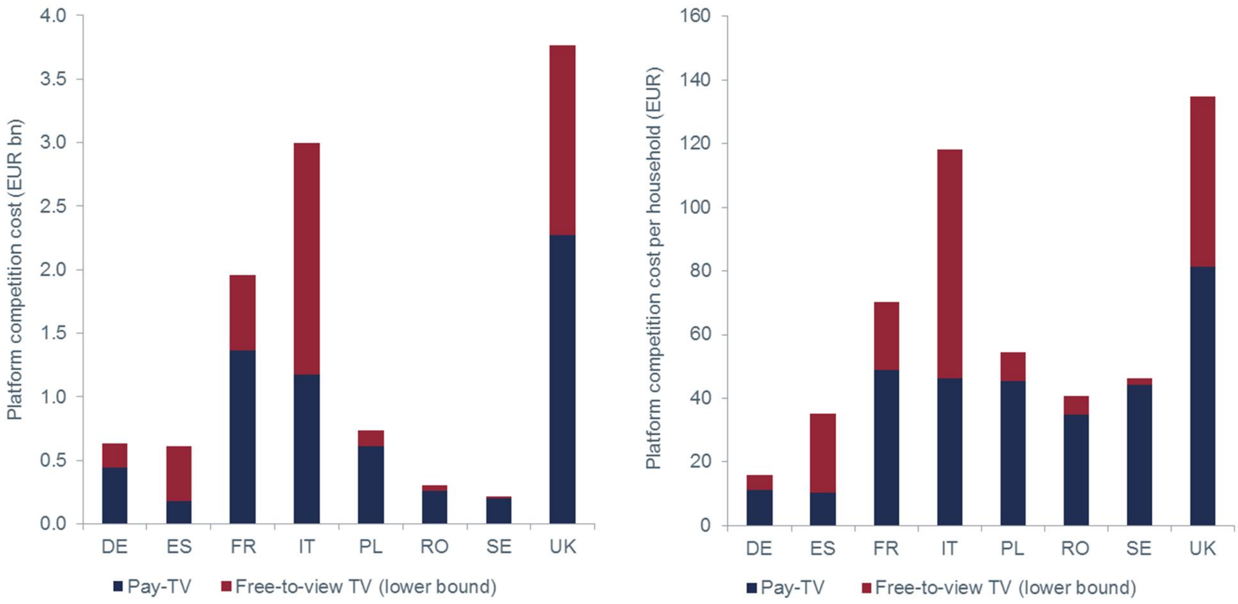
In Germany, the DTT viewer base is not large enough to have significant market impact upon migration. Despite having one of the highest penetration rates of DTT usage in households, Spain has the second lowest reduction in competition. The Spanish television market has high DTT penetration, with the DTT platform accounting for ~80% of households' primary television sets. Thus the migration of these households onto the alternative satellite platform (which has an existing share of 9%), represents little change in overall competition – one strong platform is replaced by another.

There has been recent consolidation in the Spanish market with Telefonica buying Digital+ (IPTV/satellite consolidation) and Vodafone buying Ono (IPTV/cable consolidation). The competition impact of this is however very small, as each of these platforms make up only a small proportion of households. Furthermore, whilst there might be indirect competition impacts in other parts of the value chain (e.g. at the retail level), we have considered this qualitatively in our overall assessment.

Applying the price change to our supply and demand analysis we calculate the economic impact from the reduction in platform competition for each country.

The total impact of reduced competition across the EU, after assigning the remaining countries to our case studies, is estimated to be EUR14.2 billion.

Figure A-10: Cost of reduction in platform competition from migration to alternative platforms [Source: Aetha]



Despite not producing the largest price change, the overall economic impact is greatest in the UK, due to the high relative average expenditure per household on television services. The proportion of costs resulting from free-to-view/pay-television varies between countries due to differing penetration rates of pay-television. In Sweden for example, pay-television penetration is 95%[8].

A.3 Cost savings from switching off DTT

Following the migration of viewers to alternative platforms, DTT transmissions would be switched off and the spectrum released for mobile services. Therefore, as well as the costs incurred by migrating consumers, we must also consider the benefit of the *avoided* costs of running the DTT network – i.e. those costs which would otherwise be incurred in our reference case – continuation of the DTT platform.

A.3.1 Approach

Both our scenarios consider cases in which DTT transmissions on the current high-power, high-tower network are switched off. This incurs decommissioning costs. However, there is also the benefit of the now *avoided* DTT costs that include:

- Network operating costs (opex)
- Business as usual capital expenditure (capex)
- Additional capex from expected upgrades to the network over the 15-year period – e.g. introduction of next generation technology – this is modest relative to the consumer equipment costs of set top box upgrades.

For each of these costs, it is important that we consider only the specific costs associated with DTT transmissions, since other services such as radio also operate on the same tower footprint. The costs of radio to broadcast to consumers are effectively shared with DTT, therefore unless a decision were made to transition radio technologies as well, a proportion of the costs currently attributed to DTT would continue. We therefore assume that radio will continue to operate on the existing transmission infrastructure, whilst

DTT will cease. As a result only active equipment specific to DTT is decommissioned, including any repeater sites not used for the transmission of radio.

Indeed, the counterfactual scenario of decommissioning the entire network and ceasing radio transmission would represent an even greater cost. For universal coverage, radio requires a terrestrial platform. Therefore, the cessation of radio transmissions on the current high-power, high-tower network would require a migration onto an alternative terrestrial network at substantial additional cost in order to prevent the loss of services.

We do not account for the impact of amortising DTT equipment faster than was expected (i.e. writing-off network assets). This effect would have a negative impact on the profit and loss and balance sheets of the terrestrial broadcast network operators, but are sunk costs (since the equipment has already been deployed) and therefore cannot be avoided. Therefore, they are not included in our economic assessment.

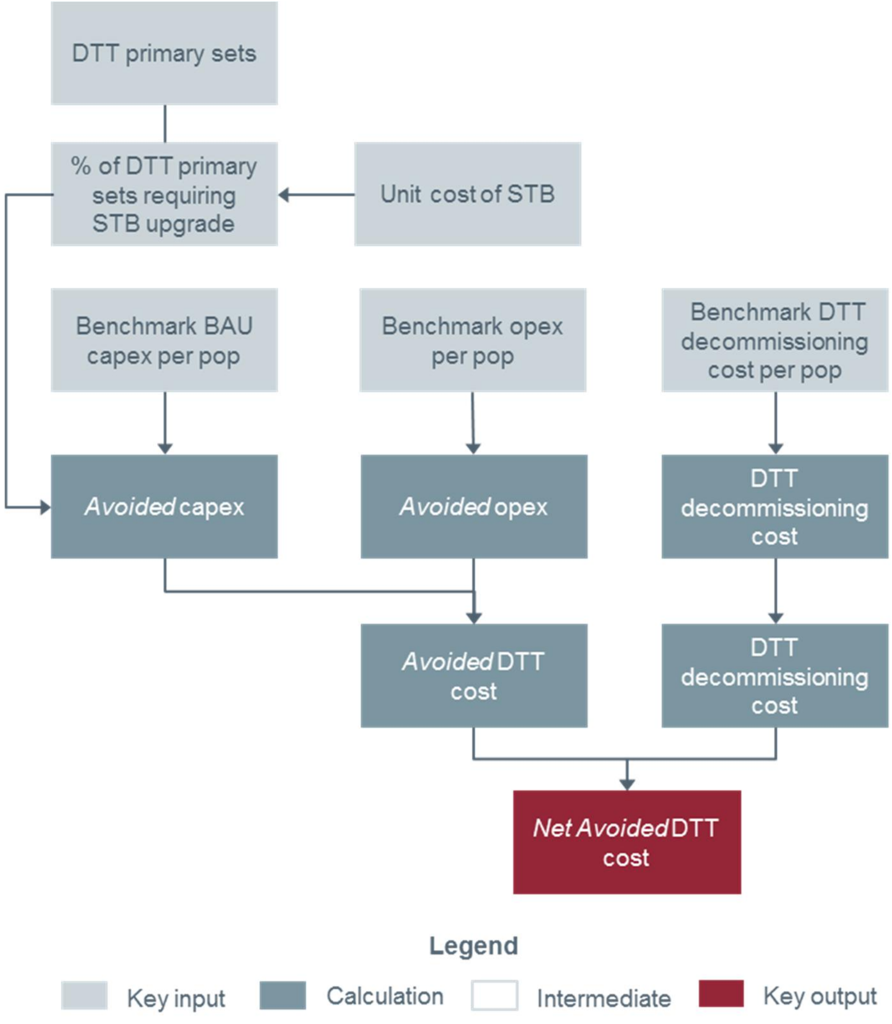
In order to provide a benchmark for these costs, we were provided with data from broadcast network operators in six of our case study countries (France, Germany, Italy, Spain, Sweden and the UK). This data provides an estimation of the annual avoided DTT opex and business as usual capex under the assumption that the 700MHz band has already been cleared prior to the displacement of DTT services from the 470–694MHz band. In addition, we were provided with estimations for the decommissioning cost of DTT equipment. For the purpose of anonymising this commercially sensitive data, we have aggregated the total cost and distributed it over our case study countries by population and the number of multiplexes deployed. Consequently the individual country data on net avoided DTT costs that is presented in this report is a scaling of average values of avoided DTT costs and decommissioning costs across six European countries rather than the input information we received for that country.

Note that when both calculating and applying these cost benchmarks, it is important that the multiplexes in each country are comparable on a cost basis. For example, in Italy there are 19 multiplexes in operation, however only a few of these have truly national coverage of >95%. Similarly, in Germany there are six multiplexes, however three of these are available only in metropolitan areas. In these cases, we therefore estimate the number of effective national multiplexes when scaling our DTT costs.

In addition to these costs, we also consider the avoided capex resulting from expected upgrades to the network, such as the introduction of next generation technologies comprising both network and CPE costs. Network upgrade costs will be modest relative to the CPE costs of set-top box upgrades, for which we assume a unit cost of EUR50. In order to estimate the percentage of DTT households requiring an upgrade, we use HDTV penetration[37] as a proxy.

To obtain a NPV for each cost, we apply the appropriate discount rate dependent upon the year(s) in which the cost is incurred. We also inflate opex and business as usual capex at 2% per year. Given an assumed release of spectrum for mobile services in 2018, decommissioning costs are incurred in 2018. For CPE capex costs we assume a three-year transition period with 33% per annum upgrades.

Figure A-11: Calculation flow for the cost savings from switching off the DTT network [Source: Aetha]

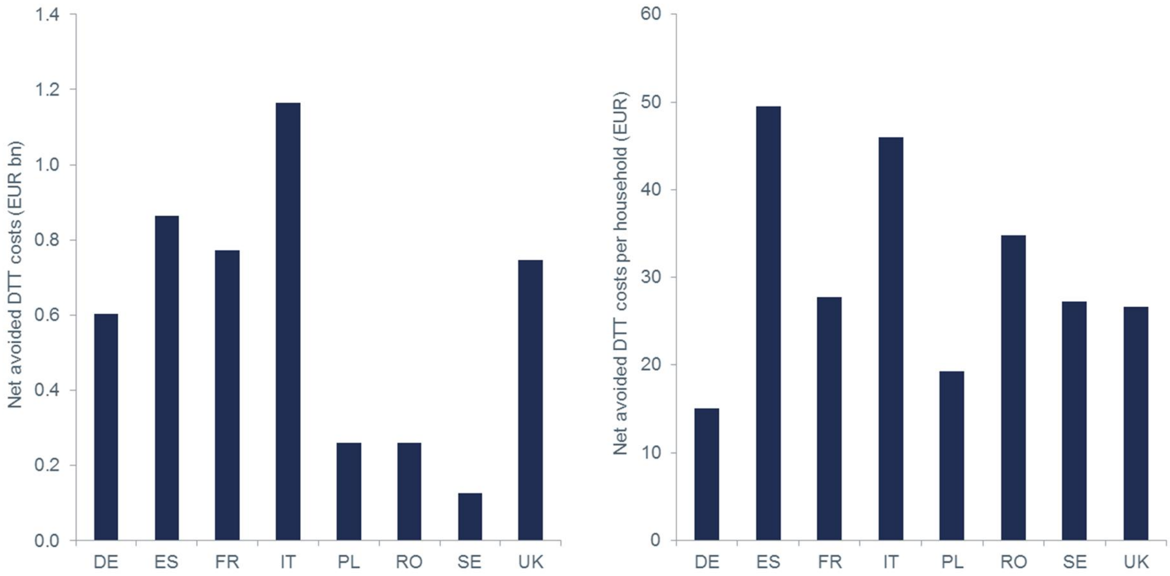


A.3.2 Results

As can be seen in the figure below, the avoided DTT capex costs scale largely with the number of DTT households since they are dominated by the CPE costs of set-top box upgrades. The opex costs are the most significant of the avoided costs and are greatest for Italy. As expected, Poland, Romania and Sweden have lower costs due to their much smaller populations. Notably however, Germany shows the smallest overall cost per household due to the smaller number of national coverage multiplexes deployed.

