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Regional differences in residential demand for very high bandwidth broadband internet in 2025

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Regional differences in residential demand for very high bandwidth broadband internet in 2025

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1 Introduction

WIK has developed a 'market potential' model in order to assess how bandwidth requirements may evolve in the near future (i.e. to 2025).¹ Originally developed in 2011, this model was revised and updated in 2017² to reflect emerging applications and new developments. Originally developed for the forecast of bandwidth demand in Germany, it has been applied to estimate bandwidth demand in the UK and Flanders in Belgium, too.³ The comparison of the results of the demand forecast in different regions allows to identify how usage patterns and demographic structures impact bandwidth demand. This information can be used to develop measures which trigger broadband demand and digitisation.

This paper focuses on the results of bandwidth demand forecasts in Germany, the UK and Flanders and the impact the difference between user profiles and household structure has on the forecast of bandwidth demand. Furthermore, we update the input data of the market potential model to reflect recent developments and new research.

Our paper is structured as follows: We start with a short introduction on broadband availability and demand in Germany, UK and Flanders in Chapter 2. The methodology of the WIK market potential model is explained in chapter 3 followed by the allocation of applications to user types and the household structure in the different regions. The forecasts of bandwidth demand in Germany, the UK and Flanders in Belgium and conclusions are presented in chapter 4.

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- 1 See Doose, A.-M.; Monti, A.; Schäfer, R. (2011): Mittelfristige Marktpotenziale im Kontext der Nachfrage nach hochbitratigen Breitbandanschlüssen in Deutschland, WIK Diskussionsbeitrag Nr. 358, Bad Honnef and Monti, A.; Schäfer, R. (2012): Marktpotenziale für hochbitratige Breitbandanschlüsse in Deutschland, Abschlussbericht für den BREKO, Bad Honnef.
 - 2 See Strube Martins, S.; Wernick, C.; Plückebaum, T.; Henseler-Unger, I. (2017): Die Privatkundennachfrage nach hochbitratigem BreitbandInternet im Jahr 2025, WIK Bericht, Bad Honnef, März 2017, downloadable at: http://www.wik.org/fileadmin/Studien/2017/Die_Privatkundennachfrage_nach_hochbitratigem_Breitbandinternet_im_Jahr_2025_FINAL.pdf.
 - 3 For the application of the model to Germany and the UK also refer to Strube Martins, S.; Wernick, C.; Plückebaum, T.; Henseler-Unger, I. (2017): Die Privatkundennachfrage nach hochbitratigem Breitband-Internet im Jahr 2025, WIK Bericht, Bad Honnef, März 2017, downloadable at: http://www.wik.org/fileadmin/Studien/2017/Die_Privatkundennachfrage_nach_hochbitratigem_Breitbandinternet_im_Jahr_2025_FINAL.pdf and Godlovitch, I.; Plückebaum, T.; Strube Martins, S.; Gantumur, T.; Elixmann, D.; Tas, S.; Arnold, R.; Wernick, C. (2018): The Benefits of Ultrafast Broadband Deployment, Report for Ofcom, downloadable at: https://www.ofcom.org.uk/data/assets/pdf_file/0016/111481/WIK-Consult-report-The-Benefits-of-Ultrafast-Broadband-Deployment.pdf. Please note that due to updates of data inputs the results from the reports may differ from the results presented here.

2 Broadband coverage and demand in Germany, the UK and Belgium/Flanders

According to the EU Commission's Digital Scoreboard, Belgium has the highest NGA availability of the three countries with 99% of total households in 2017. The availability of NGA connections in the UK is estimated at 94% of households. Germany has the lowest availability between the three countries with 84% of households, yet it remains higher than the European Union's average of 80,1%. In Germany, UK and Belgium cable networks play an important role and contribute significantly to NGA coverage. Belgium has an extensive cable coverage which reached 97% of households in 2017. In Flanders Telenet is the main cable network operator and operates a cable television network on the whole territory of the Flemish region (with the exception of Wemmel, Drogenbos and Voeren).⁴

As for FTTP technology coverage, availability in the three regions is considerably lower than in other EU countries. In 2018 the EU average of FTTP availability per household stood at 26.8%. Germany had 7.3% availability, UK and Belgium's FTTP networks reached 2% and 1% of households respectively.

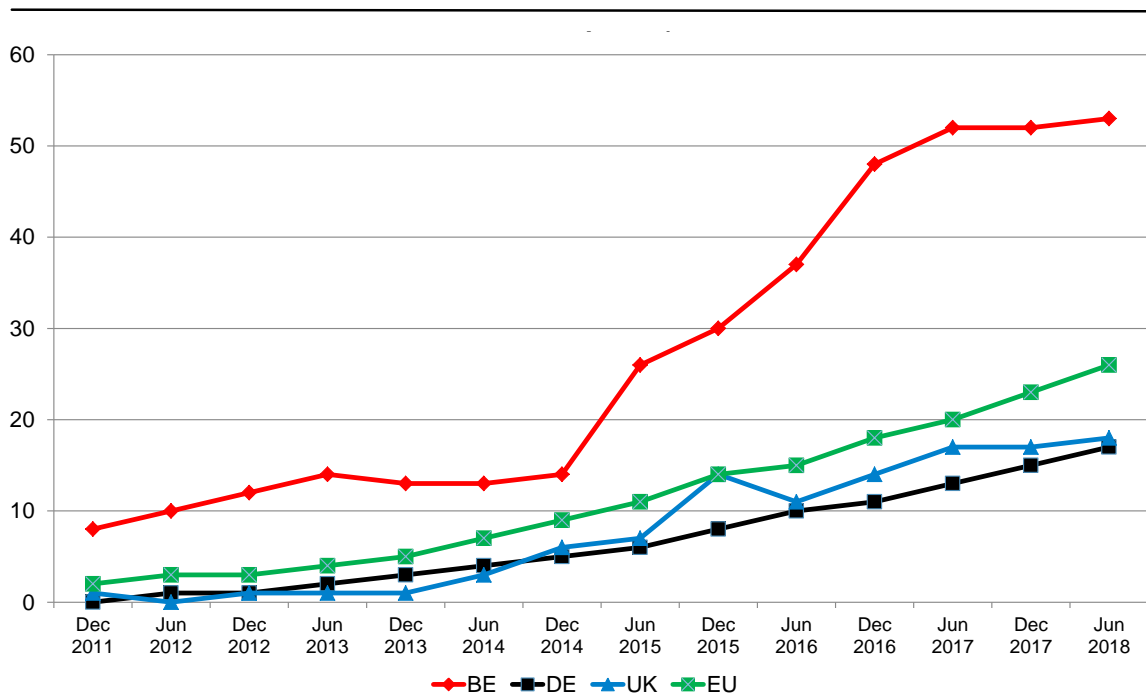
On the demand-side, Germany had a fixed broadband take-up of 88% in 2017. UK and Belgium achieve take-up rates of 88% and 81%, respectively. The take-up rates of ultrafast broadband connections (≥ 100 Mbit/s) are considerably higher in Belgium where the demand for broadband connections above 100 Mbit/s strongly increased in the last years up to 53% of Belgian broadband subscribers. The development of subscriptions to ultrafast broadband connections is shown in the figure below. In Flanders in 2018 alone 96% of the population have had internet access in their households. Moreover, nearly 86% share of households have a broadband connection there, which is somewhat higher than in Belgium.

UK and Germany have significantly lower take-up rates of broadband connections above 100 Mbit/s of 18% and 17% of households, respectively.⁵

⁴ BIPT (2018): Décision du 29 juin 2018 Analyse des marchés du haut débit et de la radiodiffusion télévisuelle Version publique, downloadable at: https://www.bipt.be/public/files/fr/22533/Decision_Analyse_marches_haut_debit_radiodiffusion.PDF.

⁵ European Commission, Digital Scoreboard.

Figure 2-1: Fixed broadband subscriptions to ultrafast broadband connections (≥ 100 Mbit/s) in % of broadband subscriptions



Source: European Commission, Digital Scoreboard.⁶

It can thus be concluded that the broadband market in Flanders is further developed in comparison to Germany and the UK. The low penetration with FTTP infrastructures in all three case study candidates points at a need for action in the next decade given the technical superiority of fibre infrastructures. In this regard, the understanding of the future development of broadband represents a highly relevant component.

⁶ [https://digital-agenda-data.eu/charts/see-the-evolution-of-an-indicator-and-compare-countries#chart={%22indicator-group%22:%22broadband%22,%22indicator%22:%22bb_lines%22,%22breakdown%22:%22speed_ge100%22,%22unit-measure%22:%22pc_bb_lines%22,%22ref-area%22:\[%22BE%22,%22EU%22,%22DE%22,%22UK%22\]}](https://digital-agenda-data.eu/charts/see-the-evolution-of-an-indicator-and-compare-countries#chart={%22indicator-group%22:%22broadband%22,%22indicator%22:%22bb_lines%22,%22breakdown%22:%22speed_ge100%22,%22unit-measure%22:%22pc_bb_lines%22,%22ref-area%22:[%22BE%22,%22EU%22,%22DE%22,%22UK%22]}).

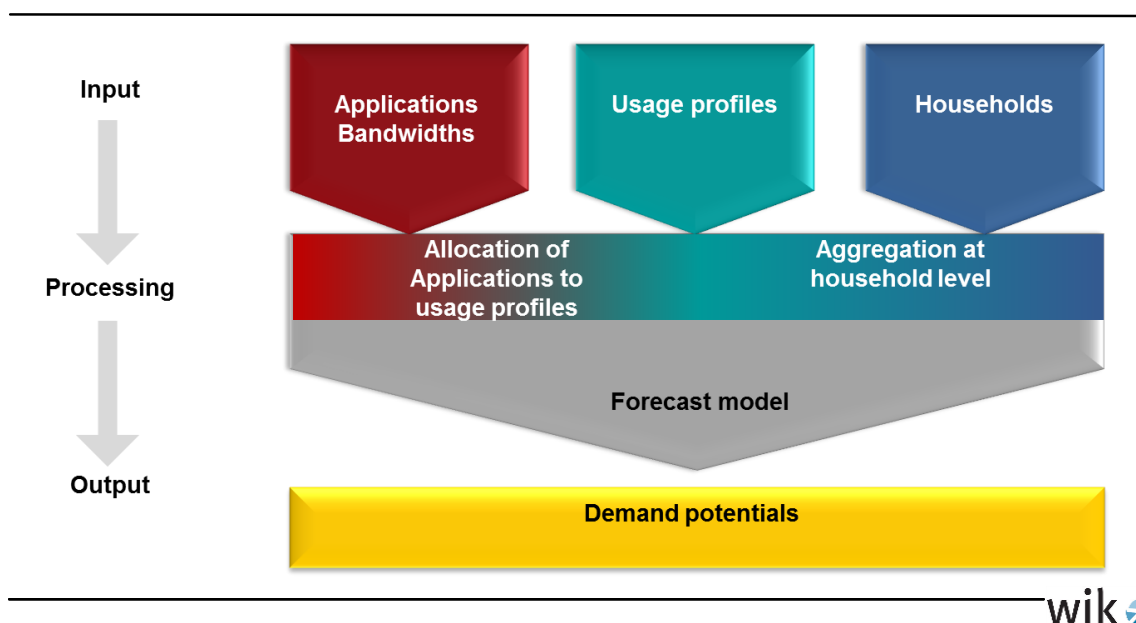
3 Bandwidth demand in 2025 in Germany, the UK and Flanders

3.1 Methodology

The starting point for the estimation of bandwidth demand in the WIK market potential model is the end customer's usage behaviour. In order to understand the full potential benefits of ultrafast broadband networks, the model focuses on “unconstrained” bandwidth demand i.e. household demand assuming no technical and commercial restrictions, such that connections of any bandwidth are available. The model is not targeted at explicitly estimating end users' willingness to pay for additional bandwidth.

The following figure shows the methodology used for the market potential model.

Figure 3-1: Methodology of the WIK market potential model



Source: WIK

The model projects the future demand for bandwidth from residential customers on the basis of three parameters:

- The applications that will be used by residential customers in 2025 and their bandwidth requirements
- The user profiles (i.e. different types of customers) that are to be expected in the future, and the applications that each user profile is likely to use
- The population structure expected in 2025 and the distribution of user profiles among the population structure

Applications are assigned to user profiles in order to estimate the bandwidth and quality requirements of different user types. In a further step, the user profiles are assigned to 1-person, 2-person or 3+-person households. The allocation of applications to user profiles and the merging of user profiles at the household level can be used to derive overall bandwidth requirements for households in 2025. This procedure is applied to Germany, UK and the region of Flanders in Belgium. Comparing the results of different regions provides additional information on the main drivers of bandwidth demand. An analysis of what can trigger differences in demand can be used to design measures to support the development of demand and of digitisation.

