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

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ABSTRACT

The future demand for data and the role of gigabit networks are central issues in the context of Next Generation Access (NGA) network roll-out. Based on a generic model, which allows to predict unconstrained future broadband demand in different regions and countries, the authors compare the results for Germany, the UK and the Flemish region, and discuss reasons for the different outcomes. The generic market potential model thereby allows to project the future demand for bandwidth from residential customers on the basis of applications and their bandwidth needs, user profiles and population structure on a household level. Despite a general trend towards an increasing need for broadband, there are clear differences. On the one hand, these point to the relevance of socio-demographic factors for broadband adoption. On the other hand, the relatively high proportion of refusals shows that there is still a need for further educational work on the part of public authorities and providers. Finally, it has to be stated, that our forecast relies on the assumption that connectivity and thus that the availability of area-wide gigabit capable broadband access does not represent a bottleneck.

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). Originally developed in 2011, this model was revised and updated in 2017 to reflect emerging applications and new
developments. The update refers to the bandwidth requirements of future applications, to the development of the share of user profiles in the population and to other data which has been used as an input to our model. In case of the latter, additional data has been taken into account concerning the demand of internet users for different applications. Originally developed for the forecast of bandwidth demand in Germany, it has been applied to estimate bandwidth demand in the UK and the Flemish region in Belgium, too. The comparison of the results of the demand forecast in different regions allows the authors 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 the Flemish region and the impact that the difference between user profiles and household structure has on the forecast of bandwidth demand. Furthermore, the input data of the market potential model has been updated to reflect recent developments and new research.

Our paper is structured as follows: It starts with a short introduction on broadband availability and demand in Germany, UK and the Flemish region 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 the Flemish region in Belgium and conclusions are presented in chapter 4.

2. Broadband coverage and demand in Germany, the UK and Belgium/Flemish region

According to the EU Commission’s Digital Scoreboard, Belgium has the highest NGA availability of the three countries with 99% of total households in 2019. The availability of NGA connections in the UK is estimated at 96% of households. Germany has the lowest availability between the three countries with 92% of households, yet it remains higher than the European Union’s average of 86%. In Germany, UK and Belgium, cable networks play an important role and contribute significantly to NGA coverage. Belgium has an extensive cable coverage which has reached 97% of households in 2017. Telenet is the main cable network operator in the Flemish region and operates a cable television network in the whole territory of the Flemish region (with the exception of Wemmel, Drogenbos and Voeren).

As for FTTP technology coverage, availability in the three regions is considerably lower than in other EU countries. In 2019 the EU average of FTTP availability per household stood at 33.5%. Germany had 10% availability, UK and Belgium’s FTTP networks reached 10% and 3.5% of households, respectively.

On the demand side, Germany had a fixed broadband take-up of 88% of total households in 2019. UK and Belgium achieved take-up rates of 94% and 79%, 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 has strongly increased in the last years up to 57% of Belgian broadband subscribers. The development of subscriptions to ultrafast broadband connections is shown in the figure below. In the Flemish region, in 2018 alone 96% of the population had internet access in their households. Moreover, nearly 86% share of households have a broadband connection there, which is somewhat higher than in the rest of Belgium (see Fig. 1).

UK and Germany have significantly lower take-up rates of broadband connections above 100 Mbit/s of 20% and 23% in 2019, respectively.

It can thus be concluded that the broadband market in the Flemish region 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, due to the technical superiority of fibre infrastructures. In this regard, the understanding of the future development of broadband demand represents a highly relevant component.

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3 For the application of the model to Germany and the UK also refer to Strube Martins et al. (2017): Die Privatkundennachfrage nach hochbitratigem BreitbandInternet im Jahr 2025, WIK Bericht, Bad Honnef, März 2017, http://www.wik.org/fileadmin/Studien/2017/Die_Privatkundennachfrage_nach_hochbitratigem_BreitbandInternet_im_Jahr_2025_FINAL.pdf and Godlovitch et al. (2018): The Benefits of Ultrafast Broadband Deployment, Report for Ofcom, 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.

4 The model could also be used for a regionally more disaggregated approach e.g. differentiating between rural and urban areas. However, this would imply more assumptions on user behaviour so that in this paper the authors chose to rely on empirical data and consumer research in Germany, UK and the Flemish Region.

5 https://digital-agenda-data.eu/datasets/digital_agenda_scoreboard_key_indicators/#download (accessed 01 July 2020).

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

7 https://digital-agenda-data.eu/datasets/digital_agenda_scoreboard_key_indicators/#download (accessed 01 July 2020).