The total decommissioning cost for the EU, after assigning the remaining countries to our case studies, is EUR0.5 billion. This is a small component of the overall avoided cost of EUR6.7 billion.

Figure A-12: Net avoided costs (avoided costs less decommissioning costs) from switching off DTT [Source: Aetha]



A.3.3 Other impacts from the loss of the DTT platform

Despite the cost savings from switching off the DTT platform, there are a number of negative impacts from the loss of the platform which, though not included in our quantitative assessment, should be considered as further costs of migration. These are explained in detail in Section 5.2, and include the following:

- Spectrum not available for Programme Making and Special Events users
- Spectrum not available for white space applications
- Spectrum not available for radio astronomy
- Loss of access to local television services
- Losses due to consumers' preference for DTT.

Annex B Benefit of using 470–694MHz spectrum for mobile services: detailed approach

This annex discusses our approach to the assessment of the economic benefits resulting from the use of 470–694MHz spectrum for mobile services, should the whole band, currently used for Digital Terrestrial Television (DTT), be made available to mobile network operators. In Section B.1, we first provide some background to the use of spectrum bands for mobile services in Europe. In Section B.2, we then discuss in detail the inputs and methodology used in our economic valuation. In Section B.3, we present the results of our analysis.

B.1 Background

In the last few years, many European mobile operators have begun to roll-out Long Term Evolution (LTE) technology across their networks, enabling them to offer faster mobile broadband services to consumers. Data traffic is forecast to grow significantly over the coming years, thus as the consumer appetite for data continues to increase, it is necessary for mobile operators to invest in their networks, in order to ensure that they have sufficient capacity to meet this demand.

A mobile network operator (MNO) will typically have base stations deployed to provide coverage to the majority of the population, however whilst providing coverage, they may not be able to meet the demand on capacity. Note that since we are concerned only with low-frequency spectrum, we assume a fixed proportion of overall traffic that must be carried by a low-frequency layer. In this case, there are two options available to the network operator in order to increase capacity:

- build additional sites
- deploy additional spectrum bands on existing sites.

The amount of traffic that a site can carry (over a specific time period) is approximately proportional to the amount of spectrum (MHz) that is deployed on it. The addition of spectrum bands to sites is typically more cost-effective than building and maintaining additional sites. Thus the availability of new spectrum bands for mobile services can represent significant cost savings for operators and is therefore a key part of the solution to coping with expected growth in traffic.

At WRC-15, additional spectrum bands are expected to be announced as having mobile services as their primary allocation in Europe. With this in mind, we attempt to value the marginal economic benefit of releasing the 470–694MHz band for mobile use throughout the European Union's 28 member states.

B.2 Methodology for calculation of economic benefit

The value of the spectrum to mobile services is derived by calculating the network cost savings that a MNO in a theoretical country would have, and then calculating the benefit to consumers resulting from the passing on of these savings in the form of reduced prices. We now discuss this methodology in more detail along with the key assumptions made.

B.2.1 Overview of approach

If the 470–694MHz band were allocated to mobile, the new spectrum could be installed on existing sites – thus increasing the capacity per site and decreasing the number of new sites needed to meet increasing traffic demands. The avoided building and operating costs of these sites, represents a network cost saving which leads to an increase in producer surplus – i.e. the profit earned by the network operators.

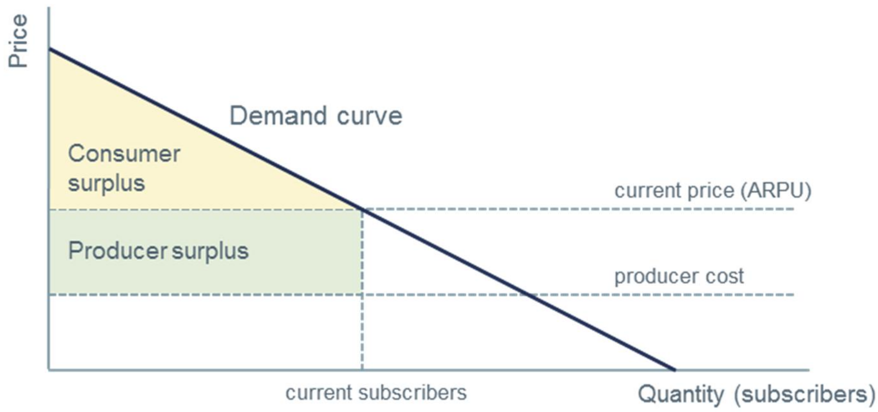
Our network cost calculations concern the cost of expansion for a generic MNO in a theoretical EU country, which we assume to have the following properties:

- a steady population of 50 million
- three MNOs, each with equal market share
- a current site grid of 10 000 sites for each operator, in order to provide sufficient coverage and carry current traffic levels.

In order to calculate the cost savings to the MNO, we consider the difference between the network costs with and without 470–694MHz spectrum.

In a competitive market, the MNOs would lower their prices in line with these cost savings, in order to retain market share. Thus for each year of the modelling period, we transfer the gain in producer surplus to a gain in consumer surplus (i.e. the difference between consumers' willingness to pay for the service and the prices actually paid). The concepts of producer and consumer surplus are illustrated in Figure B-1 below.

Figure B-1: Illustration of consumer and producer surplus [Source: Aetha]

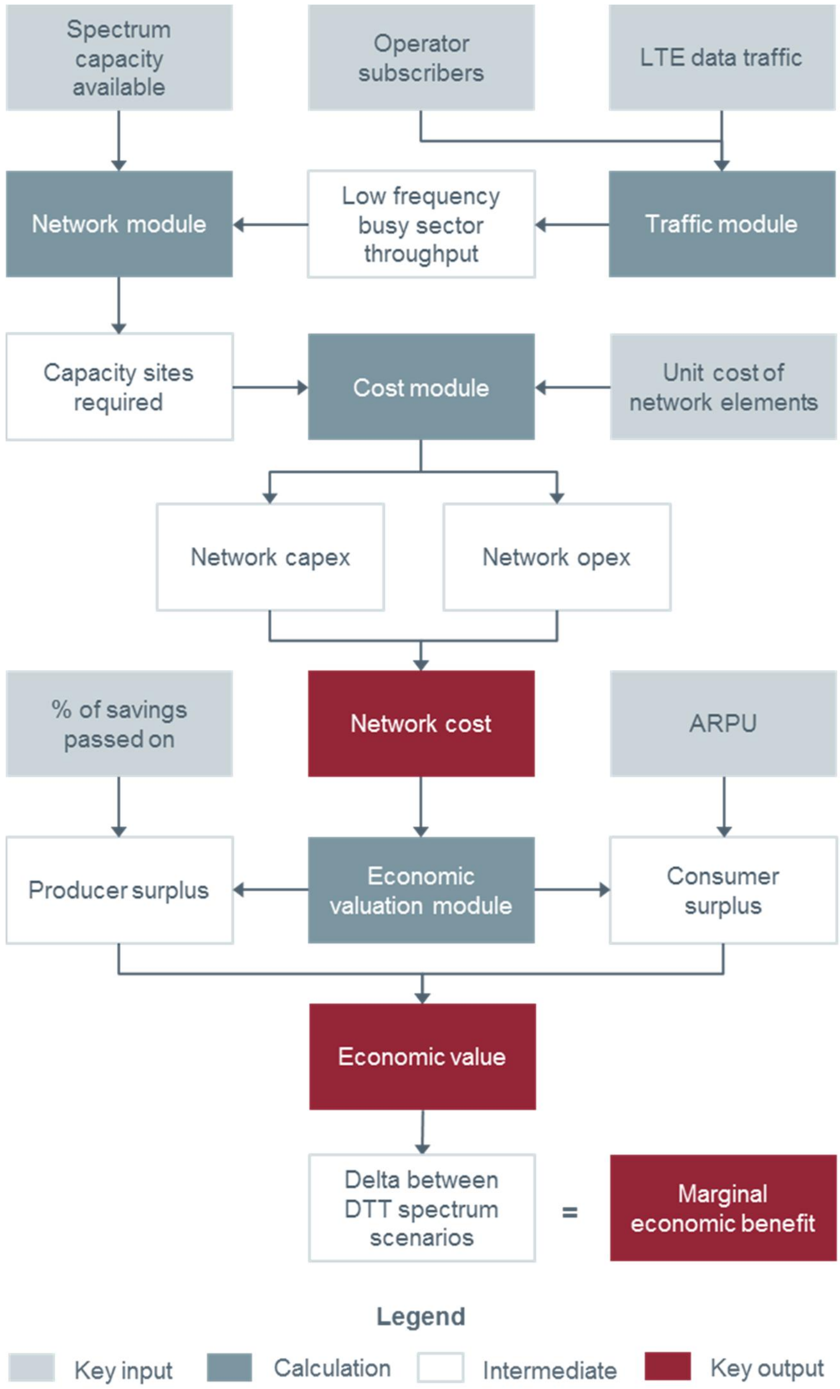


The consumer surplus is calculated at a market level for our theoretical country and then scaled by population to the EU. The difference in consumer surplus compared to our reference case thus represents the total economic benefit of the released spectrum to the EU in each year.

Our modelling period runs for 15 years from 2015–2029. This allows us to compare the economic benefit resulting from the continued use of 470–694MHz spectrum for DTT until 2030. For our net present value (NPV) calculation we sum over the period using a social discount rate of 3.5%.

The figure below provides an overview of our calculation methodology. From our traffic forecasts and the available capacity per site, we calculate the number of sites required to meet demand. From this we determine the network cost savings resulting from access to the spectrum and subsequently passed on to consumers.

Figure B-2: Calculation flow of methodology [Source: Aetha]



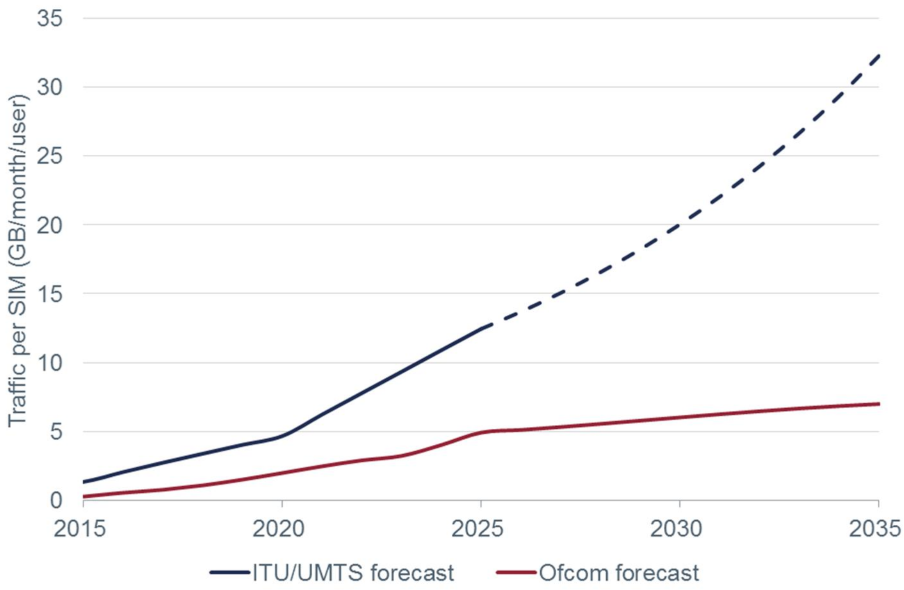
B.2.2 Traffic forecasts

The traffic forecast is a key driver in our calculations, since it is the increasing data traffic which necessitates the MNO to build additional sites and upgrade existing sites, in order to have sufficient LTE capacity in its network to meet this demand.

We use two forecasts in our model. One identical to that used in our previous study for the GSM Association[45], which is based on forecasts from the ITU and UMTS Forum, and another used by Ofcom in its assessment of the value of the 700MHz band[2].

Combining the population of the theoretical country with the operator's market share and a forecast of mobile SIM penetration gives the number of subscribers (i.e. the number of active SIMs) that the operator has each year. We have assumed that mobile penetration in the EU increases from 128% in 2011[46], to 170% by 2025, remaining constant thereafter. This is in line with our study for the GSM Association.

Figure B-3: Traffic forecast per SIM for theoretical EU operator [Source: Aetha, based on forecasts from the ITU, UMTS Forum and Ofcom]



The operator's traffic is then split into downlink and uplink during the busiest hour of the day on the busiest sector of each site, as this is the traffic that will constrain the operator and hence the traffic that the operator will dimension their network based on. We have assumed the following percentages for these parameters, based on knowledge of the network measurements of various operators:

- 80% of traffic is assumed to be downlink traffic
- 10% of the daily traffic is assumed to occur in the busiest hour of the day
- 55% of a site's traffic is assumed to occur in the busiest sector of the site.