3.2 Applications and bandwidth requirements

The model considers the applications listed below. The list of applications reflects the most important drivers of bandwidth usage and quality requirements in 2025. While most of the applications were already included when the model was developed in 2011, 'progressive media and entertainment' including virtual reality were added as current developments to show the significance of these applications for bandwidth demand.

- Basic Internet⁷
- Home-office and VPN⁸
- Cloud Computing
- State of the Art Media and Entertainment (4k, 3D, HD)
- Progressive Media and Entertainment (8K, VR/AR)
- Communication⁹
- Video communication
- Gaming
- E-Health
- E-Home/ E-Facility¹⁰
- Mobile Offloading¹¹

For each of the applications listed above, the model includes assumptions on the likely bandwidth requirements (both downstream and upstream), as well as packet loss and latency requirements by 2025. These are set out in the table below.

⁷ Basic Internet refers e.g. to surfing the Internet (including e-commerce) and social networks.

⁸ Home office and VPN refers to the file exchange and online usage of resources such as software in the context of teleworking.

⁹ Communication refers e.g. to telephony, chats on social networks etc.. Video communication includes video telephony, videoconferencing.

¹⁰ E-Home refers to anything in the home that can be controlled remotely by a smartphone, tablet or computer; e.g. a thermostat that 'learns' the desired temperature of a user throughout the day to a washing machine that orders washing powder before it runs out.

¹¹ WiFi-Offloading of mobile data.

Bandwidth growth rates have been estimated based on an analysis of the development of historic data volumes and data rates. As they have been constrained by the availability of high bandwidth broadband connections they tend to understate growth in unconstrained bandwidth demand.

These assumptions have also been supported by a review of desk research on data requirements of individual applications¹² and have been discussed with industry experts.

Table 3-1: Application categories with their capacity and quality requirements 2025

Application category	Downstream (Mbit/s) in 2025	Upstream (Mbit/s) in 2025	Packet loss	Latency
Basic Internet	≈20	≈16	o	o
Homeoffice/VPN	≈250	≈250	+	+
Cloud Computing	≈250	≈250	+	++
State of the Art Media and Entertainment (4k, 3D, HD)...	≈150	≈30	++	+
Progressive Media and Entertainment (8k, ...)	≈300	≈60	++	+
Communication	≈8	≈8	++	+
Videocommunication (HD)	≈25	≈25	++	++
Gaming	≈300	≈150	++	++
E-Health	≈50	≈50	++	+
E-Home/E-Facility	≈50	≈50	o	o
Mobile Offloading	≈15	≈12	o	o

o = Low specific importance

+ = High importance

++ = Very high importance

Source: WIK.

The main drivers of these bandwidth increases are further described below.

¹² See for example Fraunhofer FOKUS (2016): Netzinfrastrukturen für die Gigabitgesellschaft, downloadable at: https://cdn2.scrvt.com/fokus/5468ae83a4460bd2/65e3f4ee76ad/Gigabit-Studie_komplett_final_einzelseiten.pdf; BIU (2015): Positionspapier Agenda 2020: für eine starke Computer- und Videospielebranche in Deutschland, downloadable at: https://www.biu-online.de/wp-content/uploads/2015/06/20150608_BIU_Positionspapier_F%C3%B6rderung_Standort_Deutschland.pdf; Cisco (2019): VNI: Forecasts and Trends, 2017-2022 White Paper, downloadable at: <https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white-paper-c11-741490.pdf>; FTTH Council (2016): FTTH Business Guide, Edition 5 Financing Committee, Revision date: 16/02/2016, downloadable at: http://www.ftthcouncil.eu/documents/Publications/FTTH_Business_Guide_V5.pdf; CAICT and HUAWEI Technologies Co. Ltd (2017): Virtual Reality/Augmented Reality White Paper, downloadable at: <http://www-file.huawei.com/-/media/CORPORATE/PDF/ilab/vr-ar-en.pdf>;

The bandwidth requirements of applications such as progressive TV/VR, VPN,¹³ cloud and gaming are assumed to grow with a CAGR¹⁴ of around 30%. In the area of progressive TV, a significant increase in bandwidths is expected due to the introduction of new technologies such as 8K as well as Augmented and Virtual Reality (AR and VR), which demand higher data transmission rates, low latency and packet loss rates.¹⁵

The bandwidth requirements of Home Office/VPN are driven by a strongly increasing share of high definition audiovisual content transmitted by Home Office/VPN users. The main driver of bandwidth demand in gaming is expected to be virtual reality, high-definition graphics and sophisticated software that allows players to play online in a networked environment. These developments are also likely to require high levels of quality of service including low latency.

Cloud computing includes the storage of high-resolution images, movies and data as well as the use of software in the cloud. The growing need for bandwidth in this area is due to an increasing amount of data transferred via the Internet. While only a few kilobytes of data are needed to transmit a text message, a Full HD¹⁶ video requires several gigabytes of data volume.

The increasing use of E-Health and smart home applications may also generate data volumes, potentially in conjunction with cloud computing.

More moderate increases in bandwidth requirements are also expected from services that are prevalent in the market today. For instance, bandwidth requirements for basic Internet and communication will increase, as high-resolution images and videos are increasingly transmitted via the Internet. Bandwidth requirements for current TV applications (termed 'state of the art media') such as 4K, UHD¹⁷ and video communication are assumed to grow at slower CAGRs of 20% and 15% respectively.

WIK's model does not reflect aggressive assumptions concerning compression. This means that if there are substantial advances in compression technologies in future, the unconstrained bandwidth demand forecasts would (other things being equal) be overstated. More conservative approaches e.g. reflecting aggressive assumptions

13 Virtual Private Networks

14 Compound Annual Growth Rate

15 Mangiante, S. et al (2017): VR is on the Edge: How to Deliver 360° Videos in Mobile Networks, downloadable at:

https://www.researchgate.net/publication/319049968_VR_is_on_the_Edge_How_to_Deliver_360_Videos_in_Mobile_Networks/download;

CAICT and HUAWEI Technologies Co. Ltd (2017): Virtual Reality/Augmented Reality White Paper, downloadable at: <http://www-file.huawei.com/~media/CORPORATE/PDF/ilab/vr-ar-en.pdf>;

Huawei iLab (2017): Video Big Data, The Top 10 Most Demanding Videos on the Net, downloadable at: <https://www.huawei.com/~media/CORPORATE/PDF/white%20paper/Big-Data-Video-Top-Ten-Most-Demanding-Videos-en>;

<https://www.mushroomnetworks.com/infographics/bandwidth-requirements-for-virtual-reality-vr-and-augmented-reality-ar-infographic/>.

16 High Definition

17 Ultra High Definition

concerning compression technologies assume lower bandwidth requirements.¹⁸ There are several reasons behind the decision not to assume aggressive compression scenarios in the WIK model:

- In this model there are no technical and commercial restrictions. Content providers that do not have to consider technical restrictions are likely to develop applications without the need to concentrate on reducing the bandwidth requirements of their innovative products.
- There may be advantages from the absence of restrictions, where a better broadband infrastructure is likely to create incentives for new and innovative applications to be developed, without the need to consider infrastructure as a potential bottleneck.
- For a number of digital applications, bandwidth is not the only or even the main requirement to make them attractive and usable. Rather, the quality requirements concerning low latency, packet loss rate and jitter are of great importance. However, these parameters cannot readily be addressed using compression techniques.
- Compression methods are not only detrimental to quality (signal quality and delay times) but also involve high costs themselves. Moreover, the codecs of compression rates have grown at a lower rate than the growth rate of the data volume for audiovisual content (without compression).¹⁹

Furthermore, bandwidth demand cannot only be explained by existing applications. It seems likely that there will be a residual growth of internet traffic volume which cannot be explained by existing services category growth.²⁰

The bandwidth requirements assumed in the WIK model have been scrutinized in discussions with market stakeholders and crossed-checked through desk research.

Apart from the bandwidth requirements of applications it is important to note that many of the applications used in 2025 not only require high bandwidth, but also low latency, packet loss rates as well as reliable connections.

The table below shows the quality requirements of the user profiles used in the WIK market potential model. It illustrates that, while applications such as E-Health and video

¹⁸ See for example Frontier Economics (2017): Future benefits of broadband networks, downloadable at: <https://www.nic.org.uk/wp-content/uploads/Benefits-analysis.pdf>.

¹⁹ There are predictions that codecs will not be able to compress efficiently by 2020 so that efforts are being made to develop a video codec based on neurological science to achieve an efficient compression. See Doutsis, E. (2017): Compression d'images et de vidéos inspirée du fonctionnement de la rétine, downloadable at: <https://tel.archives-ouvertes.fr/tel-01584114/document>.

²⁰ This has been discussed by van der Vorst, Tommy; Brennenraedts, Reg (2018): Understanding the demand growth for digital connectivity, The 22nd Biennial Conference of the International Telecommunications Society: "Beyond the boundaries: Challenges for business, policy and society", June 24th - 27th, 2018, Seoul, Korea, International Telecommunications Society (ITS), Seoul, downloadable at: https://www.econstor.eu/bitstream/10419/190350/1/B1_2_Vorst-and-Brennenraedts.pdf.

communications do not require bandwidths as high as gaming and progressive audiovisual content, they may still require specific access technologies to satisfy their demand for low packet loss rates and low latency.

Table 3-2: Quality requirements of user profiles

Application category	Packet loss	Latency	Application driving quality requirements
Sceptical outsider	o	o	-
Occasional user	++	+	EHealth
Home Office user	++	++	Videocommunications
Trend user	++	++	Videocommunications and EHealth
Avantgardist	++	++	Gaming
Digital Professional	++	++	Progressive audiovisual content

- o = Low specific importance
- + = High importance
- ++ = Very high importance

Source: WIK.

3.3 Allocation to user types

The WIK market potential model projects the bandwidth needs of broadband households in 2025 based on user types. These are assumed to have distinct usage patterns with regard to the application categories assigned to them. In this study, we have taken Germany, UK and Flanders in Belgium as case studies to examine the differences and similarities in the user types.

The table below gives a comprehensive overview of user types that are categorized based on a number of aspects, such as level of internet usage, education and demographic characteristics.

Table 3-3: Overview of user types

User type	Description
Sceptical outsider	Digital sceptics are mainly older users who have the lowest usage of digital applications compared to other user types. They rarely use computers and the Internet and have the most negative attitude towards ICT.
Occasional user	Occasional users have a basic or medium level of formal education and live mostly in multi-person households. They have basic ICT skills which they use in the areas of basic Internet, communication, and mobile offloading. Applications perceived as essential such as E-Health may also be used.
Digital professional	Digital professionals possess a high level of ICT competence and have extensive technical equipment with the corresponding ICT infrastructure. This category uses computers, tablets and 8K TV intensively. Virtual Reality offers and E-Home applications are also represented in this technology-oriented user group. Digital professionals include both highly-educated users and users from socially disadvantaged groups who value being up to date in the media sector. Younger generations of digital professionals are likely to use progressive TV applications, which require very high bandwidths.
Trend user	The group of trend users has a high proportion of men. They are strongly represented in households with two or more persons, have a good digital infrastructure and comprehensive ICT competence, which is used in a variety of ways, though not in bandwidth-intensive applications such as gaming, or 8K TV. The preference of trend users is for applications such as state of the art media, video communication and E-Health applications. Cloud computing and mobile offloading run in the background with this user group, with the result that demand for bandwidth and quality of Internet access is also demanding for trend users.
Home office user	Home office users live predominantly in households with two or more persons. They have a very good digital infrastructure and use the Internet more than average. Since they use ICT applications intensively during working hours, their ICT skills have been significantly expanded. The outstanding digital infrastructure enables them to work in the home office on the basis of VPN. In addition, they use basic Internet with high-resolution images as well as video communication and mobile offloading to relieve the load on mobile data use, like all other user groups,.
Digital avant-gardist	The group of digital avant-gardists has the best digital equipment. The avant-gard user is very competent and professional in handling hardware and software. This user group includes both professionals with a high level of formal education and young people who spend a large proportion of their time in gaming. It is therefore very heterogeneous. Broadband connectivity requirements are driven by digital applications such as gaming and E-Home/E-Facility. Applications such as cloud computing and mobile offloading run in the background. As with the other user groups, the Basic Internet is part of everyday digital life.

Source: WIK.

In addition to the six user profiles, which make more or less intensive use of digital applications, there is also the group of broadband deniers and users who are exclusively mobile. Based on the descriptions of each user profile above, we assume that three user profiles – the home office user, the digital avant-gardist and the digital professional – use one of the three most bandwidth-intensive applications: VPN, progressive TV and gaming.

Two user profiles, the occasional user and the sceptical outsider, are more reluctant to use digital applications. The trend user does not use VPN, 8K or gaming, but relies on a variety of digital applications, including audio-visual communication and E-Health.