8 European Commission (2020): Digital Economy and Society Index (DESI) 2020, Belgium, Germany, UK, https://ec.europa.eu/digital-single-market/en/news/digital-economy-and-society-index-desi-2020.

9 https://digital-agenda-data.eu/datasets/digital_agenda_scoreboard_key_indicators/#download (accessed 01 July 2020).
3. Methodology and data input for Germany, the UK and the Flemish region

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 paper focuses on the demand side and looks at applications which are used at a fixed location. However, this does not exclude that wireless technologies can be used to provide the broadband connection as long as it fulfils bandwidth the requirements a household demands for. There is evidence of FWA based on 5G is used to provide high capacity broadband connections to households e.g. in Italy and Denmark. The model is not targeted at explicitly estimating end users’ willingness to pay for additional bandwidth.

Fig. 1 shows the methodology used for the market potential model. 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 Flemish region 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 against the background that current developments show the significance of these applications for bandwidth demand.

- Basic Internet
- Home-office and VPN
- Cloud Computing

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For an overview of future technological developments see Godlovitch et al. (2020): Future electronic communications product and service markets subject to ex-ante regulation Recommendation on relevant markets, https://ec.europa.eu/digital-single-market/en/news/study-future-electronic-communications-product-and-service-markets-subject-ex-ante-regulation.

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

Home office and VPN refers to the file exchange and online usage of resources such as software in the context of teleworking.
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 (Table 1).

Bandwidth growth rates have been estimated based on an analysis of the development of historic data volumes and data rates. In the past, three factors have contributed to growing data volumes: (i) increasing bandwidth requirements (ii) increasing number of users and devices, and (iii) increased use of one application within the user base. As a result historic growth rates of data volumes may give some orientation on bandwidth requirements, but are likely to overstate them. The development of average data rates used by households is more likely to reflect the historical development of bandwidth demand as the size of households statistically remains rather stable over time. Growth in bandwidth demand is driven by the requirements of applications and the number of devices used in a household so that this has to be taken into account when making assumptions on growth rates for bandwidth requirements based on historical data. At the same time, as they have been constrained by the availability of high bandwidth broadband connections, they tend to understate growth in unconstrained bandwidth demand.

Furthermore, it should be taken into account that future bandwidth requirements of applications cannot only be estimated on the basis of the state-of-the-art usage and bandwidth demand cannot only be explained by existing applications. It seems likely that there will be a residual growth of speed requirements and internet traffic volume which cannot be explained by the growth of existing

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**Fig. 2.** Methodology of the WIK market potential model.

Source: WIK

- State of the Art Media and Entertainment (4K, 3D, HD)
- Progressive Media and Entertainment (8K, VR/AR)
- Communication
- Video communication
- Gaming
- E-Health
- E-Home/E-Facility
- Mobile Offloading

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

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.

WiFi-Offloading of mobile data.
services categories.

The assumptions on future bandwidth requirements have also been supported by a review of desk research on data requirements of individual applications and have been discussed with industry experts. In order to assess the impact of different assumptions on the development of bandwidth requirements of individual applications, we have conducted a sensitivity analysis which is also presented in this paper (see chapter 4).

The main drivers of these bandwidth increases are further described below. They refer both to speed requirements (i.e. applications, which can be only be used if certain data rates are available (e.g. video streaming)) and data volume requirements associated with specific applications. The latter could be used with lower bandwidths, too (from a technical point of view), but tend to be unattractive if download or uploads are too time consuming. Examples represent the use of the cloud as fileserver or software updates taken from the cloud.

Bandwidth requirements of applications such as progressive TV/VR, VPN, cloud and gaming are assumed to grow with a CAGR 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.

The bandwidth requirements of Home office/VPN are driven by a strongly increasing share of high definition audio-visual content transmitted by Home office/VPN users. The covid-19 pandemic, which has lead to large number of employees working from home underlines the relevance of high data rates for an effective use of remote working.

The main driver of bandwidth demand in terms of speed requirements 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

### Table 1

| Application category | Downstream (Mbit/s) in 2025 | Upstream (Mbit/s) in 2025 | Packet loss | Latency |
|----------------------|-----------------------------|---------------------------|-------------|---------|
| Basic Internet       | ≈20                         | ≈16                       | O           | O       |
| Home office/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                        | ++          | +       |
| Video Communication (HD) | ≈25 | ≈25 | ++ | ++ |
| Gaming               | ≈300                        | ≈150                      | ++          | ++      |
| E-Health             | ≈50                         | ≈50                       | ++          | +       |
| E-Home/E-Facility    | ≈50                         | ≈50                       | 0           | O       |
| Mobile Offloading     | ≈15                         | ≈12                       | O           | O       |

Notes: O = Low specific importance, + = High importance, ++ = Very high importance. Source: WIK.