B.2.3 Importance of low-frequency spectrum

Sub-1GHz spectrum offers the additional opportunity of cost reduction for MNOs due to its superior propagation characteristics. Thus for each site, there is a certain area which lies outside the coverage of supra-1GHz spectrum, but inside that of sub-1GHz spectrum.

We have assumed that sufficient high-frequency spectrum will be made available for capacity purposes to meet the growth in mobile demand. Indeed, even in a scenario where there was a shortage of

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45 Aetha Consulting report for GSM Association, 'Economic benefits from making the 2.7-2.9GHz band available for mobile broadband services in Western Europe', June 2013.

46 GSM Association, 'European Mobile Industry Observatory 2011', November 2011.

high-frequency spectrum to meet capacity demands – the opportunity cost of freeing spectrum at higher frequencies is much lower than for lower frequencies. Therefore it is not appropriate to consider capacity benefits from traffic that could be met by higher frequencies.

Since we are therefore only interested in traffic demand on low-frequency spectrum, we assume that:

- 20% of traffic is carried over low-frequency spectrum.

This figure accounts for the fact that the majority of traffic is likely to be generated in urban areas where there is good high-frequency coverage due to denser networks. As a result, the overall proportion of national traffic that needs to be covered by the low-frequency layer should represent a minority of the total.

From application of this and our other parameters to the traffic forecast, we obtain the busy sector throughput in Mbit/s, for low-frequency downlink traffic, during the busy hour.

B.2.4 Low-frequency spectrum capacity available to operators

The amount of spectrum available to operators is a key assumption since it determines the capacity of sectors on an operator's sites. We include all paired low-frequency (sub-1GHz) spectrum currently available for LTE use (i.e. the 800MHz band), as well as that likely to become available in the near future. The amount in MHz, as well as estimated timings of availability is summarised in the table below. We consider two scenarios for the future use of 470–694MHz spectrum: 1) the continued use of all spectrum for DTT; 2) the migration of DTT viewers to alternative platforms, with a subsequent release of all 224MHz for mobile.

Figure B-4: Low-frequency spectrum available to a theoretical MNO [Source: Aetha]

Band	Total spectrum available for mobile (MHz)	Spectrum assigned to operator for LTE (MHz)	Timing of availability
900MHz	70	10	2016
800MHz	60	20	Already available
700MHz	60	20	2018
*470–694MHz	0 / 224	0 / 74	2018

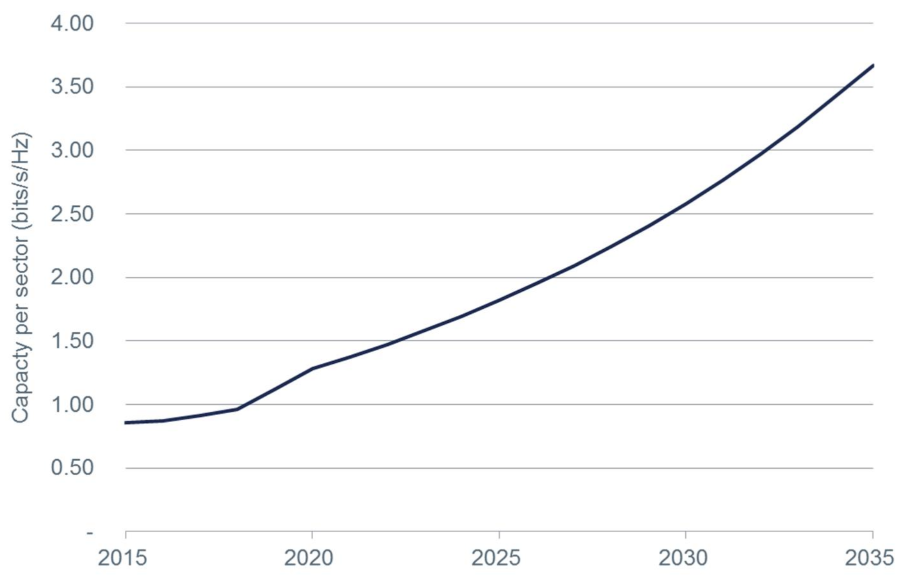
*All spectrum for DTT / all 224MHz for mobile

Note that since LTE spectrum is typically deployed in 2×5MHz blocks, we assume that each operator obtains a third of the available blocks. The notable exception is the 900MHz band. This is because we assume that each operator is only able to re-farm one block, due to legacy requirements for the continuation of GSM services. We also assume the release of the 700MHz band, currently occupied by digital terrestrial television in many countries.

As well as the amount of spectrum, an additional factor which determines site capacity available to operators is the spectral efficiency of the carrier (transmitter), since this dictates the amount of traffic which can be carried over its bandwidth. In a study for Ofcom regarding "*4G capacity gains*" [47], Real Wireless forecasts the expected increase in spectral efficiency from 2014-2020 resulting from improvements in technology and utilisation. By extrapolating at the overall CAGR from 2014 to 2020, we obtain an extended forecast which we utilise in our calculations.

[47] Real Wireless, 'Report for Ofcom: 4G Capacity Gains', 27 January 2011.

Figure B-5: Spectral efficiency of LTE [Source: Real Wireless, Aetha]

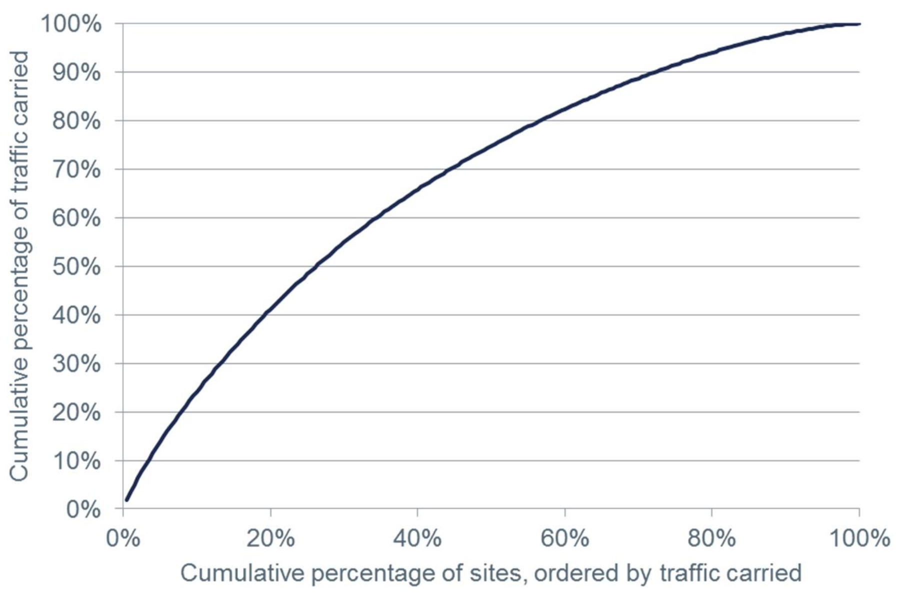


Note that this is the same forecast assumption used in our previous study on the value of 2.7-2.9GHz spectrum for the GSM Association.

B.2.5 Distribution of traffic over sites

The traffic is distributed amongst the operator's sites by splitting the total number of sites into 200 groups (percentiles of 0.5%), with similar traffic levels within each group. The distribution used as shown in Figure B-6 is based on knowledge of the traffic distribution across the sites of various relevant operators.

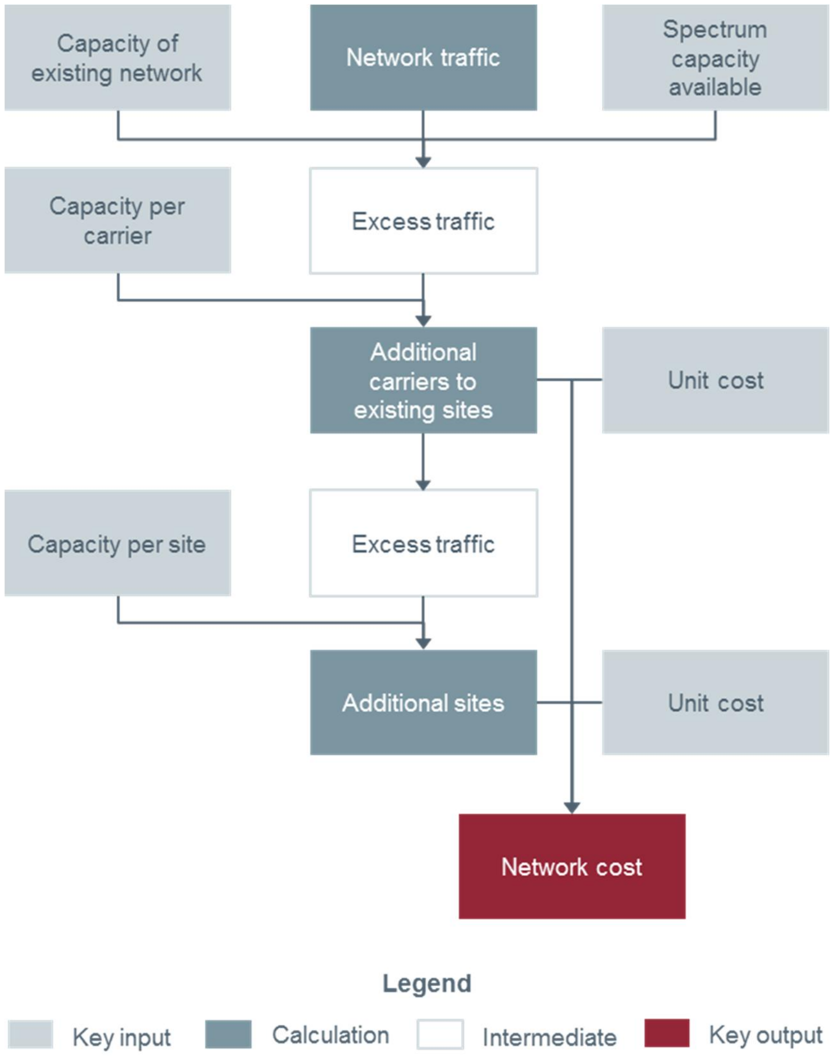
Figure B-6: Distribution of traffic over operator sites [Source: Aetha]



Note again that this is the same forecast assumption used in our previous study on the value of 2.7-2.9GHz spectrum for the GSM Association.

Having calculated the total capacity per site, our model then compares this to the total traffic and the distribution of traffic per site, in order to determine the additional carriers/sites required. A diagram of this calculation is provided in the figure below.

Figure B-7: Flow of capacity calculation [Source: Aetha]



B.2.6 Unit cost assumptions

The cost of building and operating the sites is then calculated using forecasts for unit costs. These are based on 2013 benchmarks of operators' costs combined with a predicted year-on-year price trend as displayed in the figure below (and are the same assumptions used in our study for the GSMA).

Figure B-8: Unit cost capex and opex assumptions [Source: Aetha]

Network cost element	Unit cost in 2013 (EUR)	Year-on-year price trend
New site capex	185 000	1.5%
New carrier (transmitter) capex	25 000	-2%
Site opex (per year per site)	13 000	2%
Backhaul capex (per site)	8000	-1%
Backhaul opex (per year per site)	2000	-

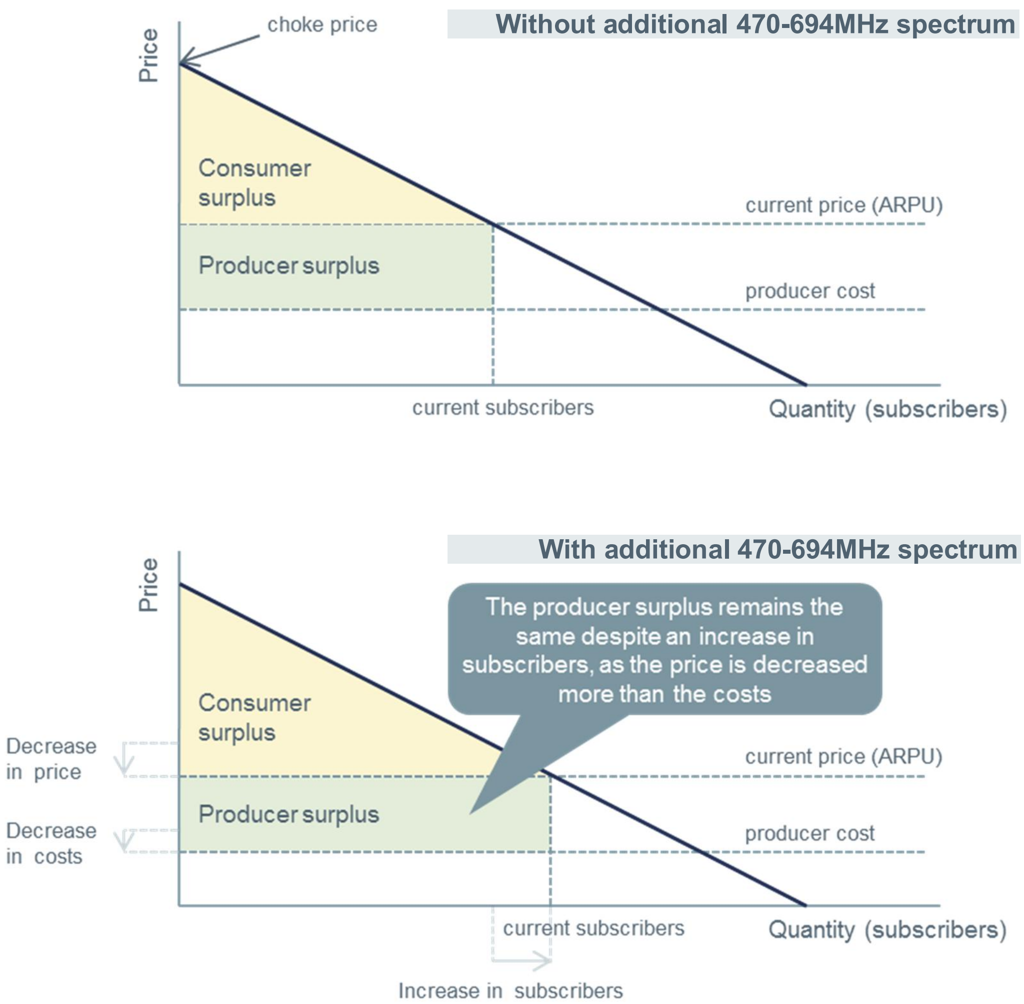
Applying these cost assumptions to the additional number of sites and carriers required for each scenario, we obtain values for the network cost savings between scenarios.