It can be assumed that in private households digital applications such as cloud, TV and gaming are typically used intensively from 8 p.m. in parallel with applications, such as cloud and mobile offloading. While there is a share in the population which uses the internet while watching TV,²¹ applications as gaming, progressive TV and VPN are only allocated to one user profile and are not used in parallel with applications as E-Health, E-Home or Video communication. The table below shows allocation of application to user types in Germany. As explained, the user profiles use different applications but not all of them simultaneously. Three user types use cloud computing in parallel with other applications and some also basic internet. The allocation differs between Germany, UK and Flanders as for example in the UK there is a stronger interest in E-Health while IPTV only plays a minor role.²²

The time from 8 p.m. is considered the time window for internet users when they have time for digital media²³. This time window is called busy hour in network planning.

The WIK market potential thus determines a peak bandwidth demand for the busy hour and is oriented towards the logic of network planning, which also aligns the capacity of its network infrastructures with the needs during the main load phase.

21 In Germany for example, market research by BVDW shows that 54% of online users watch TV and use the internet in parallel on their Laptop/Tablet or Smartphone. See BVDW (2019): Digitale Nutzung in Deutschland 2018, downloadable at: https://www.bvdw.org/fileadmin/user_upload/BVDW_Marktforschung_Digitale_Nutzung_in_Deutschland_2018.pdf.

22 For a detailed discussion of user profiles in the Germany and the UK please refer to Strube Martins, S.; Wernick, C.; Plückebaum, T.; Henseler-Unger, I. (2017): Die Privatkundennachfrage nach hochbitratigem BreitbandInternet im Jahr 2025, WIK Bericht, Bad Honnef, März 2017, downloadable at: http://www.wik.org/fileadmin/Studien/2017/Die_Privatkundennachfrage_nach_hochbitratigem_Breitbandinternet_im_Jahr_2025_FINAL.pdf and Godlovitch, I.; Plückebaum, T.; Strube Martins, S.; Gantumur, T.; Elixmann, D.; Tas, S.; Arnold, R.; Wernick, C. (2018): The Benefits of Ultrafast Broadband Deployment, Report for Ofcom, downloadable at: https://www.ofcom.org.uk/_data/assets/pdf_file/0016/111481/WIK-Consult-report-The-Benefits-of-Ultrafast-Broadband-Deployment.pdf.

23 See VAUNET (2019): .VAUNET-Mediennutzungsanalyse, Mediennutzung in Deutschland 2018, downloadable at: https://www.vau.net/system/files/documents/vaunet_mediennutzung-2018-publikation.pdf.

Table 3-4: Allocation of applications to user types

Categories / User Types	Occasional	Sceptical Outsider	Home office User	Trend User	Avantgardist	Professional
Basic Internet	✓	✓	✓		✓	✓
Homeoffice/VPN			✓			
Cloud Computing					✓	✓
State of the Art Media and Entertainment (4k, 3D, HD)...			✓			
Progressive Media and Entertainment (8k, ...)						✓
Communication	✓					
Videocommunication (HD)			✓			
Gaming					✓	
E-Health	✓					
E-Home/E-Facility					✓	✓
Mobile Offloading	✓	✓	✓		✓	✓

Source: WIK.

3.3.1 Germany

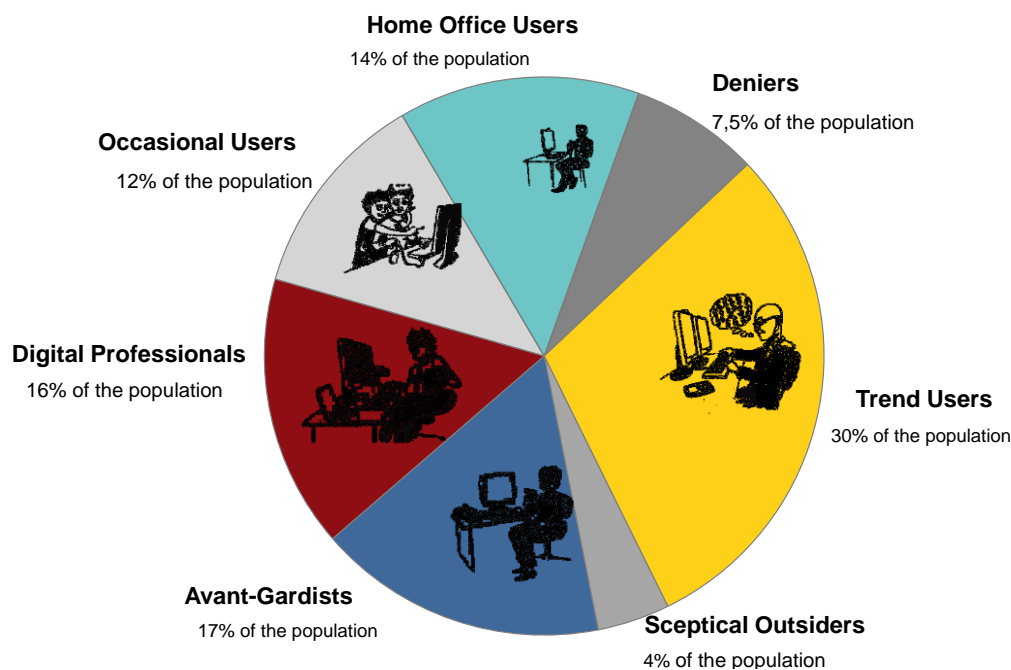
Based on the D21 Digital Index, supplemented by data from the European Commission, the Federal Statistical Office in Germany and ARD/ZDF on online behaviour and other studies on the internet usage in Germany, the WIK market potential model derives the six user profiles mentioned above. Based on usage data of the German population and research on the future development of digital demand, the model estimates the share of the six user profiles in the population in 2025.

The distribution of user profiles among the total population is initially characterized by the fact that the younger generations (with a much higher affinity for technology) will grow into the user groups, and digital applications will be more widespread than they are today. The proportion of Internet users in the 10-44 age group is 99%, while 95% of 45-65 year olds use the Internet. In contrast, only 63% of the 65+ age group use the Internet²⁴. It can therefore be assumed that only a small proportion of the population will not use the Internet in 2025.

²⁴ However, internet usage increased from 49% in 2016 for 65+ year olds and in 2016 90% of the 45-65 year olds used the internet. See Statistisches Bundesamt (2016): Private Haushalte in der Informationsgesellschaft – Nutzung von Informations- und Kommunikationstechnologien 2015, Fachserie 15 Reihe 4, p. 16; downloadable at: https://www.destatis.de/DE/Publikationen/Thematisch/EinkommenKonsumLebensbedingungen/PrivateHaushalte/PrivateHaushalteIKT2150400157004.pdf?__blob=publicationFile and Statistisches Bundesamt (2018): Wirtschaftsrechnungen, Private Haushalte in der Informationsgesellschaft – Nutzung von Informations- und Kommunikationstechnologien, downloadable at: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Einkommen-Konsum-Lebensbedingungen/IT-Nutzung/Publikationen/Downloads-IT-Nutzung/private-haushalte-ikt-2150400187004.pdf?__blob=publicationFile&v=4.

Only the population aged 15 and over is taken into account in the model, which underscores the conservative approach of the market potential calculation when one considers that the group of users under 15 years of age comes without exception from the segment of digital natives.

Figure 3-2: Internet User Profiles in Germany in 2025



Source: WIK based on Initiative D21, ARD/ZDF Onlinestudie, Statistisches Bundesamt (2018).²⁵

Looking at the proportion of households with Internet access in Germany, we can see that it has increased steadily from 69% in 2008 to 90% in 2018²⁶. Households are connected to the Internet every day or almost every day. 86% of households with Internet access had a broadband connection in 2018²⁷. Based on this data, the WIK

- 25 Initiative D21 (2018): D21 DIGITAL INDEX 2017/2018 Jährliches Lagebild zur Digitalen Gesellschaft, downloadable at: https://initiated21.de/app/uploads/2018/01/d21-digital-index_2017_2018.pdf, Statistisches Bundesamt (2018): Wirtschaftsrechnungen, Private Haushalte in der Informationsgesellschaft – Nutzung von Informations- und Kommunikationstechnologien, downloadable at: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Einkommen-Konsum-Lebensbedingungen/IT-Nutzung/Publikationen/Downloads-IT-Nutzung/private-haushalte-ikt-2150400187004.pdf?__blob=publicationFile&v=4 and <http://www.ard-zdf-onlinestudie.de/>.
- 26 Statistisches Bundesamt (2018): Wirtschaftsrechnungen, Private Haushalte in der Informationsgesellschaft – Nutzung von Informations- und Kommunikationstechnologien, downloadable at: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Einkommen-Konsum-Lebensbedingungen/IT-Nutzung/Publikationen/Downloads-IT-Nutzung/private-haushalte-ikt-2150400187004.pdf?__blob=publicationFile&v=4.
- 27 Statistisches Bundesamt (2018): Wirtschaftsrechnungen, Private Haushalte in der Informationsgesellschaft – Nutzung von Informations- und Kommunikationstechnologien, downloadable at: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Einkommen-Konsum-Lebensbedingungen/IT-Nutzung/Publikationen/Downloads-IT-Nutzung/private-haushalte-ikt-2150400187004.pdf?__blob=publicationFile&v=4.

market potential model assumes that by 2025 more than 90% of users will have a stationary broadband connection.

Some of the application categories mentioned above are already widely used, such as Basic Internet and TV in HD quality²⁸. However, they will only be fully exploited once high-bit-rate broadband connections are available. For example, three quarters of all Internet users in Germany over the age of 14 (76%) watched videos on the internet in 2018. Moreover, around 44% use Video streaming, an increase of 6% from the past year.²⁹

E-Health and smart applications are said to have great disruptive potential if the necessary infrastructure is available, especially for developers of attractive applications³⁰. Accordingly, it can be expected that by 2025 the proportion of trend users using applications such as smart homes, conventional TV and video communication will be quite high. In contrast, the share of user types digital avant-garde, professional users and digital professionals is below 20%.

In view of the fact that 24% of Internet users already work in the home office, the share of 14% (represented by professional users) seems quite realistic.

Progressive TV in 8K quality and Virtual Reality applications are used exclusively by the user group of digital professionals, who make up 17% of the population. The use of Virtual Reality applications is of interest to a large proportion of the population. A survey conducted by Bitkom in 2018 showed that every sixth German citizen (16%) aged 14

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- 28** See Statistisches Bundesamt (2018) Wirtschaftsrechnungen, Private Haushalte in der Informationsgesellschaft – Nutzung von Informations- und Kommunikationstechnologien, downloadable at: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Einkommen-Konsum-Lebensbedingungen/IT-Nutzung/Publikationen/Downloads-IT-Nutzung/private-haushalte-ikt-2150400187004.pdf?__blob=publicationFile&v=4;
- Frees, B. and Koch, W. (2018): ARD/ZDF-Onlinestudie 2018: Zuwachs bei medialer Internetnutzung und Kommunikation, in Media Perspektiven 9/2018, p. 398-413, downloadable at: http://www.ard-zdf-onlinestudie.de/files/2018/0918_Frees_Koch.pdf.
- 29** See Kupferschmitt, T. (2018): Onlinevideo-Reichweite und Nutzungsfrequenz wachsen, Altersgefälle bleibt, in Mediaperspektiven 9/2018, p. 427-437, downloadable at: http://www.ard-zdf-onlinestudie.de/files/2018/0918_Kupferschmitt.pdf.
- 30** See Nationaler IT Gipfel (2015a): Smart Home, Ergebnisdokument der Projektgruppe Smart Home Plattform „Digitale Netze und Mobilität“, downloadable at: http://www.de.digital/DIGITAL/Redaktion/DE/IT-Gipfel/Download/2015/it-gipfel-2015-smart-home.pdf?__blob=publicationFile&v=2;
- Nationaler IT Gipfel (2015b): Thesenpapier zum Schwerpunktthema Smart Data im Gesundheitswesen, downloadable at: <https://www.bitkom.org/noindex/Publikationen/2016/Positionspapiere/Thesenpapier-zum-Schwerpunktthema-Smart-Data-im-Gesundheitswesen/it-gipfel-2015-thesenpapier-zum-schwerpunktthema-smart-data-im-gesundheitswesen.pdf>;
- Bitkom (2014): Smart Home in Deutschland, downloadable at: <https://www.bitkom.org/noindex/Publikationen/2014/Studien/Smart-Home-in-Deutschland-Praesentation/Praesentation-Smart-Home.pdf>;
- DCTI (2015): DCTI GreenGuide Smart Home 2015, Die optimale Lösung für Ihr Zuhause, downloadable at: http://www.dcti.de/fileadmin/user_upload/GreenGuide_SmartHome_2015_Webversion.pdf
- und IW Consult GmbH (2016): Der Weg in die Gigabitgesellschaft, wie Netzausbau zukünftige Innovationen sichert, downloadable at: <http://www.vodafone-institut.de/wp-content/uploads/2016/07/studie-lange-version.pdf>.

and above has already tried Virtual Reality. The potential for VR remains high, as currently 17% can imagine diving into virtual realities in the future³¹.