16 This has been discussed by van der Vorst and Brennenraedts (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, https://www.econstor.eu/bitstream/10419/190350/1/B1_2_Vorst-and-Brennenraedts.pdf.

17 See for example Fraunhofer FOKUS (2016): Netzinfrastrukturen für die Gigabitgesellschaft, https://cdn2.scrvt.com/fokus/5468ae83a4460bd2/65e3f4ee76ad/Gigabit-Studie_komplett_final_einzelseiten.pdf; Godlovitch et al. (2019): Analysis of the Danish Telecommunications Market in 2030, https://www.wik.org/fileadmin/Studien/2020/Analysis_of_the_Danish_TK_Market_in_2030.pdf; BIU (2015): Positionspapier Agenda 2020: für eine starke Computer-und Videospielbranche in Deutschland, 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, 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, http://www.ftthcouncil.eu/documents/Publications/FTTH_Business_Guide_V5.pdf; CAICT and HUAWEI Technologies Co. Ltd (2017): Virtual Reality/Augmented Reality White Paper, http://www.file.huawei.com/~/media/CORPORATE/PDF/iblab/vr-ar-en.pdf.

18 Virtual Private Networks.

19 Compound Annual Growth Rate.

20 Mangiante et al. (2017): VR is on the Edge: How to Deliver 360° Videos in Mobile Networks, 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, http://www-file.huawei.com/~/media/CORPORATE/PDF/iblab/vr-ar-en.pdf; Huawei iLab (2017): Video Big Data, The Top 10 Most Demanding Videos on the Net, https://www.huawei.com/~/media/CORPORATE/PDF/white%20paper/Big-Data-Video-Top-Ten-Most-Demanding-Videos-en.pdf; https://www.mushroomnetworks.com/infographics/bandwidth-requirements-for-virtual-reality-vr-and-augmented-reality-ar-infographic/.


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 HD video requires several gigabytes of data volume and as a result high data rates if the transmission is to take place without major delays.

The increasing use of E-Health and smart home applications may also generate data volumes, potentially in conjunction with cloud computing. While today’s data volumes and speed requirements associated with many telemedicine and telecare solutions are straightforward, upcoming E-Health applications are likely to require more advanced forms of connectivity with reference to increased bandwidth as well as quality of service and/or reliability. For example, virtual reality technology is used to treat certain medical conditions such as dementia and phobias. Interactivity, virtual reality and tactile internet are increasingly used in the area of e-Learning. They all require high bandwidth and quality of service. Remote students also require high bandwidth symmetric connections to engage in remote lectures and seminars. 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, UHD 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 concerning compression technologies assume lower bandwidth requirements. 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 nor 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 audio-visual content (without compression).

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. Applications such as E-Health and video communications do not require bandwidths as high as gaming and progressive audio-visual content, but they may still require specific access technologies to satisfy their demand for low packet loss rates and low latency.

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 the Flemish region in Belgium as case studies to examine the differences and similarities in the user types.

Table 2 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. The increase in demand for new applications (which is reflected in growing shares of user types using those applications) does not always mean that users churn from existing applications to new ones. While the user types either demand for state of the art television or progressive media or gaming, cloud and smart home applications are used complementarily (and to some extent simultaneously) by some user types. Also, gaming and progressive TV are not substituting for internet usage, i.e. user types using them do not churn from internet to gaming and progressive TV but continue to use the internet.

In addition to the six user profiles, which make more or less intensive use of digital applications, there is also the group of

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21 High Definition.
22 Godlovitch et al. (2019): Analysis of the Danish Telecommunications Market in 2030, https://www.wik.org/fileadmin/Studien/2020/Analysis_of_the_Danish_TK_Market_in_2030.pdf.
23 Ultra High Definition.
24 See for example Frontier Economics (2017): Future benefits of broadband networks, https://www.nic.org.uk/wp-content/uploads/Benefits-analysis.pdf.
25 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 Doutsi, E. (2017): Compression d’images et de vidéos inspirée du fonctionnement de la rétine, https://tel.archives-ouvertes.fr/tel-01584114/document.
Table 2
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. Applications perceived as essential such as E-Health may also be used. |
| 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, 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. |
| 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.

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 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, 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. Table 3 shows the allocation of applications to user types in Germany.