However, we also make adjustments to these costs to account for the impact of tower sharing. It is unlikely that all three operators would build out their new sites independently. We assume that 40% of new sites would in fact be shared with another operator. For these shared sites, capex would be 60% of that of a new site, and opex, 65%.

B.2.7 Passing of cost savings to consumers

In a competitive market, the MNOs would pass on these cost savings to consumers in the form of lower prices, such that one might expect the average revenue per user (ARPU) to fall by an equivalent amount. However, as the MNOs lower their prices, this also has the effect of attracting more subscribers. Hence operators, whilst maintaining a constant profit, are able to drop their prices by more than their cost savings. This is illustrated in the figure below.

Figure B-9: Producer and consumer surplus in the scenarios with and without additional DTT spectrum for mobile services [Source: Aetha]



It is worth noting that we have assumed the best case in respect of the cost savings of the mobile operators being passed on to consumers *in full*. In reality however, this may not necessarily be the case.

We have forecasted ARPU levels for our theoretical EU country. The 2011 ARPU (approximately EUR16.6 per month) is based on data from a Merrill Lynch study[48]. We have assumed a 1% decrease each

48 Merrill Lynch, 'Global Wireless Matrix 3Q11', 28 September 2011.

year until 2015, in line with current trends mainly due to decreases in mobile termination rates (though they are now levelling out). Between 2015 and 2020 we therefore keep nominal ARPUs constant before increasing by 1% each year thereafter, due to an expected upturn in the economic situation in Europe.

The demand curve can then be derived from the ARPU forecast and subscriber numbers for the theoretical market, along with a price elasticity of demand (i.e. how the subscriber numbers would react to a change in the price of the service). The value of -0.55 which we use is a ‘symbolic average’ of estimates from a variety of studies, as is suggested by a recent survey by Benzoni & Deffains[49].

From the demand curve for 2013 we have inferred a choke price (i.e. the price point at which there would be no subscribers). Demand curves for the years following 2013 are then based on a forecast trend of the choke price. We have assumed that the choke price follows the same trend as the ARPU, but with an additional decrease of 1% each year, to reflect the decreasing value of the service as it increases in age.

To calculate the producer surplus, we assume that operator costs are 50% of revenues, based on the current financial situation of various operators. We have assumed that an increase in subscribers does not affect the producer cost per subscriber (i.e. overall producer costs are proportional to the number of subscribers). With the producer surplus fixed and producer costs calculated, the demand curves then define both the current subscriber numbers and ARPU for each year. From this the consumer surplus is calculated.

The total consumer surplus over the 15-year period for each scenario is then discounted to give a net present value for 2015, using a social discount rate of 3.5%. This is calculated for the whole theoretical market and then scaled up to the EU by population. The difference between scenarios is the total economic benefit of the spectrum to mobile services.

[49] L. Benzoni & B. Deffains, ‘Market Homogenisation or Regulation Harmonisation? The Welfare Cost of a European Mobile Market without the Later Entrant Operators’, 2012.

B.3 Results

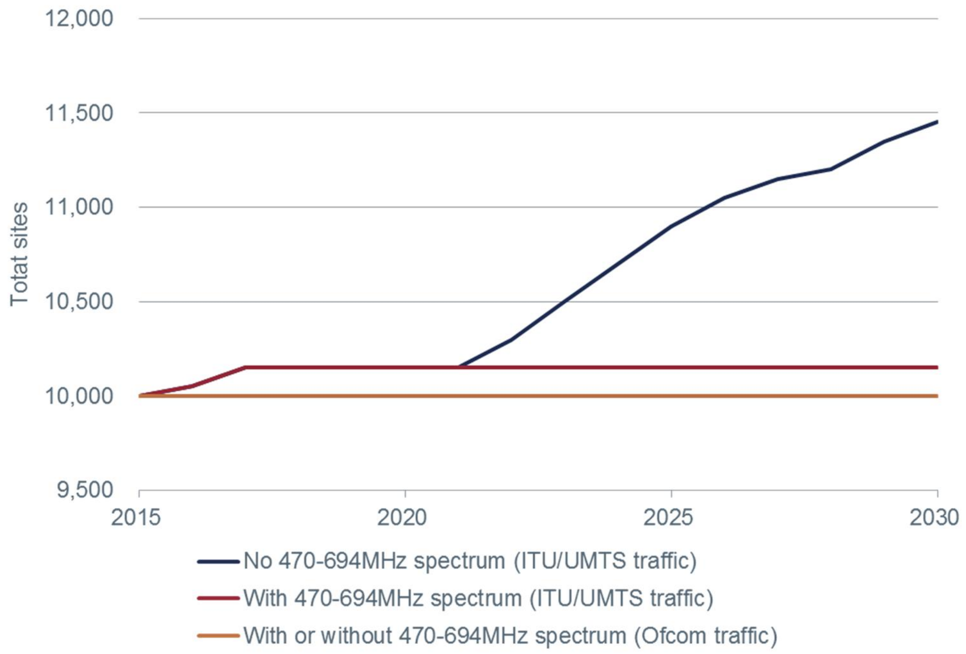
The table below summarises the main model outputs for the 15-year period under both traffic forecasts.

Figure B-10: Summary of key outputs from model [Source: Aetha]

Traffic forecast	ITU/UMTS forecast		Ofcom forecast	
	EU operator	Scaled to EU	EU operator	Scaled to EU
Additional sites required				
No 470–694MHz spectrum	1350	40 962	0	0
With 470–694MHz spectrum	150	4551	0	0
NPV of cost saving (EUR billion)				
No 470–694MHz spectrum	-	-	-	-
With 470–694MHz spectrum	0.23	6.92	0	0
	EU country	Scaled to EU	EU country	Scaled to EU
Economic benefit (EUR billion)				
No 470–694MHz spectrum	-	-	-	-
With 470–694MHz spectrum	1.0	**10.3**	0	0

Note that under the lower Ofcom-based traffic forecast, there is no economic benefit of the spectrum for mobile, since no new sites are required (as shown in the figure below) as the service is not capacity-constrained. Under the ITU/UMTS-based forecast however, the economic benefit to the EU of making the 470–694MHz band available for mobile use is shown to be around EUR10.3 billion over 15 years. We have also estimated the economic benefit in the event that traffic levels were at a level equivalent to the average of the ITU/UMTS and Ofcom-based forecasts – this amounts to EUR1.7 billion.

Figure B-11: Total capacity sites required by an EU country operator under each DTT spectrum scenario [Source: Aetha]



Annex C Case study countries: television market profiles

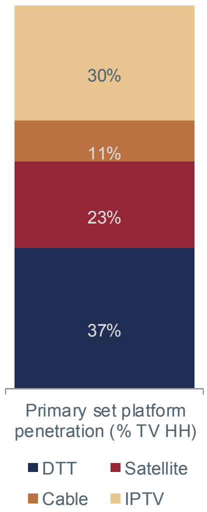
The characteristics of the television market vary considerably between countries, particularly with regards to the up-take of the different distribution platforms: digital terrestrial television (DTT), satellite, cable and IPTV. The benefits of DTT and the likely costs of migration to alternative platforms are therefore likely to also vary widely. In modelling these economic impacts, we use a case study approach, which looks at eight large European markets which are representative of the overall range in factors such as DTT penetration, availability of other platforms and relative wealth across the European Union.

In this Annex we provide short profiles of the television markets in our chosen case study countries, along with the country specific inputs used in our modelling.

C.1 France

C.1.1 Market overview

Figure C-1: Country specific inputs used in modelling [Source: Aetha]



Primary sets source: MAVISE 2012 Subscriber data
Secondary sets source: CREDOC 2013

Market inputs	UNITS		
Population	million	65.7	World Bank 2012
GDP/capita	PPP USD	36,104	World Bank 2012
Number of households	million	27.8	Eurostat 2012
TV penetration	% households	95%	Eurobarometer 2013
DTT primary sets	million	9.7	Aetha calculation primary set share data
DTT secondary sets	million	13.9	Aetha calculation secondary set share data
Platform competition inputs	**UNITS**		
Pay-TV penetration	% households	64%	International Communications Report 2013, Ofcom
Pay-TV expenditure per user	EUR/year	271	International Communications Report 2013, Ofcom
Platform coverage			
DTT	% households	97.5%	TDF
Satellite	% households	96.0%	Aetha estimate
Cable	% households	25.5%	Broadband Coverage 2012, European Commission
IPTV	% households	68.0%	Analysys Mason 2017 forecast
Migration cost inputs	**UNITS**		
Migration of DTT households			
DTT to satellite	% households	94.5%	Aetha estimate
DTT to cable (and IPTV)	% households	5.5%	Aetha estimate
CPE unit cost inputs			
Satellite installation cost	EUR	120	Aetha estimate
Cable installation cost	EUR	96	Aetha estimate
New platform cost inputs			
National SD	#	22	TDF
National HD	#	11	TDF
Number of regions	#	24	Aetha research
Regional SD	#	1	Aetha research
Regional HD	#	-	Aetha research
TOTAL (1HD~4SD)	#	90	
DTT channels available on FTV satellite?	YES/NO	YES	Aetha research (free channels only)

The digitisation of 100% of French households is largely due to the widespread adoption of the DTT platform, with analogue switch-off having been completed in 2011. DTT is currently the most popular platform, present in 58% of households and used exclusively by 37% of all primary sets (and enabled on 51% of primary sets as many are connected to multiple means of reception[50]). This is followed by IPTV, which is present in 41% of households and has a share of 30% of primary sets – the highest in Europe for IPTV. This may be partially due to the limited network of the alternative fixed line distribution method, cable, which is used in 11% of households. Satellite is the primary means of viewing television for 23% of French households. Pay-television take-up is 64% with a relatively high cross-platform ARPU of EUR271.

Household coverage for both the DTT and satellite platforms approaches 100%, whilst IPTV is expected to have country-wide coverage of 70% by 2017. Estimated cable coverage is just 26% of households.

C.1.2 DTT

In France, the DTT service Télévision Numérique Terrestre (TNT) consists of 25 free-to-air national channels (10 of them available in HD), in addition to eight national pay-television channels (one in HD). France 3 (part of state-funded France Télévisions) provides regional television in metropolitan France, with regional and sub-regional opt-outs via 13 regional stations and 25 regional news offices.[51]

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50 Conseil supérieur de l'audiovisuel (CSA) 2014.

51 Ofcom, 'Case studies on local and regional media outside the UK', September 2009.

In October 2011, the CSA issued a call for applications for six new HD channels on free-to-air DTT. The selected channels launched in December 2012 on two new multiplexes, R7 and R8, in the DVB-T standard and not the DVB-T2 standard originally planned by the CSA. In addition, these channels must be carried by the pay-television platforms: cable, satellite and IPTV.

C.1.3 Satellite, cable and IPTV

The cable market is highly concentrated with the main operator being Numéricâble (Civen and Altice), with more than 3.5 million subscribers. While Canal+ has long enjoyed a monopoly on the satellite television market after the merger of the CanalSat and TPS packages it now faces competition from several alternative packages: Bis (AB group) and Orange (France Télécom) as well as FRANSAT (Eutelsat) and TNTSat (Canal+), two packages that provide access to free-to-air DTT channels for households not covered by the terrestrial network and claim to reach more than 800 000 and 3.3 million households respectively.[52]

We assume therefore that all DTT channels are already replicated on the FRANSAT/TNTSat services.