Gaming is now widespread among about half the population in Germany. The use is not limited to individual age groups or educational groups. People from all social classes and age groups play on the PC, on the console or on the tablet and smartphone when on the road. It is reported in 2018 that around 34.3 million Germans played computer or video games, which rounds up to more than 40% of the population. More than 20% of the population can imagine using augmented reality.³² Furthermore, Cisco predicts that gaming traffic will grow 15 fold from 2017 to 2022, thus achieving a compound annual growth rate of 59%.³³

Overall, it can be said that in the future there will be a significantly higher proportion of Internet users in the cloud if there are no restrictions on the available bandwidths on the supply side. Cloud computing will then run in the background with technology-oriented user profiles (trend users, digital professionals and avant-gardists). The prerequisite for this is the fact that security concerns about the use of the cloud will be greatly reduced by 2025, due to better protection mechanisms. The cloud not only serves to store data (high-resolution images and videos, music, etc.), but also to use software and support applications in the E-Home and E-Health sectors. As for the use of cloud computing services, Germany stood with 31% in 2018, marking a growth of 7% from 2016.³⁴

It should not be forgotten in this context that the model assumes that there are no technical restrictions, i.e. users have no reason to ensure that software updates, synchronizations and similar functions are carried out in their applications at times when the Internet is not used as intensively.

31 See Deloitte; Bitkom (2018), Zukunft der Consumer Technology – 2018, Marktentwicklung, Trends, Mediennutzung, Technologien, Geschäftsmodelle, p. 37, downloadable at: <https://www.bitkom.org/sites/default/files/file/import/180822-CT-Studie-2018-online.pdf>.

32 See Game (2019): The German games industry, Insights, facts and reports, downloadable at: https://www.game.de/wp-content/uploads/2017/02/2019_Guide-to-the-German-Games-Industry_web.pdf; BIU (2016), Jahresreport der Computer- und Videospiegelbranche in Deutschland 2016, pp. 30 ff., downloadable at: https://www.biu-online.de/wp-content/uploads/2016/07/BIU_Jahresreport_2016.pdf; Game (2018): Jahresreport der deutschen Games-Branche 2018, p.7, downloadable at: <https://www.game.de/wp-content/uploads/2018/08/Jahresreport-der-deutschen-Games-Branche-2018.pdf>.

33 Cisco (2019): VNI: Forecasts and Trends, 2017-2022 White Paper, downloadable at: <https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white-paper-c11-741490.pdf>.

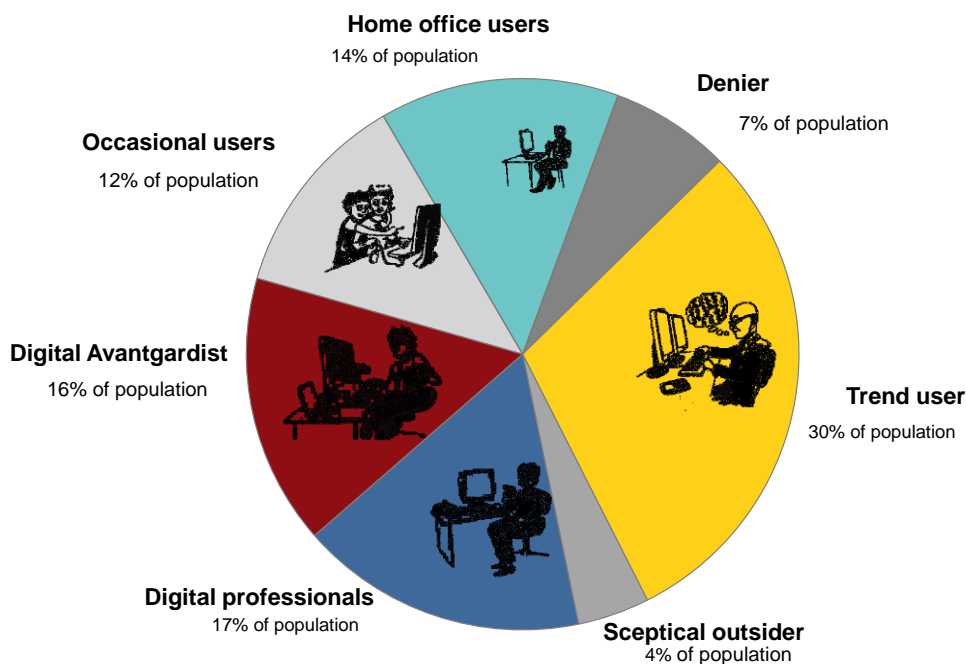
34 <http://appsso.eurostat.ec.europa.eu/nui/show.do>.

3.3.2 UK

Based on data about Internet and media usage from Eurostat (statistical office of the European Union), Ofcom, BARB (Broadcasters' Audience Research Board) and ONS (Office for National Statistics) the applicability of the user profiles described above to the UK has been critically assessed.³⁵

The assumed share of different user types as a proportion of the population is shown in the following figure.

Figure 3-3: Internet user profiles in the UK in 2025



Source: WIK.

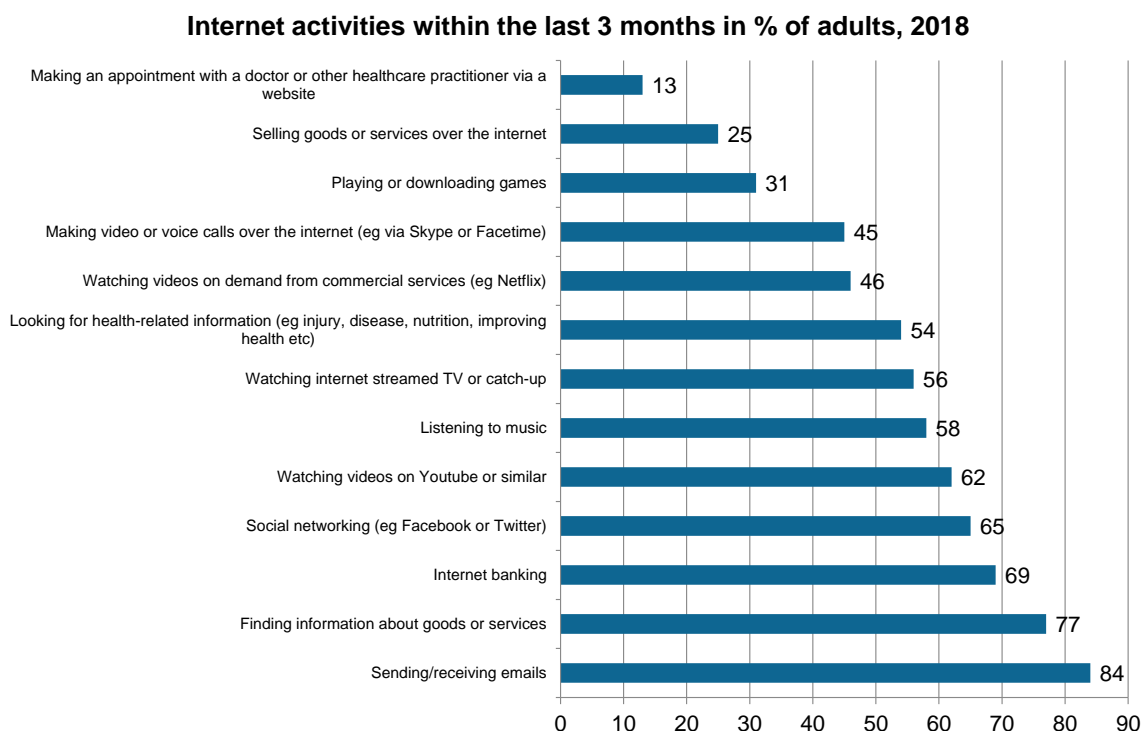


These shares have been developed based on an assessment of the available data concerning the proportions of the population using particular applications. The figure below shows the results of survey data collected for Ofcom on the use of the Internet for

³⁵ See for example Eurostat (2019), Individuals – use of cloud services, downloadable at: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_cicci_use&lang=en; Eurostat (2019), Internet use by individuals, downloadable at: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_ci_ifp_iu&lang=en; <https://ec.europa.eu/eurostat/data/database>; Ofcom (2018), Communications Markets Report, downloadable at: https://www.ofcom.org.uk/_data/assets/pdf_file/0022/117256/CMR-2018-narrative-report.pdf; BARB (2019), UK TV households by reception type, downloadable at: <https://www.barb.co.uk/tv-landscape-reports/tracker-uk-households-by-tv-platform/>; ONS (2018): Internet access – households and individuals, downloadable at: <https://www.ons.gov.uk/peoplepopulationandcommunity/householdcharacteristics/homeinternetandsocialmediausage/datasets/internetaccesshouseholdsandindividualsreferencetables>.

selected activities. This has been complemented with other data to validate the estimates as detailed below.

Figure 3-4: Use of the Internet for selected activities



Source: Office of National Statistics (2018).³⁶

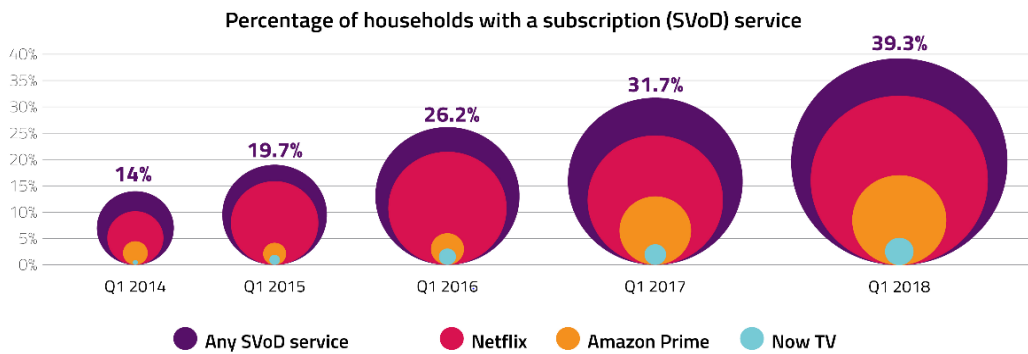
- The estimated 30% share of trend users by 2025 is based on usage of Video on Demand (VoD). In this context, we note that in 2018, 46% of adults in UK used VoD services³⁷. The usage of VoD in the UK has increased significantly, with 9.1 million subscriptions to Netflix in Q1 2018, achieving a 32.2% increase since Q1 2017. While Amazon Prime Video had a slightly greater Year-on-Year growth than Netflix with 32.7% by reaching 4.8 million subscribers in Q1 2018. This rapid take-up of VoD has led the total number of superscriptions to Netflix, Amazon and NOW TV to surpass the number of subscriptions to “traditional” pay-TV services for the first time. Netflix, Amazon and NOW TV’s total number of subscriptions totalled 15.4 million, whereas pay-TV subscriptions in the UK amounted to 15.1 million in Q1 2018.³⁸

³⁶ ONS (2018): Internet access – households and individuals, downloadable at: <https://www.ons.gov.uk/peoplepopulationandcommunity/householdcharacteristics/homeinternetandsocialmediausage/datasets/internetaccesshouseholdsandindividualsreferencetables>.

³⁷ BARB (2019): UK TV households by reception type, downloadable at: <https://www.barb.co.uk/tv-landscape-reports/tracker-uk-households-by-tv-platform/>.

³⁸ Ofcom(2018), downloadable at: https://www.ofcom.org.uk/data/assets/pdf_file/0014/116006/media-nations-2018-uk.pdf.

Figure 3-5: Take up of subscriptions on-demand services



Source: BARB Establishment Survey Q1 2014 – Q1 2018

The growth in Video on Demand is fuelled by the growth in connected devices as well as the increase in access to faster broadband speeds. 80% of households in UK have a fixed broadband connection, where by the end of 2017 58% of which were super-fast (30 Mbit or higher).³⁹

- The share of digital professionals, estimated at 17% by 2025 is influenced by the growth of virtual reality markets and 8K TV services and reflects the growth which is expected for Internet video, VoD and other innovative applications based on these technologies. In this context, we note that in 2017, 6% of the UK population were already reported to be using a virtual reality device,⁴⁰ with the popularity of these devices exceeding those of tablets and wearables at the same stage of their development.
- The proportion of home workers in the UK was 14% in 2018.⁴¹ Accordingly, the model assumes that 14% of the population will be home office users in 2025. This could however be considered a conservative estimate, as this proportion could increase over time, especially if higher bandwidths facilitate home working.⁴²
- The proportion of avant-gardist users draws on the popularity of gaming. As previously mentioned, according to the UK games industry, the UK is estimated to have the largest and fastest growing VR hardware market in EMEA, growing at 76% CAGR in the next five years.⁴³ As of 2018 the UK has the 6th largest

³⁹ Ofcom (2018), downloadable at:

https://www.ofcom.org.uk/_data/assets/pdf_file/0014/116006/media-nations-2018-uk.pdf.