The WIK market potential thus determines a peak time for internet users to use for digital media. This time window is called busy hour in network planning.

For a detailed discussion of user profiles in the Germany and the UK please refer to Strube Martins et al. (2017): Die Privatkundennachfrage nach hochbitratigem Breitbandinternet im Jahr 2025, WIK Bericht, Bad Honnef, März 2017, http://www.wik.org/fileadmin/Studien/2017/Die_Privatkundennachfrage_nach_hochbitratigem_Breitbandinternet_im_Jahr_2025_FINAL.pdf and Godlovitch et al. (2018): The Benefits of Ultrafast Broadband Deployment, Report for Ofcom, https://www.ofcom.org.uk/_data/assets/pdf_file/0016/111481/WIK-Consult-report-The-Benefits-of-Ultrafast-Broadband-Deployment.pdf.

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26 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, https://www.bvdw.org/fileadmin/user_upload/BVDW_Marktforschung_Digitale_Nutzung_in_Deutschland_2018.pdf.

27 For a detailed discussion of user profiles in the Germany and the UK please refer to Strube Martins et al. (2017): Die Privatkundennachfrage nach hochbitratigem Breitbandinternet im Jahr 2025, WIK Bericht, Bad Honnef, März 2017, http://www.wik.org/fileadmin/Studien/2017/Die_Privatkundennachfrage_nach_hochbitratigem_Breitbandinternet_im_Jahr_2025_FINAL.pdf and Godlovitch et al. (2018): The Benefits of Ultrafast Broadband Deployment, Report for Ofcom, https://www.ofcom.org.uk/_data/assets/pdf_file/0016/111481/WIK-Consult-report-The-Benefits-of-Ultrafast-Broadband-Deployment.pdf.

28 See VAUNET (2019): VAUNET-Mediennutzungsanalyse, Mediennutzung in Deutschland 2018, https://www.vau.net/system/files/documents/vaunet_mediennutzung-2018-publikation.pdf.
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.29 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 (see Fig. 3).

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 Internet.30 It can therefore be assumed that only a small proportion of the population will not use the Internet in 2025.

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.

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 2018.31 Households are connected to the Internet every day or almost every day. 86% of households with Internet access had a broadband connection in 2018.32 Based on this data, the WIK 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 quality.33 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.34

E-Health and smart applications are said to have great disruptive potential if the necessary infrastructure is available, especially for developers of attractive applications.35 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.

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29 See for example Initiative D21 (2018): D21 DIGITAL INDEX 2017/2018 Jährliches Lagebild zur Digitalen Gesellschaft, https://initiative21.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, 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/.

30 However, internet usage increased from 49% in 2016 for 65+ years 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: https://www.destatis.de/DE/Publikationen/Thematisch/EinkommenKonsumLebensbedingungen/PrivateHaushalte/PrivateHaushalte1FKT2150400157004.pdf?_blob=publicationFile and Statistisches Bundesamt (2018): Wirtschaftsrechnungen, Private Haushalte in der Informationsgesellschaft – Nutzung von Informations-und Kommunikationstechnologien, 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.

31 Statistisches Bundesamt (2018): Wirtschaftsrechnungen, Private Haushalte in der Informationsgesellschaft – Nutzung von Informations-und Kommunikationstechnologien, 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.

32 Statistisches Bundesamt (2018): Wirtschaftsrechnungen, Private Haushalte in der Informationsgesellschaft – Nutzung von Informations-und Kommunikationstechnologien, 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.

33 See Statistisches Bundesamt (2018) Wirtschaftsrechnungen, Private Haushalte in der Informationsgesellschaft – Nutzung von Informations-und Kommunikationstechnologien, 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 and Koch (2018): Onlinevideo-Reichweite und Nutzungsfrequenz wachsen, Altersgef

34 See Kupferschmitt (2018): Onlinevideo-Reichweite und Nutzungsfrequenz wachsen, Altersgefüße bleibt, in Mediaperspektiven 9/2018, p. 398–413, http://www.ard-zdf-onlinestudie.de/files/2018/09/18/Frees_Koch.pdf.