According to the telecommunications and posts regulator ARCEP, two out of three internet subscribers (14.7 million homes) had the means to access an IP-based television service in Q1 2014.[53]

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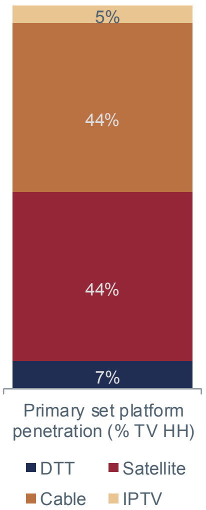
[52] MAVISE, 'Description of the French audiovisual market', November 2012.

[53] ARCEP, 'Observatoire des marchés des communications électroniques en France', 3 July 2014

C.2 Germany

C.2.1 Market overview

Figure C-2: Country specific inputs used in modelling [Source: Aetha]



Primary sets source: Digitalisierungsbericht 2013 Subscriber data

Secondary sets source: Aetha calculation

Market inputs	UNITS		
Population	million	81.9	World Bank 2012
GDP/capita	PPP USD	41,245	World Bank 2012
Number of households	million	40.1	Eurostat 2012
TV penetration	% households	96%	Eurobarometer 2013
DTT primary sets	million	2.7	Aetha calculation primary set share data
DTT secondary sets	million	3.2	Aetha calculation secondary set share data
Platform competition inputs	**UNITS**		
Pay-TV penetration	% households	64%	International Communications Report 2013, Ofcom
Pay-TV expenditure per user	EUR/year	157	International Communications Report 2013, Ofcom
Platform coverage			
DTT	% households	98.0%	Aetha estimate (for national multiplexes)
Satellite	% households	96.0%	Aetha estimate
Cable	% households	59.1%	Broadband Coverage 2012, European Commission
IPTV	% households	85.0%	Analysys Mason 2017 forecast
Migration cost inputs	**UNITS**		
Migration of DTT households			
DTT to satellite	% households	77.5%	Aetha estimate
DTT to cable (and IPTV)	% households	22.5%	Aetha estimate
CPE unit cost inputs			
Satellite installation cost	EUR	145	Aetha estimate
Cable installation cost	EUR	116	Aetha estimate
New platform cost inputs			
National SD	#	24	MAVISE
National HD	#	-	MAVISE
Number of regions	#	9	Aetha research
Regional SD	#	2	Aetha research
Regional HD	#	-	Aetha research
TOTAL (1HD~4SD)	#	42	
DTT channels available on FTV satellite?	YES/NO	YES	Aetha research (free channels only)

With over 40 million households, Germany represents the largest market by volume in Europe. According to the latest market research, cable (historically the leading platform) has been continuously losing ground in recent years, due to increasing pressure from satellite such that each now hold around 44% of the market[54]. Since 2012, DTT penetration amongst primary television sets has been around 7%. IPTV's market share has increased – though still behind the other platforms at 5%.

Across all platforms, pay-television take-up is 64%, driven largely by the subscription fees paid to cable services. Germany's average ARPU for television services is EUR188, significantly lower than that of its Western European neighbours. This is representative of the weaker pay-television market in Germany, where nearly 40% of total television industry revenues originate from public funding – in turn encouraging a strong market position for public (and ad-funded) free channels.[55]

Household coverage for both the DTT and satellite platforms approaches 100%, whilst cable also has extensive coverage of nearly 60%.

54 die medienanstalten, 'Digitalisierungsbericht 2013', September 2013.

55 Ofcom, 'International Communications Report', December 2013.

C.2.2 DTT

DTT is used by 11% of households (considering both primary and secondary sets), with a much higher penetration (circa 21%) in dense urban areas where more channels are available.

Because DTT is transmitted in a mode allowing portable reception, DTT is also received in nomadic or mobile receivers: At least 7% of television consumers stated that they own such a mobile device enabling reception of DTT. While travelling, 2.2% of the German television audience resort to terrestrial reception, and it is noteworthy that more than one million cars are equipped with a DTT receiver. Because these usages are quite specific to Germany, and their value is difficult to assess precisely, their value or cost of replacement by other platforms has not been included in the economic model.

Political support for modernisation of the DTT platform with the transition to DVB-T2 has been shown with its inclusion in the government coalition political program. The introduction of DVB-T2 would allow broadcasters to provide HD channels (currently available only on other platforms) and would increase the number of channels available in a number of areas, a key factor for DTT penetration.

All channels on the DTT platform are free-to-view (of which there are around 24). The German network hosts six multiplexes, however since three of these are available only in metropolitan areas, the channel offering can vary by location. The main PSB (ARD) is a joint organisation of seven regional television networks operated by nine regional PSBs. It provides a mixture of common, national and regional programming. The second German PSB organisation, ZDF does not carry regional or local content, however many Länder (i.e. German administrative regions) broadcasting bodies also offer so-called 'third channels' that provide regional-only programming.

C.2.3 Satellite, cable and IPTV

Technological developments are significant drivers of the changing competition in the market. Whilst there has been an evolution towards HD in satellite broadcasts (enabled by the utilisation of MPEG-4), 44%[54] of cable households still view their television over an analogue signal. Given that the analogue switch-off for terrestrial transmission occurred as early as 2008, and 2012 for satellite, the slow rate of digitisation on the cable platform is the reason for the overall penetration of digital television reaching only ~75%.

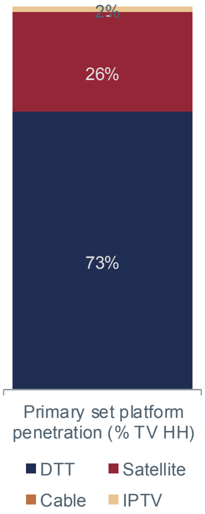
As in the UK, the German satellite platform provides two services: a pay-television service from Sky Deutschland and a separate free-to-view service.

We assume that the existing free-to-view satellite service fully replicates the DTT service.

C.3 Italy

C.3.1 Market overview

Figure C-3: Country specific inputs used in modelling [Source: Aetha]



Primary sets source: Subscriber data
Secondary sets source: Aetha calculation

Market inputs	UNITS		
Population	million	60.9	World Bank 2012
GDP/capita	PPP USD	33,134	World Bank 2012
Number of households	million	25.3	Eurostat 2012
TV penetration	% households	99%	Eurobarometer 2013
DTT primary sets	million	18.2	Aetha calculation primary set share data
DTT secondary sets	million	18.9	Aetha calculation secondary set share data
Platform competition inputs	**UNITS**		
Pay-TV penetration	% households	33%	International Communications Report 2013, Ofcom
Pay-TV expenditure per user	EUR/year	264	International Communications Report 2013, Ofcom
Platform coverage			
DTT	% households	98.0%	Aetha estimate (for national multiplexes)
Satellite	% households	96.0%	Aetha estimate
Cable	% households	2.0%	Broadband Coverage 2012, European Commission
IPTV	% households	53.0%	Analysys Mason 2017 forecast
Migration cost inputs	**UNITS**		
Migration of DTT households			
DTT to satellite	% households	100.0%	Aetha estimate
DTT to cable (and IPTV)	% households	-	Aetha estimate
CPE unit cost inputs			
Satellite installation cost	EUR	117	Aetha estimate
Cable installation cost	EUR	93	Aetha estimate
New platform cost inputs			
National SD	#	96	RaiWay
National HD	#	6	RaiWay
Number of regions	#	20	Aetha research
Regional SD	#	1	Aetha research
Regional HD	#	-	Aetha research
TOTAL (1HD~4SD)	#	140	
DTT channels available on FTV satellite?	YES/NO	NO	Aetha research (free channels only)

Following the analogue switch-off in 2012, digital take-up is now 100%. Regarding distribution, Italy is a country characterised by the predominance of terrestrial television. The DTT platform provides television to an estimated 73% of Italian primary sets, with 26% using the satellite platform and less than 2% using IPTV. Notably for a developed country, Italy has very limited cable infrastructure owing to historically tight regulation due to its potential as a competitor to the state-owned networks. Furthermore, the IPTV market largely collapsed in 2012 with Fastweb and Infrostrada TV (Wind) exiting the market and leaving only Telecom Italia. As a result, there is very little competition in the non-terrestrial platform market.

Italy has one of the highest audience concentrations in Europe, with the main channels of the two incumbent broadcasters (RAI and Mediaset) retaining over 75% of viewing. According to the communications regulator AGCOM, the two groups shared 85% of the resources of the national television sector in 2011. The channels operated by Sky Italia achieved a 6% market share and those run by Telecom Italia Media 4.1%.[56]

C.3.2 DTT

The Italian DTT platform offers more national free and paid channels than in any other European market. In November 2012, over 60 free-to-view channels and some 40 pay-television channels were transmitted on the national DTT network.

Overall pay-television take-up across all platforms in Italy is 33%, driven mostly by Sky's 4.8 million subscribers (19% market share). The service however does face stiff competition from pay-television

[56] MAVISE, 'Description of the Italian audiovisual market', November 2012.

packages on DTT, particularly the Mediaset Premium service (which, like Sky, holds rights to broadcast Italian football). In addition to the ~30 channels that it transmits, Mediaset Premium also offers its own on-demand television service, Premium Play. The next largest pay-television service is Europa 7 HD, which provides a package of 12 channels (8 in HD) transmitted using the DVB-T2 standard. Overall ARPU for the pay-television sector is around EUR317. Whilst not as high as the UK, it is arguable that prices could be lowered with greater platform competition.

C.3.3 Satellite, cable and IPTV

In September 2012, AGCOM's register of satellite licences contained 274 channels, of which most were available on Sky Italia's service. However, modelled on the Freesat package in the UK, Italy also offers a free-to-air satellite service, TivùSat which provides free access to the Italian free-to-view DTT channels. The company tivù S.r.l. is 48% owned by RAI, 48% by Mediaset and 4% by Telecom Italia. The package had 0.75 million subscribers at the end of 2010, which has since grown to 1.8 million (7% market share)[57].

Cable and IPTV services have little presence in the Italian market.

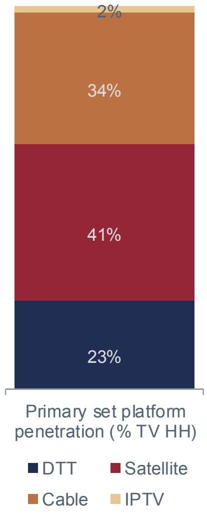
We assume therefore that all free-to-view DTT channels are already replicated on the TivùSat service, but not pay-television channels.

57 Telecompaper, 'Tivusat reaches 1.8 mln active subscribers', March 2013.

C.4 Poland

C.4.1 Market overview

Figure C-4: Country specific inputs used in modelling [Source: Aetha]



Primary sets source: Nielson, April 2014
Secondary sets source: Aetha calculation

Market inputs	UNITS		
Population	million	38.5	World Bank 2012
GDP/capita	PPP USD	22,162	World Bank 2012
Number of households	million	13.4	Eurostat 2012
TV penetration	% households	98%	Eurobarometer 2013
DTT primary sets	million	3.0	Aetha calculation primary set share data
DTT secondary sets	million	2.7	Aetha calculation secondary set share data
Platform competition inputs	**UNITS**		
Pay-TV penetration	% households	80%	International Communications Report 2013, Ofcom
Pay-TV expenditure per user	EUR/year	148	International Communications Report 2013, Ofcom
Platform coverage			
DTT	% households	98.0%	Aetha estimate (for national multiplexes)
Satellite	% households	96.0%	Aetha estimate
Cable	% households	34.0%	Broadband Coverage 2012, European Commission
IPTV	% households	67.5%	Aetha estimate
Migration cost inputs	**UNITS**		
Migration of DTT households			
DTT to satellite	% households	82.7%	Aetha estimate
DTT to cable (and IPTV)	% households	17.3%	Aetha estimate
CPE unit cost inputs			
Satellite installation cost	EUR	78	Aetha estimate
Cable installation cost	EUR	62	Aetha estimate
New platform cost inputs			
National SD	#	96	MAVISE
National HD	#	6	MAVISE
Number of regions	#	20	Aetha research
Regional SD	#	1	Aetha research
Regional HD	#	-	Aetha research
TOTAL (1HD~4SD)	#	140	
DTT channels available on FTV satellite?	YES/NO	NO	Aetha research (free channels only)

Following the conclusion of the digital switchover in 2013, the penetration of digital television stands at around 82%, due to the only partial digitisation of cable services. The new DTT platform holds a current market share of around 23%, with 34% for cable and 41% for satellite – the most popular platform for receiving television.

C.4.2 DTT

DTT is currently the only means of receiving free-to-view channels, which are broadcast over three national multiplexes offering 21 SD channels and 2 HD channels.[58] In addition there is a fourth multiplex, launched in 2012, which offers 8 channels on a subscription fee basis as part of a DVB-T ‘mobile’ television service (which can be viewed on regular television sets but also mobile devices using a separate mobile decoder). The service, known as TV Mobilna, is run by Poland’s leading satellite television provider, Cyfrowy Polsat, and costs around EUR4.5 per month.