⁴⁰ <https://yougov.co.uk/news/2017/05/19/vr-headsets-more-popular-tablets-and-wearables-wer/>.

⁴¹ ONS (2018): Internet access – households and individuals, downloadable at:

<https://www.ons.gov.uk/peoplepopulationandcommunity/householdcharacteristics/homeinternetandsocialmediausage/datasets/internetaccesshouseholdsandindividualsreferencetables> and

<https://www.thehrdirector.com/business-news/health-and-wellbeing/four-million-working-from-home/>.

⁴² See UK Commission for Employment and Skills (2014): The Future of Work, Jobs and Skills in 2030, downloadable at:

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/303334/er84-the-future-of-work-evidence-report.pdf.

⁴³ See ukie (2017): UK Video Games Fact Sheet, downloadable at: <https://ukie.org.uk/research>.

video games market worldwide in terms of consumer revenues. It is reported that approximately 37.7 million people in the UK play video games. Furthermore, the UK games market will be Europe's largest video games market by 2021.⁴⁴ Noting that 31% of Internet users played and downloaded games, the share of 16% for the digital avant-gardist in 2025 may underestimate the use of gaming services in the model.

- The occasional user of the WIK model can be compared to the “narrow user” in the Ofcom report on adults’ media use and attitudes.⁴⁵ In 2017 25% of Internet users were considered to be narrow users compared to 28% in 2016. When estimating the share of occasional users it should be taken into account that there is a high share of adults and those aged 75 and higher in this group. In 2025 it can be assumed that the number of occasional users will decrease as younger generations with higher Internet usage and more affinity to technological innovation grow into older age groups. As a result we estimate that the share of occasional users will decrease significantly to 12% in 2025.
- The share of sceptical outsiders has been estimated on the basis of the share of “newer users” in the Ofcom report on adults’ media use and attitudes.⁴⁶ In 2017 there were 7% newer users. When estimating the share of sceptical outsiders, it should be taken into account that there is a high share of adults and those aged 75 and higher in this group. In 2025 it can be assumed that the number of sceptical outsiders will decrease as younger generations with higher Internet usage grow into older age groups. As a result we estimate the share of sceptical outsiders in the population to be 4% in 2025.
- When estimating the share of deniers in 2025 it should be noted that today's younger generations (with a significantly higher affinity for technology)⁴⁷ are likely to grow into user profiles with high bandwidth and quality requirements. It can therefore be assumed that only a small proportion of the population will not use the Internet in 2025. The group of deniers is estimated at around 7% of the population, a decline from the 13% of adults who were estimated to have had no Internet access at home in 2018.⁴⁸

44 PWC (2017): The 2017 UK entertainment and media outlook, downloadable at:

<https://www.pwc.co.uk/industries/entertainment-media/insights/entertainment-media-outlook.html>.

45 See Ofcom (2017): Adults’ media use and attitudes Report 2017, downloadable at:

https://www.ofcom.org.uk/_data/assets/pdf_file/0020/102755/adults-media-use-attitudes-2017.pdf

and Ofcom (2018): Adults’ media use and attitudes Report 2018, downloadable at:

https://www.ofcom.org.uk/_data/assets/pdf_file/0011/113222/Adults-Media-Use-and-Attitudes-Report-2018.pdf.

46 Compared to established Internet users who first went online five years ago or more, newer users spend less time online, are less confident Internet users and are more likely to only use websites or apps they have used previously. See Ofcom (2018): Adults’ media use and attitudes Report 2017, downloadable at: https://www.ofcom.org.uk/_data/assets/pdf_file/0011/113222/Adults-Media-Use-and-Attitudes-Report-2018.pdf.

47 The percentage of Internet usage is highest among younger age groups, although over half (64%) of over-65s are Internet users. See Ofcom (2018): Communications Markets Report, p. 69, downloadable at: https://www.ofcom.org.uk/_data/assets/pdf_file/0022/117256/CMR-2018-narrative-report.pdf.

48 Ofcom (2018): Communications Market Report 2018 – United Kingdom, downloadable at: https://www.ofcom.org.uk/_data/assets/pdf_file/0022/117256/CMR-2018-narrative-report.pdf.

In addition, a cross-check of the distribution of usage of key applications such as cloud computing and E-Health across user types with reference to current usage and trends shows that:

- In 2018 50% of individuals used cloud services in the UK.⁴⁹ This is one of the highest percentages of cloud usage among Internet users in comparison to other European countries.⁵⁰ Cisco forecasts that by 2020, 59% of the consumer Internet population will use personal cloud storage, up from 47% in 2015.⁵¹ Against this background, the share of cloud users in sum (trend users, digital professionals and avant-gardists) is estimated to be 63% in 2025 in the WIK model. It is assumed that cloud serves not only to store data (high-resolution images and videos, music, etc.), but also to use software and support applications in the E-Home and E-Health sector.
- The UK was an early adopter of using telemedicine (sometimes referred to as telecare in the UK).⁵² As a result, telecare is a mature market in the UK with the highest penetration per capita in the over 65s category of any global market. On the other hand, the market is well established and therefore not expected to grow so rapidly in future (the UK market in 2014 was forecast to grow at a compound annual growth rate (CAGR) of four to five percent to 2018).⁵³ Accordingly, E-Health is assumed to be used by occasional users and trend users with a total share of 42%.
- In 2014 11% of UK households were estimated to use smart home applications and the market was expected to grow at rates of almost 30%.⁵⁴ More recent reports forecast the Internet of Things market to grow at 17% CAGR in 2017 and at 9% in 2021.⁵⁵ The share of user profiles using E-Home applications is estimated to be 33% in sum in 2025.

⁴⁹ <http://appsso.eurostat.ec.europa.eu/nui/show.do>.

⁵⁰ In 2016 46% of Internet users used Internet storage space to save documents, pictures, music, video or other files. See <http://appsso.eurostat.ec.europa.eu/nui/show.do>.

⁵¹ See Cisco (2016): Cisco Global Cloud Index: Forecast and Methodology, 2015–2020, White Paper, downloadable at: <https://www.cisco.com/c/dam/en/us/solutions/collateral/service-provider/global-cloud-index-gci/white-paper-c11-738085.pdf>.

⁵² See U.S. Department of Commerce International Trade Administration (2017): 2017 Top Markets Report Health Information Technology Country Case Study, downloadable at: https://www.trade.gov/topmarkets/pdf/Health_IT_UnitedKingdom.pdf.

⁵³ Please note that despite the maturity of the market the bandwidth and quality requirements change because of the introduction of new applications which for example include the transmission of high definition audiovisual files.

⁵⁴ <https://www.alliedmarketresearch.com/smart-home-automated-building-market>

⁵⁵ <https://www.strategyanalytics.com/strategy-analytics/news/strategy-analytics-press-releases/strategy-analytics-press-release/2017/10/26/smart-home-will-drive-Internet-of-things-to-50-billion-devices-says-strategy-analytics#.WnA76nkxmos>

3.3.3 Flanders

The user typologies in the model have also been critically reflected against specific data collected for the Flanders population in Belgium. In addition to the specific data from statistical offices and government sites, the user profiles from the model have been mapped to the four user profiles created by the 2016 report by IMEC⁵⁶ specifically for the Flanders population in the context of media usage as it reflects the usage patterns of digital media and technology of the Flemish population. In 2018 IMEC published a report with new segmentation of user profiles that focuses on the attitudes of the population towards digital technology. The justification of their new approach is the fact that segmenting user profiles by only looking at usage and ownership does no longer add significant value, as they report that only 2% of Flemish households did not have access to a smart device. Despite the rise of digitization, it is noted that the negative views and attitudes of the Flemish population towards digital technology has increased, the attitudes are depicted in the new user profiles⁵⁷. The new user profiles would imply a different methodology in the categorisation of user profiles so that it was not possible to update the data on user profiles from 2016 with data from 2018 for the WIK model. In consequence, the WIK Model, continues to focus on the usage patterns of digital technology. To some extent there is data on usage patterns included in the 2018 IMEC report which confirms the development of shares of user profiles in population assumed for 2025 in the WIK model. For example, with regards to Virtual Reality 63% of the population claim that they have knowledge of it, and around 9% own VR glasses⁵⁸. As for video games, half of the Flemish population play digital games monthly⁵⁹. When it comes to social media usage, it is reported that nearly 87% use at least one social network monthly.⁶⁰

The following table shows the 4 user profiles identified in the 2016 IMEC report and the characteristics per user profile followed by a table showing the mapping of these four user profiles on the user profiles of the demand model.

⁵⁶ User profiles: Disruptors, cumulator, struggler and resistor, see <http://www.imec-int.com/assets/imec-digimeter-2016-report.pdf>.





⁵⁷ IMEC (2019): IMEC.DIGIMETER 2018, Measuring Digital Media Trends in Flanders, p. 12, downloadable at: <https://www.imec-int.com/drupal/sites/default/files/inline-files/457015-IMEC-DIGIMETER-2018-ENG.pdf>.

⁵⁸ IMEC (2019): IMEC.DIGIMETER 2018, Measuring Digital Media Trends in Flanders, p. 94, downloadable at: <https://www.imec-int.com/drupal/sites/default/files/inline-files/457015-IMEC-DIGIMETER-2018-ENG.pdf>.

⁵⁹ IMEC (2019): IMEC.DIGIMETER 2018, Measuring Digital Media Trends in Flanders, p. 38, downloadable at: <https://www.imec-int.com/drupal/sites/default/files/inline-files/457015-IMEC-DIGIMETER-2018-ENG.pdf>.

⁶⁰ IMEC (2019): IMEC.DIGIMETER 2018, Measuring Digital Media Trends in Flanders, p. 53, downloadable at: <https://www.imec-int.com/drupal/sites/default/files/inline-files/457015-IMEC-DIGIMETER-2018-ENG.pdf>.

Table 3-5: Description of IMEC user profiles

User profiles (% of Flanders population)	Characteristics per user profile
Disruptor (24,1%) 	<ul style="list-style-type: none"> • Average age 35, tend to live with parents • Digital media replaced traditional media (sms, calling) • Smart phone is core device • Big fans of streaming music (62%), social media (89% facebook) and gaming (83% monthly) • Generally buying online (70%)
Cumulator (38,6%) 	<ul style="list-style-type: none"> • Average age 44, generally live with partner, high education • Mix usage new technology with traditional • Daily habits; mobile calls (52%), emails (77%) and SMS (74%) and messaging apps and social media • News junkies, 52% gaming monthly and familiar with buying online
Struggler (10,9%) 	<ul style="list-style-type: none"> • 50+ years, including subgroup of 15-19 years • Traditional media but central use of tablet • Want to explore but lack skills. Still use landline and SMS daily but also FB and Whatsapp (subgroup). • Traditional radio and CD dominant but most common gamers (75%, subgroup especially on PC or tablet)
Resistor (26,3%) 	<ul style="list-style-type: none"> • 60+ years, either single or without children, lower education • Low adoption and use of internet, smartphone, tablet • Little interest in digital media • Use mobile (42%) and landline (16%) daily • Messaging apps less popular except Whatsapp (21% daily) • Traditional radio and news sources and less familiar with online buying (29%)

Source: IMEC Digimeter 2016.

Table 3-6: Mapping of specific Flanders user profiles to user profiles in the model

IMEC Digimeter 2016	WIK Market potential model
Disruptor (24,1% > 25%)	Trend user (23%) -profile match-
Cumulator (38,6 > 40%)	Home office (10%) - Fits in cumulator profile, lower than other EU countries -
	Digital professional (25%) - Profile match, this group prominent in Flanders according IMEC report-
	Digital avantgardist (8%) - profile match, same as in other EU countries
Struggler (10,9%)	} 37,2% > 35%
Resistor (26,3%)	
	Occasional user (19%) -profile match-
	Denier (9,8%)

Source: IMEC Digimeter 2016, WIK.

The distribution of user profiles among the population as a whole is initially characterised by the fact that today's younger generations (with a significantly higher affinity for technology) will grow into user groups and digital applications in 2025 will be more widespread than they are today.

In 2018, 96% of the population in Flanders, Belgium, had access to internet in their households. In 2016, 76% of the Flemish population used internet on a daily basis⁶¹. It is therefore assumed that only a small proportion of the population will not use the Internet in 2025.

With respect to video streaming (TV/Video viewing), Cisco forecasts a yearly growth rate of 24% for IP Video data traffic until 2021⁶². In 2018, 43% of the Flemish population streamed music monthly, while 49% watched internet television or other online material⁶³.

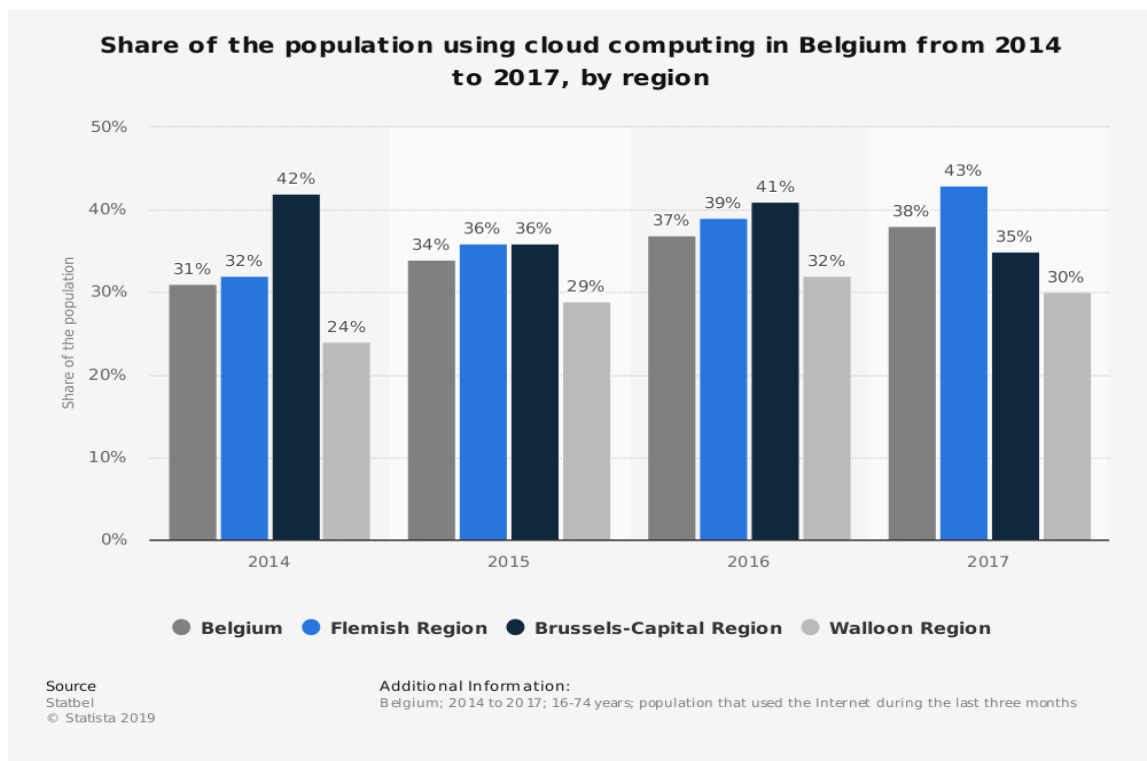
Applications such as VPN, cloud computing, gaming and video communications are already being used, but the potential is not fully exploited until high-bit-rate broadband connections are available. Figure 3-6 shows that the use of cloud computing is constantly growing in Flanders (43% of population in 2017) and thus surpassing Brussels for the first time.

61 <http://regionalestatistieken.vlaanderen.be/sites/default/files/docs/vrind2017-0-volledig-bladwijzers.pdf>

62 See Cisco (2017), VNI Complete Forecast Highlights, Western Europe, downloadable at: https://www.cisco.com/c/m/en_us/solutions/service-provider/vni-forecast-highlights.html. Although data volume does not relate directly to the required bandwidth in a household, the trends observed in the past and projected for the future are an indicator of the usage behaviour of end customers.

63 <http://regionalestatistieken.vlaanderen.be/sites/default/files/docs/vrind2017-0-volledig-bladwijzers.pdf>, page 333.

Figure 3-6: Share of the population using cloud computing in Belgium from 2014 to 2017, by region



Source: Statista 2019. ⁶⁴

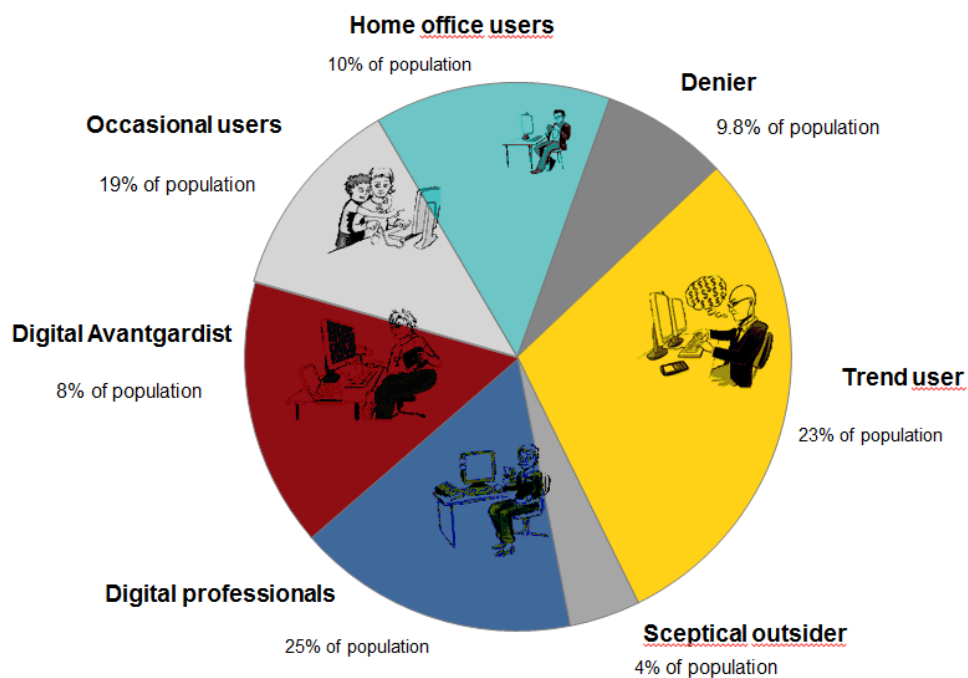
In 2016 5.5% of the population in Flanders owned a VR headset while in 2018 the percentage grew to 10% ⁶⁵. The use of virtual reality applications is attracting interest among a high proportion of the population.

E-Health and smart applications are believed to have great disruptive potential, especially when the necessary infrastructure is in place. Accordingly, the proportion of trend users using applications such as E-Health, video streaming and video communication is expected to be quite high by 2025. In contrast, we expect the role of the user profiles digital avant-gardist, home office users and digital professionals to be less than 20% for VR applications.

⁶⁴ <https://www.statista.com/statistics/570294/share-of-the-population-using-cloud-computing-in-belgium-by-region/>

⁶⁵ IMEC (2019): IMEC.DIGIMETER 2018, Measuring Digital Media Trends in Flanders, p. 53, downloadable at: <https://www.imec-int.com/drupal/sites/default/files/inline-files/457015-IMEC-DIGIMETER-2018-ENG.pdf>.

Figure 3-7: Internet user profiles and share in population in Flanders in 2025



Source: WIK

3.4 Aggregating demand across households

The aggregation of bandwidth demand from individual users into household demand, is based on the population size and household structure estimated for 2025.

The table below shows the household structure in Germany, the UK and in Flanders.⁶⁶

⁶⁶ For Germany and Flanders projections of the household structure in 2025 and 2022 were available, for the UK the current household structure was applied under the assumption that the households structure would remain stable as it has from 2006 until 2016 according to the Office of National Statistics. Statistisches Bundesamt (2011): Bevölkerung und Erwerbstätigkeit, Entwicklung der Privathaushalte bis 2030, Ergebnisse der Haushaltsvorausberechnung; downloadable at: https://www.google.de/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwjAmdCnpbrQAhXMCMaKHqSC1sQFggdMAA&url=https%3A%2F%2Fwww.bpb.de%2Fsystem%2Ffiles%2Fdokument_pdf%2FEntwicklung%2520der%2520Privathaushalte%2520bis%25202030.pdf&usq=AFQjCNH7p5d2SYSIBC3YqieORBdXDyobLA; ONS (2016): Families and households in the UK: 2016, downloadable at: <https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/families/bulletins/familiesandhouseholds/2017> and Statistiek Vlaanderen (2017): Meer en kleinere huishoudens in Vlaanderen in de komende 10 jaar, downloadable at: <https://www.statistiekvlaanderen.be/sites/default/files/docs/proj2018-kleinere-huishoudens.pdf>.

Table 3-7: Household structure in Germany, the UK and in Flanders

Region / Household members	1	2	3	4+
Germany	43,4%	38,4%	9,1%	9,1%
UK	28%	35%	16%	21%
Flanders	32,1%	35,1%	13,6%	19,2%

Source: Statistisches Bundesamt (2011), ONS (2016) and Statistiek Vlaanderen (2017).⁶⁷

The aggregation of user profiles across households also has an impact on the results of the WIK model as it influences the extent to which applications are used simultaneously in a multi-person household.

All users are represented in all household sizes, i.e. all user profiles live in all household types. However, the distribution of user profiles among household types reflects which household size is more frequent in the respective user profile. For example, more than half of sceptical users live in one person households. Occasional users typically live in one and two person households. As mentioned above, home office users predominantly live in households with two or more persons, similar to professional users. Trend users have a considerable share living in two person households while avant-gardists live to a great extent in one and two person households.

In multiple user households, the profiles are assigned based on the assumption that user profiles within a household are similar. This means e.g. that a sceptical outsider mainly lives either with other sceptical outsiders or with occasional users in the household. Occasional users live with sceptical outsiders, other occasional users and with home office users in multi-person households, but not with trend users, professional users or avant-gardists. The home office user is assumed to live with occasional users or trend users in a household while trend users are also combined with professional users. If the assumption that user profiles in one household are similar were not applied, there would be more households with high level demand and less at the extremes with low or top level demand.

Based on these assumptions, we can estimate aggregated demand across all users for each household in Germany, in the UK and in Flanders. This is shown in the next section.

⁶⁷ For the household structure in Germany, the UK and Flanders see Statistisches Bundesamt (2011): Bevölkerung und Erwerbstätigkeit, Entwicklung der Privathaushalte bis 2030, Ergebnisse der Haushaltsvorausberechnung; downloadable at:

https://www.google.de/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwjAmdCnpbrQAhXMCMAKHqSC1sQFggdMAA&url=https%3A%2F%2Fwww.bpb.de%2Fsystem%2Ffiles%2Fdokument_pdf%2FEntwicklung%2520der%2520Privathaushalte%2520bis%25202030.pdf&usg=AFQjCNH7p5d2SYSIBC3Yqie0RBdXDyobLA;

ONS (2016): Families and households in the UK: 2016, downloadable at:

<https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/families/bulletins/familiesandhouseholds/2017> and Statistiek Vlaanderen (2017): Meer en kleinere huishoudens in Vlaanderen in de komende 10 jaar, downloadable at:

<https://www.statistiekvlaanderen.be/sites/default/files/docs/proj2018-kleinere-huishoudens.pdf>.

4 Unconstrained bandwidth demand in 2025

As already mentioned, the forecast bandwidth demands are not primarily driven by individual applications such as TV/Video viewing, but rather by the simultaneous use of digital services in households. This mainly reflects several people in one household using applications with high bandwidth requirements and also, but to a lesser extent, the parallel use of applications/devices, such as simultaneous use of cloud and mobile offloading by one person.

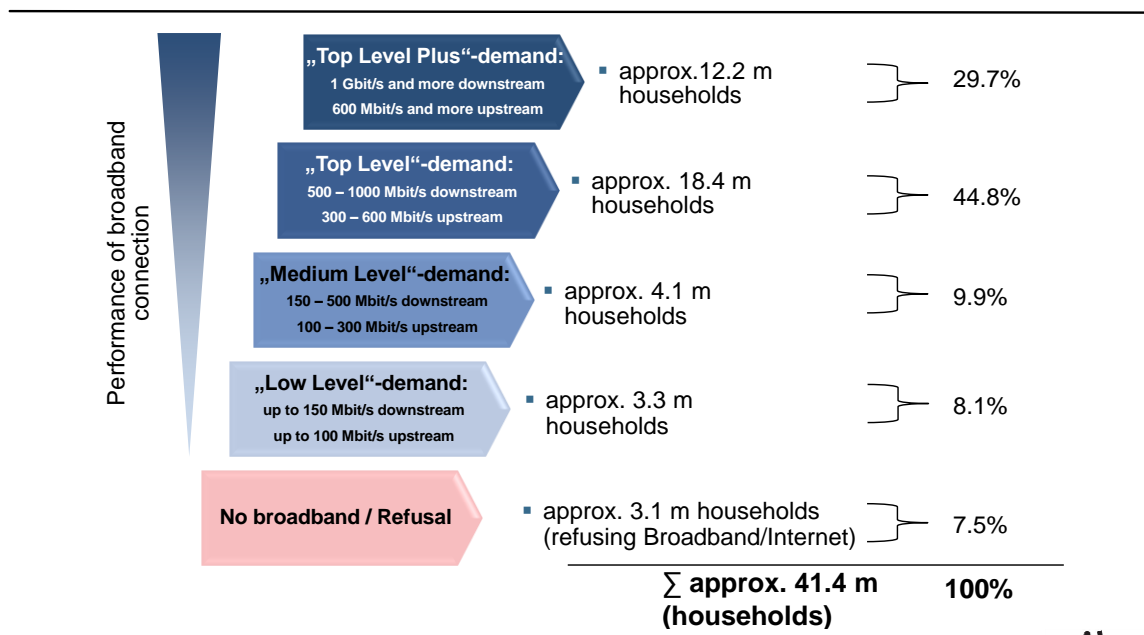
It is important to note that these forecasts are based on the assumption that there are no technical restrictions, such that users do not have to worry about overloading their broadband connection. As for instance, when they synchronize their devices with the cloud while they are watching an 8K movie on a TV streaming platform.