C.4.3 Satellite, cable and IPTV

The pay TV market in Poland makes up 80% of all households, and is dominated by satellite and cable. The IPTV market, led by Orange Polska has a very small subscriber base and growth is slow due to technological constraints resulting from the lack of modern infrastructure and network capacity to provide high-quality and profitable services. Cable television was once the main form of access to pay-television services in Poland. Cable television operators focus on customers in densely populated areas, where

58 RSPG, ‘DTT survey questionnaire response’, September 2012.

extensive infrastructure already exists or can be developed at a relatively low cost per subscriber. National coverage is around 34% for cable. On the other hand, satellite operators are able to offer their services to customers in both urban areas, as well as less densely populated areas with non-existent or poorly developed cable television infrastructure, with no incremental costs.

Overall competition in the pay-television market is strong, and the blended ARPU of EUR178 is relatively low. The satellite market has consolidated in recent years having moved from four operators in 2011 to two dominant players in 2012: Cyfrowy Polsat and nc+. The nc+ platform was formed from a merger of the "n" and Cyfra+ services.[59] It was launched on March 21st, 2013, and has over 2.5 million subscribers at an ARPU of EUR190. Since 2006, Cyfrowy Polsat has been the market leader in terms of subscriber base and market share, with more than 3.5 million subscribers. Its service offers over 130 channels in Polish, including 36 in HD, as well as its own VOD and catch-up services. The cable television market (~4.6 million subscribers) comprises three main players, UPC Polska, Multimedia Polska and Vectra.[60]

No free-to-view satellite platform exists in Poland, therefore we assume the creation of a new service.

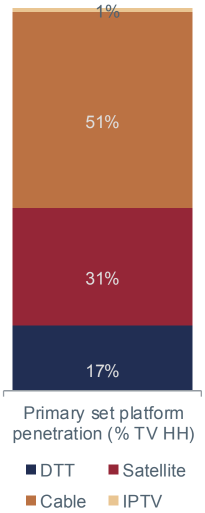
[59] MAVISE, ‘Description of the Polish audiovisual market’, November 2012.

[60] Cyfowry Polsat Investor Relations, ‘Industry Overview’, 2012.

C.5 Romania

C.5.1 Market overview

Figure C-5: Country specific inputs used in modelling [Source: Aetha]



Primary sets source: MAVISE Subscriber data
Secondary sets source: Aetha calculation

Market inputs	UNITS		
Population	million	21.3	World Bank 2012
GDP/capita	PPP USD	17,004	World Bank 2012
Number of households	million	7.4	Eurostat 2012
TV penetration	% households	98%	Eurobarometer 2013
DTT primary sets	million	1.2	Aetha calculation primary set share data
DTT secondary sets	million	0.4	Aetha calculation secondary set share data
Platform competition inputs	**UNITS**		
Pay-TV penetration	% households	83%	Aetha estimate
Pay-TV expenditure per user	EUR/year	148	Aetha estimate
Platform coverage			
DTT	% households	98.0%	Aetha estimate (for proposed multiplexes)
Satellite	% households	96.0%	Aetha estimate
Cable	% households	51.2%	Broadband Coverage 2012, European Commission
IPTV	% households	73.0%	Aetha estimate
Migration cost inputs	**UNITS**		
Migration of DTT households			
DTT to satellite	% households	73.9%	Aetha estimate
DTT to cable (and IPTV)	% households	26.1%	Aetha estimate
CPE unit cost inputs			
Satellite installation cost	EUR	60	Aetha estimate
Cable installation cost	EUR	48	Aetha estimate
New platform cost inputs			
National SD	#	7	MAVISE
National HD	#	-	MAVISE
Number of regions	#	6	Aetha research
Regional SD	#	1	Aetha research
Regional HD	#	-	Aetha research
TOTAL (1HD~4SD)	#	13	
DTT channels available on FTV satellite?	YES/NO	NO	Aetha research (free channels only)

The Romanian television market is characterised by a high penetration of cable usage – around 51%[61] of all households. This has been higher in the past, but has been eroded by an increase in satellite television services, which now account for around 31% of households[62].

C.5.2 DTT

Terrestrial broadcast television transmissions remain in the analogue format. The launch of DTT services has been subject to on-going delay. In August 2010, the regulatory authority ANCOM cancelled the procedure for allocating multiplex frequencies. A new strategy was agreed by the government in 2012 that paves the way for the launch of DTT. It will introduce 5 Multiplexes (4 UHF and 1 VHF) using the DVB-T2 standard. One multiplex will be allocated to the public service broadcaster. A tender process will take place to allocate the other multiplexes, with a planned switch-off of analogue services to take place in 2015. Romania's terrestrial platform currently offers just 7 channels (all free-to-view) and is used by 16% of households. The transition to DTT will thus allow for a significant increase in the channel capacity of the platform, which may increase the attractiveness of the platform in the future.

C.5.3 Satellite, cable and IPTV

Cable currently dominates the market, however only about 13% of homes have *digital* cable. The market is mainly split between two operators: RCS-RDS and UPC Romania. RCS-RDS is considered the main

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[61] Telecompaper, 'RCS & RDS claims 46.7% of internet market', November 2013.

[62] MAVISE, 'TV and on-demand audiovisual services in Romania', December 2012.

player in the market with 1.6 million subscribers at the end of 2011. In March 2012, UPC Romania had 856 500 subscribers of which about 44% had digital services. The other important player is Romtelecom (who recently took over AKTA and Nextgen). Cable television is very cheap, the standard/basic service, offering about 50 channels, is around EUR5-7, with the most expensive service, offering 10-15 channels more costing no more than around EUR14-17.

Satellite is the most important driver of digital television. The satellite sector in Romania has experienced major consolidation, resulting in the formation of three major players. The most important is DigiTV (RCS-RDS) which has more than 1 million subscribers in Romania (the service also operates in Croatia, the Czech Republic, Hungary, Serbia and Slovakia). Romtelecom has increased its market share – in 2011, it took over both Boom TV and Akta TV to add to its own satellite package (Dolce) giving the company also more than 1 million subscribers in total. The other main player is UPC with 283 800 subscribers in March 2012. In March 2013, a free satellite television service named Freesat was launched providing access to all main Romanian channels in addition to a large selection of international channels, in return for a EUR23 yearly service charge[63].

We note that the cost of subsidising the service charge and expanding the Freesat service is no cheaper than creating a new service, therefore we assume this in our calculations.

There are five IPTV services available in Romania, the most popular being provided by Romtelecom. In 2012, the Competition Council in Romania launched an investigation into possible abuse of a dominant position on the market of television services. A recent report from the Council noted that "the degree of concentration of the market is also at a very high level, which is due to the fact that the first three operators on the market, RCS&RDS, Romtelecom and UPC hold a cumulated market share of over 90 percent at national level." This is a genuine concern for competition in the market.

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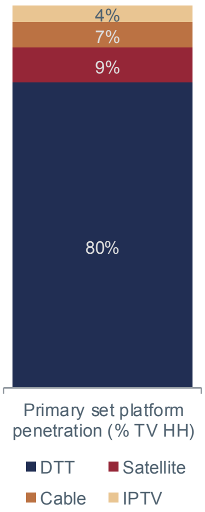
63 Eutelsat Press Release, 'Digital TV market in Romania takes new step forward with the launch of the Freesat platform on EUTELSAT 16A', 2013.

C.6 Spain

C.6.1 Market overview

Figure C-6: Country specific inputs used in modelling [Source: Aetha]



Primary sets source: CNMC data
Secondary sets source: Aetha calculation

Market inputs	UNITS		
Population	million	46.2	World Bank 2012
GDP/capita	PPP USD	32,043	World Bank 2012
Number of households	million	17.4	Eurostat 2012
TV penetration	% households	99%	Eurobarometer 2013
DTT primary sets	million	13.8	Aetha calculation primary set share data
DTT secondary sets	million	18.7	Aetha calculation secondary set share data
Platform competition inputs	**UNITS**		
Pay-TV penetration	% households	24%	International Communications Report 2013, Ofcom
Pay-TV expenditure per user	EUR/year	294	International Communications Report 2013, Ofcom
Platform coverage			
DTT	% households	98.5%	Abertis Telecom
Satellite	% households	96.0%	Aetha estimate
Cable	% households	51.3%	Broadband Coverage 2012, European Commission
IPTV	% households	70.0%	Analysys Mason 2017 forecast
Migration cost inputs	**UNITS**		
Migration of DTT households			
DTT to satellite	% households	96.6%	Aetha estimate
DTT to cable (and IPTV)	% households	3.4%	Aetha estimate
CPE unit cost inputs			
Satellite installation cost	EUR	120	Aetha estimate
Cable installation cost	EUR	96	Aetha estimate
New platform cost inputs			
National SD	#	29	Abertis Telecom
National HD	#	6	Abertis Telecom
Number of regions	#	17	Abertis Telecom
Regional SD	#	3	Abertis Telecom
Regional HD	#	1	Abertis Telecom
TOTAL (1HD~4SD)	#	172	
DTT channels available on FTV satellite?	YES/NO	NO	Aetha research (free channels only)

Following the digital switchover in 2010, penetration of digital television in Spain is now at 100%. DTT is by far the most popular platform – used for 80% of primary sets. Up-take of satellite television significantly lags behind most other European countries at just 9%. Cable penetration is 7%, whilst IPTV has the lowest penetration at 4%.

C.6.2 DTT

The DTT platform currently hosts 29 nationwide channels in addition to six in HD. Furthermore, there is significant regional content across 17 different regions. Spain has the highest number of local and regional channels of any European country. However, the Spanish DTT market continues to face several challenges (irregularities have led to the cancellation of procedures in certain regions, and many new local and regional channels are struggling to compete with larger national stations).

C.6.3 Satellite, cable and IPTV

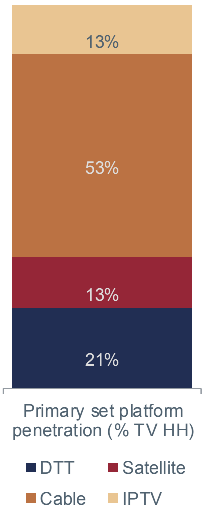
Given the predominance of the free-to-view offering on the DTT platform, the pay-television market in Spain is limited – pay-television penetration is just 24% though typical ARPUs are relatively high at EUR294. The market is divided between the satellite package offered by Canal+ and the cable operator ONO. IPTV services via ADSL connections are delivered by Imagenio (Telefónica de España). There has however been recent consolidation in the market, with Telefonica purchasing Canal+ and Vodafone purchasing ONO. Orange has recently made an offer to acquire Jazztel. Estimated cable reach is around half of Spanish households.

No free-to-view satellite platform exists in Spain, therefore we assume the creation of a new service.

C.7 Sweden

C.7.1 Market overview

Figure C-7: Country specific inputs used in modelling [Source: Aetha]



Primary sets source: MAVISE Subscriber data
Secondary sets source: Aetha calculation

Market inputs	UNITS		
Population	million	9.5	World Bank 2012
GDP/capita	PPP USD	43,021	World Bank 2012
Number of households	million	4.6	Eurostat 2012
TV penetration	% households	97%	Eurobarometer 2013
DTT primary sets	million	0.9	Aetha calculation primary set share data
DTT secondary sets	million	2.4	Aetha calculation secondary set share data
Platform competition inputs	**UNITS**		
Pay-TV penetration	% households	95%	International Communications Report 2013, Ofcom
Pay-TV expenditure per user	EUR/year	195	International Communications Report 2013, Ofcom
Platform coverage			
DTT	% households	98.0%	Teracom
Satellite	% households	96.0%	Aetha estimate
Cable	% households	53.0%	Broadband Coverage 2012, European Commission
IPTV	% households	65.0%	Analysys Mason 2017 forecast
Migration cost inputs	**UNITS**		
Migration of DTT households			
DTT to satellite	% households	73.0%	Aetha estimate
DTT to cable (and IPTV)	% households	27.0%	Aetha estimate
CPE unit cost inputs			
Satellite installation cost	EUR	132	Aetha estimate
Cable installation cost	EUR	121	Aetha estimate
New platform cost inputs			
National SD	#	44	Teracom
National HD	#	8	Teracom
Number of regions	#	19	Aetha research
Regional SD	#	1	Aetha research
Regional HD	#	-	Aetha research
TOTAL (1HD~4SD)	#	95	
DTT channels available on FTV satellite?	YES/NO	NO	Aetha research

Having completed its digital switchover in 2007, Sweden was one of the first countries in Europe to do so. DTT is now used for approximately 21% of primary sets, with 13% for satellite usage – the same as for IPTV. Cable is the most widely used platform at 53%.

Household coverage for both the DTT and satellite platforms approaches 100%, whilst cable has coverage of at least 53%. IPTV coverage is estimated to reach around 65% of households by 2017.