4.1 Forecasts

4.1.1 Germany

By 2025 it is predicted that approximately 30.6 million households, which present 74.5% of households in Germany will demand top level and higher bandwidths representing downstream bandwidth of 500 Mbit/s or more. Only 7.5% of households are expected to refuse internet connection or broadband. The following figure demonstrates the bandwidth demand forecast for fixed broadband access in 2025 in Germany.

Figure 4-1: Bandwidth demand in Germany in 2025

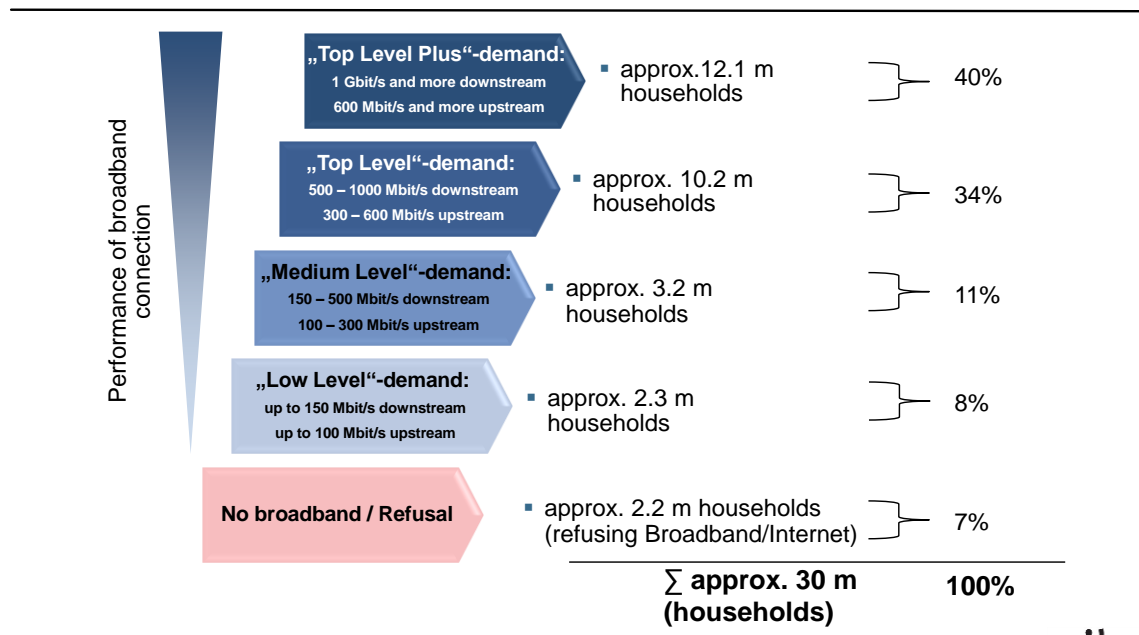


Source: WIK.

4.1.2 UK

The United Kingdom’s forecast bandwidth demands exhibits that 74% of all households will be in a top level broadband connection by 2025. Out of approximately 30 million households, only 2.2 million households will not have access to a broadband connection.

Figure 4-2: Bandwidth demand in the UK in 2025

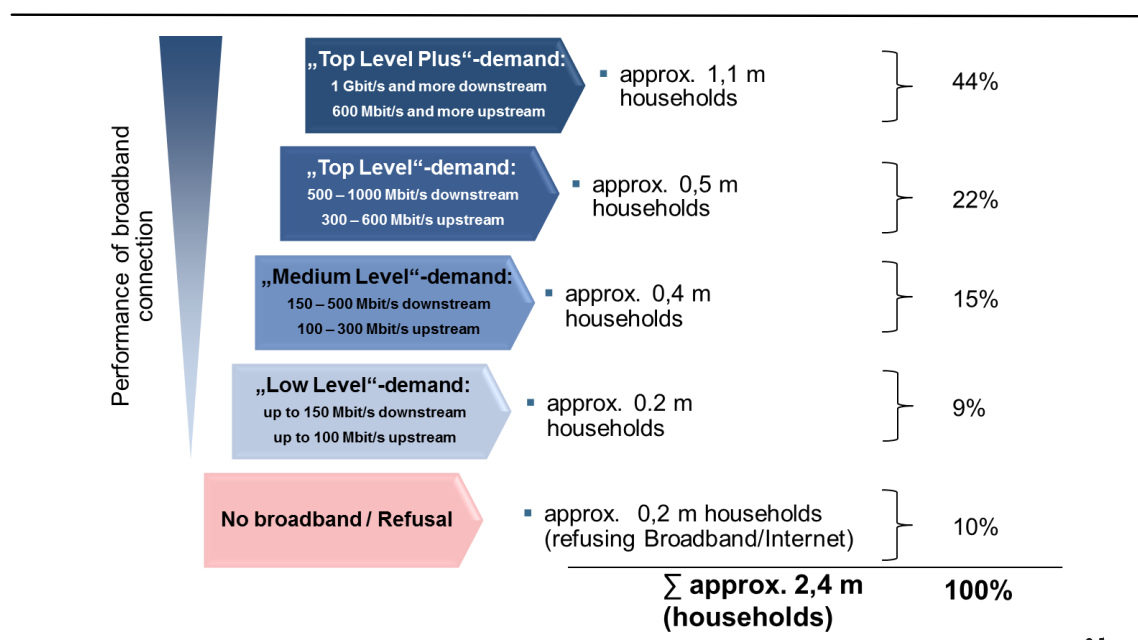


Source: WIK.

4.1.3 Flanders

In Flanders, Belgium 44% of all households will demand Top Level Plus broadband connection by 2025. This means a 1 Gbit/s and more downstream. A significant number of households totaling 10% will not have or refuse to have a broadband connection.

Figure 4-3: Bandwidth demand in Flanders in 2025



Source: WIK.

4.2 Comparative analysis, sensitivity and conclusions

The comparison of future demand in the different regions shows an ambiguous picture. In Flanders, one third of households is designated to have bandwidth needs in 2025 which could (under favourable conditions) be satisfied with upgraded copper technology. The share of deniers is striking against the backdrop of an increasingly digitised environment which can be expected for 2025. On the other hand, the share of households which are expected to use gigabit bandwidths is considerably higher than in Germany and the UK. In sum, this seems to point at an increasing digital divide in Flanders.

Germany and the UK show comparable results for the demand of bandwidths of up to 500 Mbit/s. Again, the share of deniers represents a political issue given the political goal of a highly digitised future environment. The most striking difference between Germany and the UK is the share of top level and top level plus users. The higher share of top level plus users in the UK comes both from a higher openness and usage of advanced digital applications with high requirements for bandwidth and quality and from a high share of multi-person households.

Table 4-1: Future bandwidth demand in Germany, the UK and Flanders in % of households

Region / Download capacity	Gigabit	500 Mbit/s - Gigabit	150-500 Mbit/s	Up to 150 Mbit/s	Deniers
Germany	29,7	44,8	9,9	8,1	7,5
UK	40	34	11	8	7
Flanders	43,9	22	14,8	9,3	10

Source: WIK.

It is possible to identify other plausible outcomes through conducting sensitivity tests. Therefore, the impact of taking a more optimistic view of compression technologies was tested by also modelling scenarios where applications such as cloud, VPN and progressive media have lower bandwidth requirements by 2025 and where more simultaneous use of applications was assumed to take place. The results of the sensitivity tests are show in the table below.

Table 4-2: Overview of forecast results of sensitivity analysis

	Region/download	Gigabit	500 Mbit/s - Gigabit	150-500 Mbit/s	Up to 150 Mbit/s	Deniers
	Germany	29,7	44,8	9,9	8,1	7,5
	UK	40	34	11	8	7
	Flanders	44	22	15	9	10
Forecast assuming lower bandwidths for TV and VPN	Germany	20,8	53,7	9,9	8,1	7,5
	UK	20	42	22	8	7
	Flanders	32	27	22	9	10
Forecast assuming more simultaneous use of applications	Germany	51,5	31	2	8	7,5
	UK	53	24	8	8	7
	Flanders	49	22	10	9	10

Source: WIK.

In an alternative scenario, which assumes a slower bandwidth development for the application categories state of the art media, progressive TV in 8K quality and VPN/Home Office,⁶⁸ the share of households requiring download bandwidths of 1 Gbit/s and above falls to less 21% and 20% in Germany and the UK, and to 32% in Flanders. However, the majority of households is expected have demands calling for top level bandwidths (above 500 Mbit/s) under this scenario as well.

⁶⁸ This scenario is based on lower bandwidth growth rates for the two applications for which compression could play a significant role to reduce bandwidth requirements (State of the art media; and TV in 8K quality). VPN has also been reduced to show that the bandwidth requirements of one single application is not decisive for the results. Rather, it is the simultaneous use of applications which drives broadband demand.

Increasing the simultaneous use of applications unsurprisingly has an impact on the share of gigabit bandwidth demand. In sum, overall broadband demand is partially sensitive to the assumptions on the required bandwidths for and the simultaneous use of applications but there still remains a high share of households which will use top level bandwidths above 500 Mbit/s. The primary reason for this lies in the importance that the parallel use of applications in multi-person households has on bandwidth demand. The share of high-end user profiles in the population such as the professional and avant-gardist users also play an important role in future bandwidth demand.

The different household structures and allocation of user profiles explain the regional differences in our forecast on future bandwidth demand. The UK and Flanders have a household structure with a higher share of multi-person households than Germany. This results in a higher share of gigabit bandwidth demand. In Belgium/Flanders the current demand for bandwidths already reflects this as the share of subscriptions to bandwidths above 100 Mbit/s has strongly increased in the last years. The demand for higher bandwidths has also increased considerably in the UK but has not reached the same level as in Belgium/Flanders due to the more limited availability of high capacity connections in the UK.

With reference to the user profiles between the regions analysed there are differences in the applications which are used by the respective user profiles as well as in the share the user profiles have in the population. While in Germany IPTV has a higher share in the transmission of broadcasting, in the UK broadband platforms are only used for broadcasting transmissions to a limited extent. The share of the respective user profiles in Germany and UK is similar. The higher share of professional and home office users results in a higher share of households in the top level bandwidth segment.

In Flanders the allocation of user profiles is considerably different. Home office and trend users as well as avant-gardists have a smaller share in the population. In contrast with that the strong interest in virtual/augmented reality is reflected in a higher share of professional users. Deniers and occasional users are estimated to play a more important role in Flanders than in Germany and in the UK. As a result of the higher share of deniers and occasional/sceptical users the future share of low bandwidth demand is estimated to be higher in Flanders than in the UK and Germany.

Table 4-3: Geographical differences in user profiles

Country/ User Types	Occasional	Sceptical Outsider	Job User	Trend User	Avantgardist	Professional	Denier
Germany	12%	4%	14%	30%	17%	16%	7,5%
UK	12%	4%	14%	30%	16%	17%	7%
Flanders	19%	4%	10%	23%	8%	25%	9,8%

Source: WIK.

It should be taken into account that the share of user profiles such as professional and avant-gardist users demanding for a high quality of broadband connections is considerable in the UK and in Germany so that eventually, future demand for gigabit connections may also be driven by quality requirements (low latency and low packet loss rate), which are not reflected in the share of households with top level bandwidth demand shown above.

Our results also imply some interesting implications with regard to public policy. Apart from commercially driven applications such as gaming and progressive TV, we see a number of (potential) fields of growth with a high level of impact of public policymakers. Our model shows that teleworking is a relevant trigger for broadband demand. Today, the share of employees using teleworking is still limited despite obvious positive impacts with regard to pollutant emissions or flexibility. By enforcing wider reaching rules enabling a larger share of employees to use teleworking, a positive impact on bandwidth demand could be achieved.

Other potential drivers affect the public policy beyond its role as a rule-maker. There is potential to increase the demand for and with it the penetration of VHC networks if it were possible to trigger the development of E-Health and E-government services. As these are highly regulated sectors the main impetus has to come from politics to realise this potential.

Finally, against the backdrop of far reaching political goals with regard to the digitisation of society and economy, public politics need to identify ways to deal with the group of deniers, sceptical outsiders and (to less extent) occasional users to prevent an increasing digital divide. The more an economy is digitised the more important it is to prevent that there are groups in the population which are e.g. excluded from education, labour and public services provided in the context of E-learning, digitised companies and E-government.