C.7.2 DTT

The DTT platform is operated by Teracom AB. The platform carries 8 free-to-air channels (public service and commercial) and more than 40 pay-television channels since the latest award of licences on the DTT network in March 2014 by the Swedish Radio and Television Authority (MRTV). Some channels are simulcast in both SD and HD. The service provider for pay-television is Boxer which is a wholly owned subsidiary of Teracom. At the end of 2013, Boxer had a total of 580 000 subscribers. Despite substantially increased levels of competition for other television platforms, Boxer has retained (and slightly grown) its subscriber base over time due to the introduction of a number of innovations to Boxer's services.

Notably, the vast majority of the platform is pay-television, with only 8 of the available 52 channels available free-to-view. As a result, pay-television penetration in Sweden is 95%. Blended ARPU across all platforms is EUR234.

C.7.3 Satellite, cable and IPTV

The main platform players in the market are the Swedish groups MTG (Viasat Broadcasting), TeliaSonera and Teracom, as well as cable operator Com Hem and the Norwegian Telenor group (Canal Digital). Com Hem dominated the cable television market with 1.73 million total connected households in December 2013, including approximately more than 575 000 households with a subscription to one of its *digital* pay-television packages[64]. The majority of cable households in Sweden still receive analogue signals, such that overall digital take-up across all platforms is just 68%.

As in the other Nordic countries, two satellite packages are in competition in the market: Canal Digital (Telenor) and Viasat (MTG), who each have more than 300 000 subscribers in Sweden, with many more across Norway and Denmark.

No free-to-view satellite platform exists in Sweden, therefore we assume the creation of a new service.

Finally, the Telia platform (TeliaSonera) continues to dominate the IPTV market with 575 000 subscribers at the end of December 2013. Thanks to its rapidly growing number of subscribers, Telia is now the third largest pay-television operator behind Com Hem (cable) and Boxer (DTT). Although Boxer (Teracom) has traditionally concentrated on digital terrestrial television, it has offered additional video on demand services since 2009 and recently also introduced 'Boxer Play' with OTT/VOD services using the open internet. Several other operators are active in the IPTV market, such as TeliaSonera, Telenor, Tele2, Banhof and Sappa.

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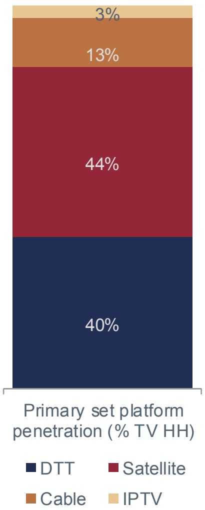
[64] MAVISE, 'Description of the Swedish audiovisual market', November 2012.

C.8 United Kingdom

C.8.1 Market overview

Figure C-8: Country specific inputs used in modelling [Source: Aetha]



Primary sets source: Ofcom
Secondary sets source: Aetha calculation

Market inputs	UNITS		
Population	million	63.2	World Bank 2012
GDP/capita	PPP USD	37,456	World Bank 2012
Number of households	million	28.0	Eurostat 2012
TV penetration	% households	98%	Eurobarometer 2013
DTT primary sets	million	10.8	Aetha calculation primary set share data
DTT secondary sets	million	24.2	Aetha calculation secondary set share data
Platform competition inputs	**UNITS**		
Pay-TV penetration	% households	54%	International Communications Report 2013, Ofcom
Pay-TV expenditure per user	EUR/year	390	International Communications Report 2013, Ofcom
Platform coverage			
DTT	% households	98.5%	Ofcom
Satellite	% households	96.0%	UK study, Rutherford Appleton Labs
Cable	% households	48.0%	Broadband Coverage 2012, European Commission
IPTV	% households	95.0%	Analysys Mason 2017 forecast
Migration cost inputs	**UNITS**		
Migration of DTT households			
DTT to satellite	% households	93.5%	Aetha estimate
DTT to cable (and IPTV)	% households	6.5%	Aetha estimate
CPE unit cost inputs			
Satellite installation cost	EUR	132	Aetha estimate
Cable installation cost	EUR	106	Aetha estimate
New platform cost inputs			
National SD	#	51	Digital UK
National HD	#	5	Digital UK
Number of regions	#	15	Aetha research
Regional SD	#	2	Aetha research
Regional HD	#	-	Aetha research
TOTAL (1HD~4SD)	#	101	
DTT channels available on FTV satellite?	YES/NO	YES	Aetha research

By revenues, the UK television industry is the largest in Europe (EUR14 billion in 2012). Following the conclusion of the digital switchover (DSO) in 2012, the penetration of digital television in the UK is now at 100%. Satellite constitutes the most widely used platform for television with a subscriber share of 44%[65]. We note however that this comprises two separate services: the free-to-view Freesat service (~8% including 'Freesat from Sky') and the pay-television Sky service (~36%)[65].

Household coverage for both the DTT and satellite platforms approaches 100%, whilst estimated IPTV coverage in 2012 was around 70%. Given the high cost of roll-out, cable has the lowest coverage with only 48% of homes passed (concentrated on urban areas). The UK has an addressable market of 25.7 million households (of which 2% watch over connected devices (e.g. games consoles), do not have a television set or cannot receive a digital signal).

C.8.2 DTT

Freeview, the free-to-view service hosted on the DTT platform, is the most widely used service by subscriber share (40%) in the UK. It provides 50+ SD channels and approximately 10 HD channels. There are also a limited number of pay-television channels on the DTT platform, however uptake is minimal given the popularity of the Freeview service and pay-television services on satellite, cable and IPTV platforms.

[65] Ofcom, 'Digital Television Update', April 2013.

C.8.3 Satellite, cable and IPTV

A free-to-view satellite service named Freesat is also available and has grown significantly in popularity in recent years, showing the highest growth rate of any television service. In the UK, therefore it stands as an established alternative free-to-view service to Freeview. The majority of the Freeview channels are also available on Freesat, which now hosts over 130 SD channels and 11 in HD.

We assume therefore that all DTT channels are already replicated on the Freesat service.

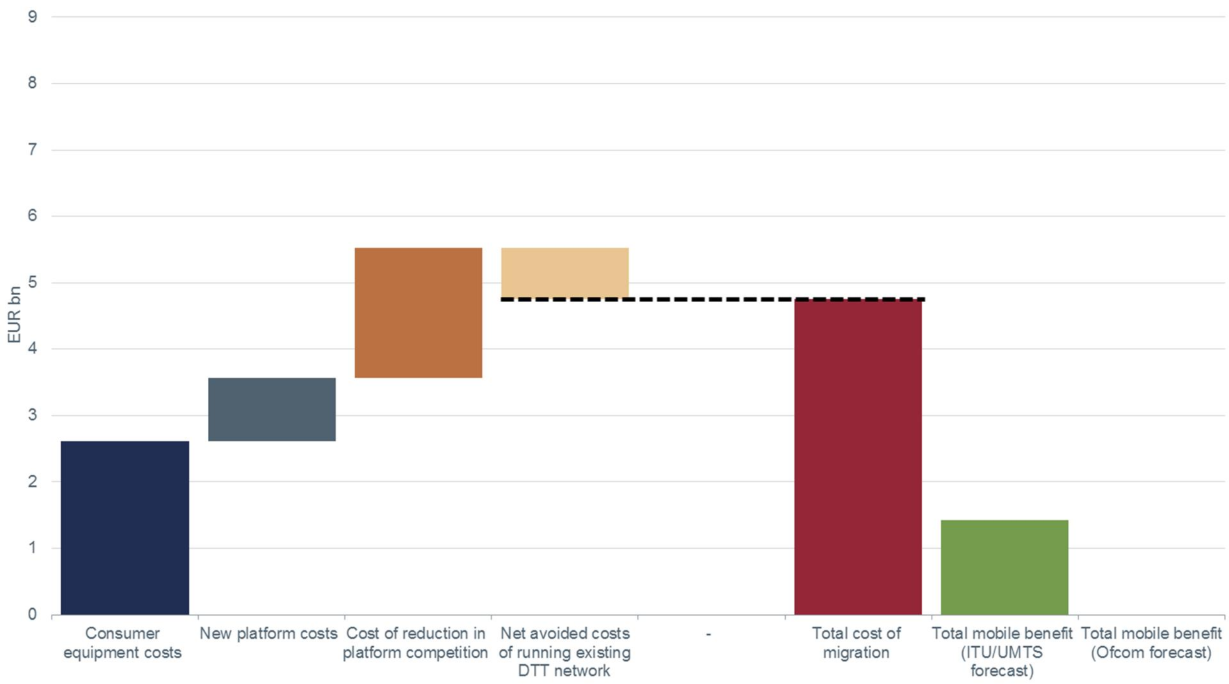
Across all platforms, pay-television take-up is 54%, driven largely by Sky's 36% market share, but also by the UK's sole cable provider, Virgin Media who currently holds 13% of the overall market on its platform. Around 3% of the market subscribes to alternative platforms such as BT Vision's IPTV platform, which provides a hybrid service with access to the Freeview DTT channels plus an IPTV video on-demand service, and several pay-television sports channels. The blended ARPU across all pay-television services stands at around EUR468 – the highest in Europe, given the high up-take of bundled services in the UK (i.e. bundling television, broadband and fixed-line services into a single package).

Annex D Case study countries: breakdown of migration costs

In this Annex, we provide the full breakdown of migration costs for each of our case study countries. We also compare this with the benefit from making the 470–694MHz band available for mobile services.

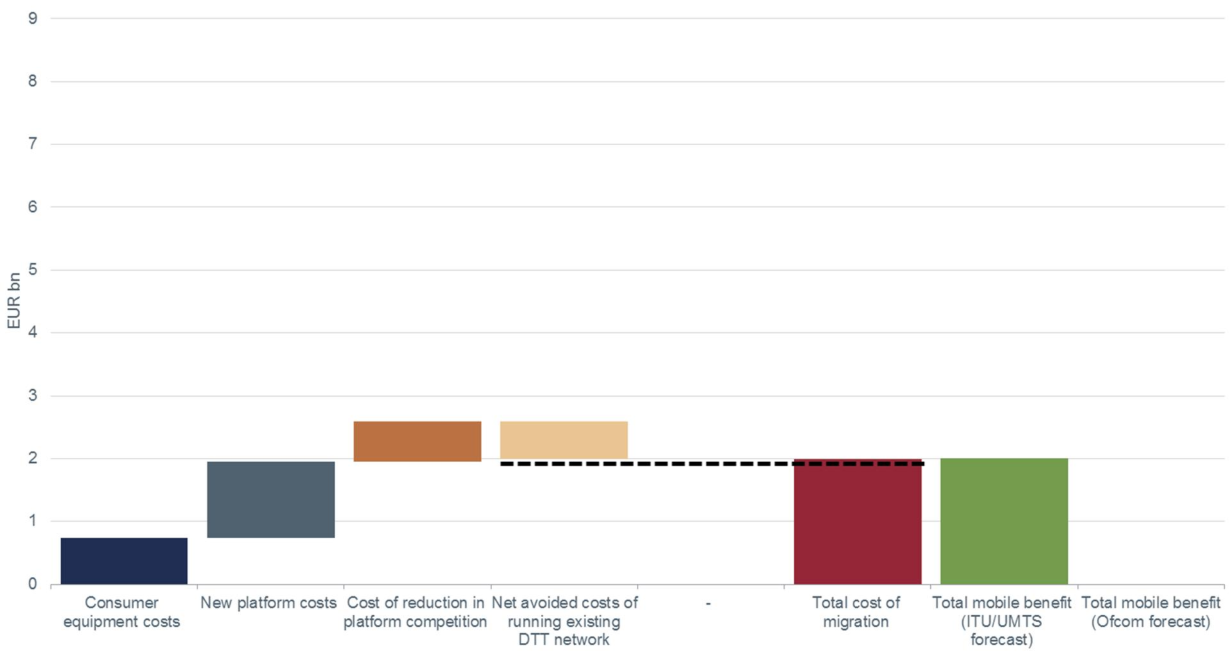
D.1 France

Figure D-1: Cost breakdown for DTT migration to alternative platforms [Source: Aetha]



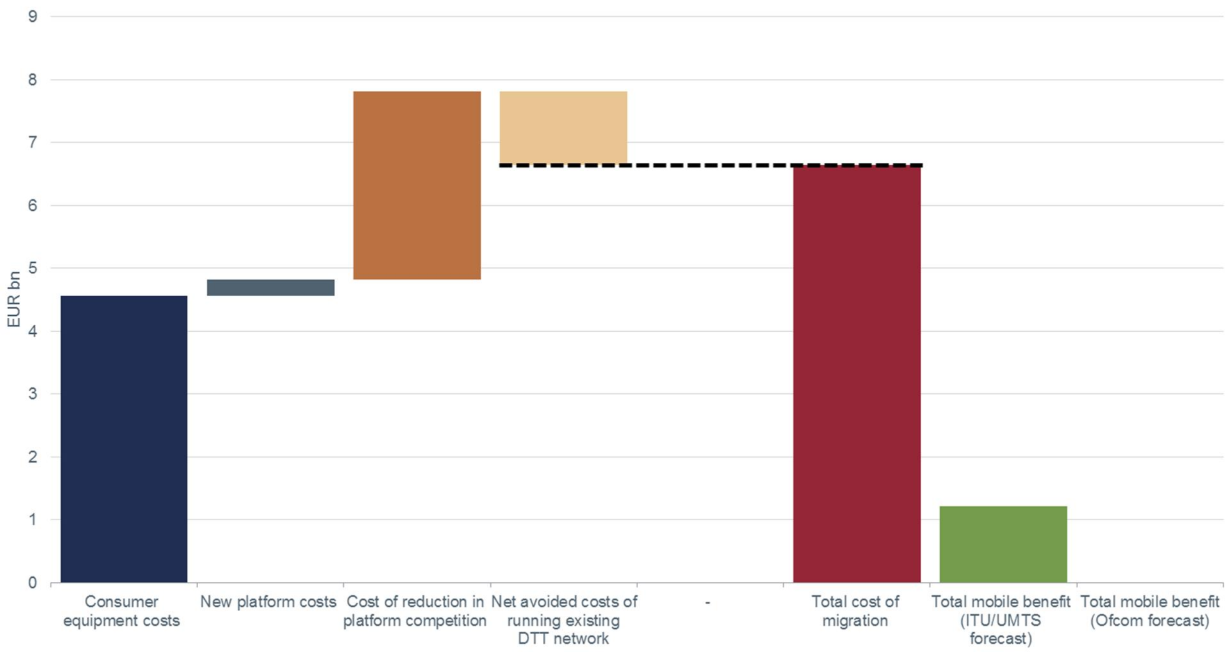
D.2 Germany

Figure D-2: Cost breakdown for DTT migration to alternative platforms [Source: Aetha]



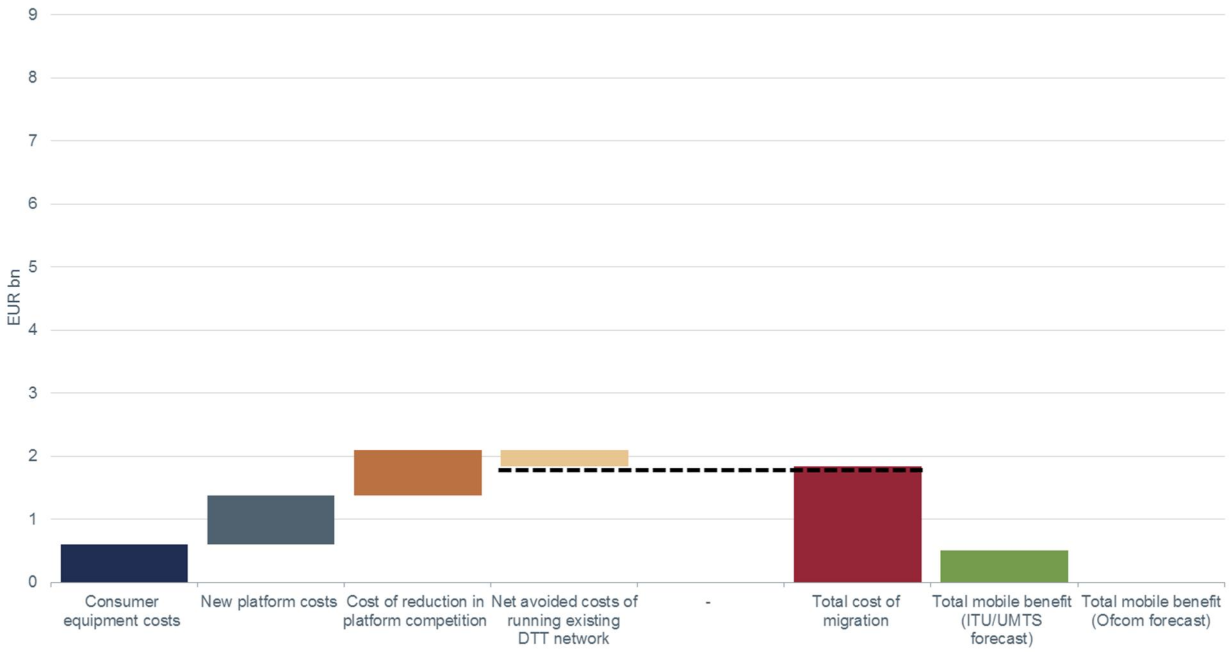
D.3 Italy

Figure D-3: Cost breakdown for DTT migration to alternative platforms [Source: Aetha]



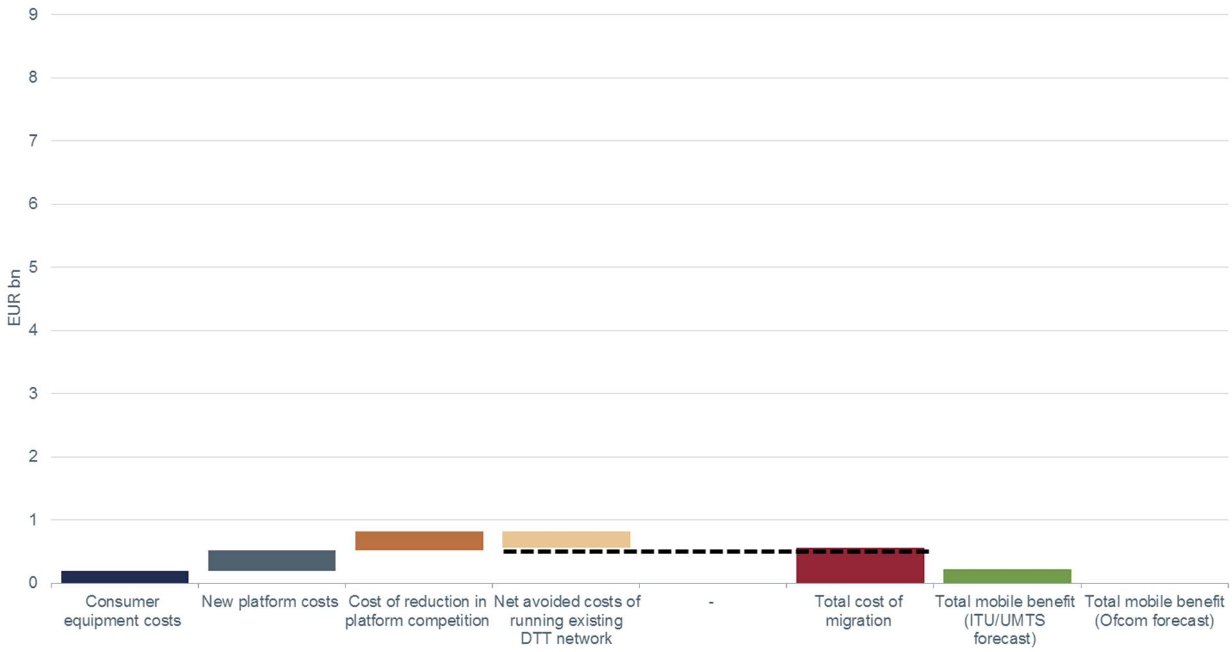
D.4 Poland

Figure D-4: Cost breakdown for DTT migration to alternative platforms [Source: Aetha]



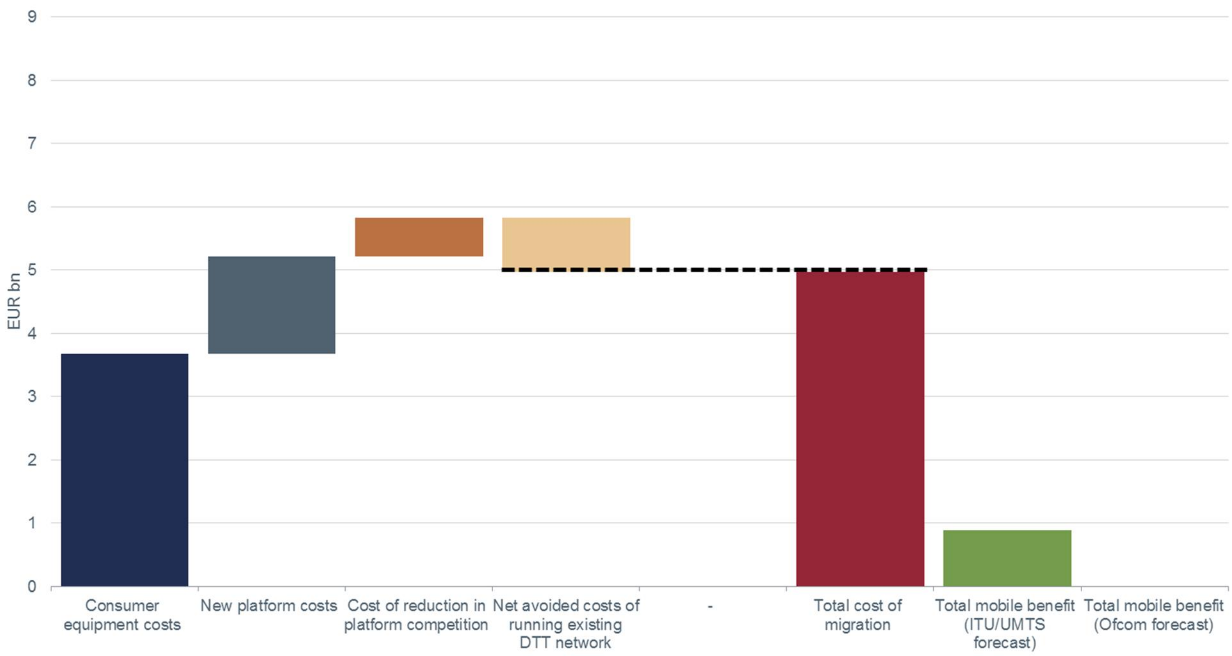
D.5 Romania

Figure D-5: Cost breakdown for DTT migration to alternative platforms [Source: Aetha]



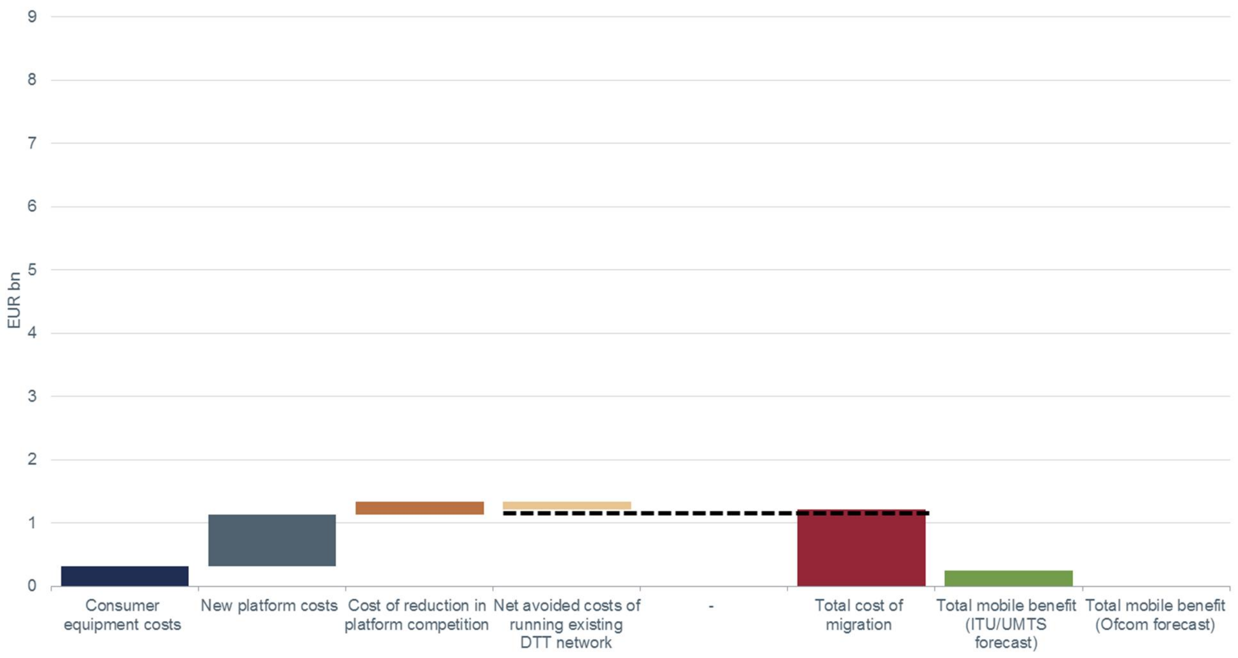
D.6 Spain

Figure D-6: Cost breakdown for DTT migration to alternative platforms [Source: Aetha]



D.7 Sweden

Figure D-7: Cost breakdown for DTT migration to alternative platforms [Source: Aetha]



D.8 United Kingdom

Figure D-8: Cost breakdown for DTT migration to alternative platforms [Source: Aetha]