It is obvious, that measures designed to reduce the scepticism and refusal to use internet applications as well as to increase the digitisation of the economy and society in Germany, the UK and Flanders are likely to represent a challenge for providers of communication services if they have to deal with that on their own. Again, the role of public policy as an avant-gardist in digitisation in areas like e-Government and e-Health can help to deal with that kind of concerns.

Last but not least, it is fair to say that efforts to develop the supply of and the demand for digital applications can only succeed if connectivity is available which fulfils the necessary bandwidth and quality requirements (low latency and low packet loss rate). In this regard, all three case study candidates still have a long way ahead.

5 References

- BARB (2019), UK TV households by reception type, downloadable at: <https://www.barb.co.uk/tv-landscape-reports/tracker-uk-households-by-tv-platform/>.
- Bitkom (2014): Smart Home in Deutschland, downloadable at: <https://www.bitkom.org/noindex/Publikationen/2014/Studien/Smart-Home-in-Deutschland-Praesentation/Praesentation-Smart-Home.pdf>.
- BIU (2015): Positionspapier Agenda 2020: für eine starke Computer- und Videospielebranche in Deutschland, downloadable at: https://www.biu-online.de/wp-content/uploads/2015/06/20150608_BIU_Positionspapier_F%C3%B6rderung_Standort_Deutschland.pdf.
- BIU (2016), Jahresreport der Computer- und Videospielebranche in Deutschland 2016, downloadable at: https://www.biu-online.de/wp-content/uploads/2016/07/BIU_Jahresreport_2016.pdf.
- BVDW (2019): Digitale Nutzung in Deutschland 2018, downloadable at: https://www.bvdw.org/fileadmin/user_upload/BVDW_Marktforschung_Digitale_Nutzung_in_Deutschland_2018.pdf.
- CAICT and HUAWEI Technologies Co. Ltd (2017): Virtual Reality/Augmented Reality White Paper, downloadable at: <http://www-file.huawei.com/-/media/CORPORATE/PDF/ilab/vr-ar-en.pdf>.
- Cisco (2016): Cisco Global Cloud Index: Forecast and Methodology, 2015–2020, White Paper, downloadable at: <https://www.cisco.com/c/dam/en/us/solutions/collateral/service-provider/global-cloud-index-gci/white-paper-c11-738085.pdf>.
- Cisco (2017), VNI Complete Forecast Highlights, Western Europe, https://www.cisco.com/c/m/en_us/solutions/service-provider/vni-forecast-highlights.html.
- Cisco (2019): VNI: Forecasts and Trends, 2017-2022 White Paper, downloadable at: <https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white-paper-c11-741490.pdf>.
- DCTI (2015): DCTI GreenGuide Smart Home 2015, Die optimale Lösung für Ihr Zuhause, downloadable at: http://www.dcti.de/fileadmin/user_upload/GreenGuide_SmartHome_2015_Webversion.pdf.
- Deloitte; Bitkom (2018), Zukunft der Consumer Technology – 2018, Marktentwicklung, Trends, Mediennutzung, Technologien, Geschäftsmodelle, downloadable at: <https://www.bitkom.org/sites/default/files/file/import/180822-CT-Studie-2018-online.pdf>.
- Doose, A.-M.; Monti, A.; Schäfer, R. (2011): Mittelfristige Marktpotenziale im Kontext der Nachfrage nach hochbitratigen Breitbandanschlüssen in Deutschland, WIK Diskussionsbeitrag Nr. 358, Bad Honnef.
- Doutsi, E. (2017): Compression d'images et de vidéos inspirée du fonctionnement de la rétine, downloadable at: <https://tel.archives-ouvertes.fr/tel-01584114/document>.
- Eurostat (2019), Individuals – use of cloud services, downloadable at: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_cicci_use&lang=en;
- Eurostat (2019), Internet use by individuals, downloadable at: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_ci_ifp_iu&lang=en, <https://ec.europa.eu/eurostat/data/database>;
- Fraunhofer FOKUS (2016): Netzinfrastrukturen für die Gigabitgesellschaft, downloadable at: https://cdn2.scrvt.com/fokus/5468ae83a4460bd2/65e3f4ee76ad/Gigabit-Studie_komplett_final_einzelseiten.pdf.
- Frees, B. and Koch, W. (2018): ARD/ZDF-Onlinestudie 2018: Zuwachs bei medialer Internetnutzung und Kommunikation, in Media Perspektiven 9/2018, p. 398-413, downloadable at: http://www.ard-zdf-onlinestudie.de/files/2018/0918_Frees_Koch.pdf.
- Frontier Economics (2017): Future benefits of broadband networks, downloadable at: <https://www.nic.org.uk/wp-content/uploads/Benefits-analysis.pdf>.

- FTTH Council (2016): FTTH Business Guide, Edition 5 Financing Committee, Revision date: 16/02/2016, downloadable at: http://www.ftthcouncil.eu/documents/Publications/FTTH_Business_Guide_V5.pdf.
- Game (2018): Jahresreport der deutschen Games-Branche 2018, downloadable at: <https://www.game.de/wp-content/uploads/2018/08/Jahresreport-der-deutschen-Games-Branche-2018.pdf>.
- Game (2019): The German games industry, Insights, facts and reports, downloadable at: https://www.game.de/wp-content/uploads/2017/02/2019_Guide-to-the-German-Games-Industry_web.pdf.
- Godlovitch, I.; Plückerbaum, T.; Strube Martins, S.; Gantumur, T.; Elixmann, D.; Tas, S.; Arnold, R.; Wernick, C. (2018): The Benefits of Ultrafast Broadband Deployment, Report for Ofcom, downloadable at: https://www.ofcom.org.uk/_data/assets/pdf_file/0016/111481/WIK-Consult-report-The-Benefits-of-Ultrafast-Broadband-Deployment.pdf.
- Huawei iLab (2017): Video Big Data, The Top 10 Most Demanding Videos on the Net, downloadable at: <https://www.huawei.com/~media/CORPORATE/PDF/white%20paper/Big-Data-Video-Top-Ten-Most-Demanding-Videos-en>.
- IMEC (2019): IMEC.DIGIMETER 2018, Measuring Digital Media Trends in Flanders, downloadable at: <https://www.imec-int.com/drupal/sites/default/files/inline-files/457015-IMEC-DIGIMETER-2018-ENG.pdf>.
- Initiative D21 (2018): D21 DIGITAL INDEX 2017/2018 Jährliches Lagebild zur Digitalen Gesellschaft, downloadable at: https://initiatived21.de/app/uploads/2018/01/d21-digital-index_2017_2018.pdf.
- IW Consult GmbH (2016): Der Weg in die Gigabitgesellschaft, wie Netzausbau zukünftige Innovationen sichert, downloadable at: <http://www.vodafone-institut.de/wp-content/uploads/2016/07/studie-lange-version.pdf>.
- Kupferschmitt, T. (2018): Onlinevideo-Reichweite und Nutzungsfrequenz wachsen, Altersgefälle bleibt, in Mediaperspektiven 9/2018, p. 427-437, downloadable at: http://www.ard-zdf-onlinestudie.de/files/2018/0918_Kupferschmitt.pdf.
- Mangiante, S. et al (2017): VR is on the Edge: How to Deliver 360° Videos in Mobile Networks, downloadable at: https://www.researchgate.net/publication/319049968_VR_is_on_the_Edge_How_to_Deliver_360_Videos_in_Mobile_Networks/download.
- Monti, A.; Schäfer, R. (2012): Marktpotenziale für hochbitratige Breitbandanschlüssen in Deutschland, Abschlussbericht für den BREKO, Bad Honnef.
- Nationaler IT Gipfel (2015a): Smart Home, Ergebnisdokument der Projektgruppe Smart Home Plattform „Digitale Netze und Mobilität“, downloadable at: http://www.de.digital/DIGITAL/Redaktion/DE/IT-Gipfel/Download/2015/it-gipfel-2015-smart-home.pdf?__blob=publicationFile&v=2.
- Nationaler IT Gipfel (2015b): Thesenpapier zum Schwerpunktthema Smart Data im Gesundheitswesen, downloadable at: <https://www.bitkom.org/noindex/Publikationen/2016/Positionspapiere/Thesenpapier-zum-Schwerpunktthema-Smart-Data-im-Gesundheitswesen/it-gipfel-2015-thesenpapier-zum-schwerpunktthema-smart-data-im-gesundheitswesen.pdf>.
- Ofcom (2017): Adults' media use and attitudes Report 2017, downloadable at: https://www.ofcom.org.uk/_data/assets/pdf_file/0020/102755/adults-media-use-attitudes-2017.pdf.
- Ofcom (2018): Adults' media use and attitudes Report 2018, downloadable at: https://www.ofcom.org.uk/_data/assets/pdf_file/0011/113222/Adults-Media-Use-and-Attitudes-Report-2018.pdf.
- Ofcom (2018), Communications Markets Report, https://www.ofcom.org.uk/_data/assets/pdf_file/0022/117256/CMR-2018-narrative-report.pdf.

- ONS (2016) : Families and households in the UK : 2016, downloadable at :
<https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/families/bulletins/familiesandhouseholds/2017>.
- ONS (2018): Internet access – households and individuals, downloadable at:
<https://www.ons.gov.uk/peoplepopulationandcommunity/householdcharacteristics/homeinternetandsocialmediausage/datasets/internetaccesshouseholdsandindividualsreferencetables>.
- PWC (2017), The 2017 UK entertainment and media outlook,
<https://www.pwc.co.uk/industries/entertainment-media/insights/entertainment-media-outlook.html>.
- Statistiek Vlaanderen (2017): Meer en kleinere huishoudens in Vlaanderen in de komende 10 jaar, downloadable at: <https://www.statistiekvlaanderen.be/sites/default/files/docs/proj2018-kleinere-huishoudens.pdf>.
- Statistisches Bundesamt (2011): Bevölkerung und Erwerbstätigkeit, Entwicklung der Privathaushalte bis 2030, Ergebnisse der Haushaltsvorausberechnung ; downloadable at: https://www.google.de/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwjAmdCnpbrQAhXMCMAKHqSC1sQFggdMAA&url=https%3A%2F%2Fwww.bpb.de%2Fsystem%2Ffiles%2Fdokument_pdf%2FEntwicklung%2520der%2520Privathaushalte%2520bis%25202030.pdf&usq=AFQjCNH7p5d2SYSIBC3Yqie0RBdXDyobLA.
- Statistisches Bundesamt (2016): Private Haushalte in der Informationsgesellschaft - Nutzung von Informations- und Kommunikationstechnologien 2015, Fachserie 15 Reihe 4; downloadable at:
https://www.destatis.de/DE/Publikationen/Thematisch/EinkommenKonsumLebensbedingungen/PrivateHaushalte/PrivateHaushalteIKT2150400157004.pdf?__blob=publicationFile.
- Statistisches Bundesamt (2018): Wirtschaftsrechnungen, Private Haushalte in der Informationsgesellschaft – Nutzung von Informations- und Kommunikationstechnologien, downloadable at: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Einkommen-Konsum-Lebensbedingungen/IT-Nutzung/Publikationen/Downloads-IT-Nutzung/private-haushalte-ikt-2150400187004.pdf?__blob=publicationFile&v=4.
- Strube Martins, S.; Wernick, C.; Plückebaum, T.; Henseler-Unger, I. (2017): Die Privatkundennachfrage nach hochbitratigem BreitbandInternet im Jahr 2025, WIK Bericht, Bad Honnef, März 2017, downloadable at:
http://www.wik.org/fileadmin/Studien/2017/Die_Privatkundennachfrage_nach_hochbitratigem_BreitbandInternet_im_Jahr_2025_FINAL.pdf.
- UK Commission for Employment and Skills (2014), The Future of Work, Jobs and Skills in 2030, downloadable at:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/303334/er8-4-the-future-of-work-evidence-report.pdf.
- ukie (2017), UK Video Games Fact Sheet, <https://ukie.org.uk/research>.
- U.S. Department of Commerce International Trade Administration (2017): 2017 Top Markets Report Health Information Technology Country Case Study, downloadable at:
https://www.trade.gov/topmarkets/pdf/Health_IT_UnitedKingdom.pdf.
- van der Vorst, Tommy; Brennenraedts, Reg (2018) : Understanding the demand growth for digital connectivity, The 22nd Biennial Conference of the International Telecommunications Society: "Beyond the boundaries: Challenges for business, policy and society", June 24th - 27th, 2018, Seoul, Korea, International Telecommunications Society (ITS), Seoul, downloadable at: https://www.econstor.eu/bitstream/10419/190350/1/B1_2_Vorst-and-Brennenraedts.pdf.
- VAUNET (2019): .VAUNET-Mediennutzungsanalyse, Mediennutzung in Deutschland 2018, downloadable at: https://www.vau.net/system/files/documents/vaunet_mediennutzung-2018-publikation.pdf.