35 See Nationaler IT Gipfel (2015): Smart Home, Ergebnisdokument der Projektgruppe Smart Home Plattform „Digitale Netze und Mobilität“, http://www.de.digital/DIGITAL/Redaktion/IT-Gipfel/Download/2015/it-gipfel-2015-smart-home.pdf?_blob=publicationFile&v=2; Nationaler IT Gipfel (2015): Thesenpaper zum Schwerpunktthema Smart Data im Gesundheitswesen, https://www.bitkom.org/noindex/Publikationen/2016/Positionspapier/Thesenpaper-zum-Schwerpunktthema-Smart-Data-im-Gesundheitswesen/it-gipfel-2015-thesenpaper-zum-schwerpunktthema-smart-data-im-gesundheitswesen.pdf; Bitkom (2014): Smart Home in Deutschland, 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, 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, http://www.vodafone-institut.de/wp-content/uploads/2016/07/studie-large-version.pdf.
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 and above has already tried Virtual Reality. The potential for VR remains high, as currently 17% can imagine diving into virtual realities in the future.

Gaming is now widespread among about half the population in Germany. The use is not limited to individual age groups or educated 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.

Furthermore, Cisco predicts that gaming traffic will grow 15 fold from 2017 to 2022, thus achieving a compound annual growth rate of 59%.

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-

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**Table 3**

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                          | ✓          | ✓                  | ✓                | ✓          | ✓            | ✓            |
| Video communication (HD)               | ✓          | ✓                  | ✓                | ✓          | ✓            | ✓            |
| Gaming                                 | ✓          | ✓                  | ✓                | ✓          | ✓            | ✓            |
| E-Health                               | ✓          | ✓                  | ✓                | ✓          | ✓            | ✓            |
| E-Home/E-Facility                     | ✓          | ✓                  | ✓                | ✓          | ✓            | ✓            |
| Mobile Offloading                      | ✓          | ✓                  | ✓                | ✓          | ✓            | ✓            |

Source: WIK.

**Fig. 3.** Internet user profiles in Germany in 2025.
Source: WIK.

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

37 See Game (2019); The German games industry, Insights, facts and reports, https://www.game.de/wp-content/uploads/2017/02/2019_Guide-to-the-German-Games-Industry_web.pdf; BIU (2016), Jahresreport der Computer-und Videospielbranche in Deutschland 2016, pp. 30 ff., https://www.biu-online.de/wp-content/uploads/2016/07/BIU_Jahresbericht_2016.pdf; Game (2018): Jahresreport der deutschen Games-Branche 2018, p.7, https://www.game.de/wp-content/uploads/2018/08/Jahresbericht-der-deutschen-Games-Branche-2018.pdf.

38 Cisco (2019): VNI: Forecasts and Trends, 2017–2022 White Paper, https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white-paper-c11-741490.pdf.
Health sectors. As for the use of cloud computing services, Germany stood with 31% in 2019, marking a growth of 9% from 2016.\(^{39}\)

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.

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.\(^ {40}\)

The assumed share of different user types as a proportion of the population is shown in Fig. 4.

These shares have been developed based on an assessment of the available data concerning the proportions of the population using particular applications. Fig. 5 shows the results of survey data collected for Ofcom on the use of the Internet for selected activities. This has been complemented with other data to validate the estimates as detailed below.

- 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 Q1 2019, 47% of homes in UK subscribed to at least one of the VoD services (Netflix, Amazon, Now TV or Disney Life).\(^ {41}\) The total number of subscriptions totalled 19.1 million subscriptions in Q1 2019.\(^ {42}\) The growth in Video on Demand is driven 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).\(^ {43}\)

- 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,\(^ {44}\) 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.\(^ {45}\) 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.\(^ {46}\)

- The proportion of avant-gardist users draws on the popularity of gaming. As previously mentioned, 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.\(^ {47}\) As of 2018 the UK has the 6th largest 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.\(^ {48}\) 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.\(^ {49}\) 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 a decrease of occasional users will decrease as younger generations with higher Internet usage and

\(^{39}\) Eurostat (2019), Individuals – use of cloud services, http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_cicci_use&lang=en.

\(^{40}\) See for example Eurostat (2019), Individuals – use of cloud services, http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_cicci_use&lang=en; Eurostat (2019), Internet use by individuals, http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_ci_ifp_jukl&lang=en; http://ec.europa.eu/eurostat/data/database; Ofcom (2018), Communications Markets Report, https://www.ofcom.org.uk/__data/assets/pdf_file/0022/117256/CMR-2018-narrative-report.pdf; BARB (2019), UK TV households by reception type, https://www.barb.co.uk/tv-landscape-reports/tracker-uk-households-by-tv-platform/; ONS (2018): Internet access – households and individuals, https://www.ons.gov.uk/peoplepopulationandcommunity/householdcharacteristics/homeinternetandsocialmediausage/datasets/internetaccesshouseholdsandindividualsreferencetables.

\(^{41}\) BARB (2019): UK TV households by reception type, https://www.barb.co.uk/tv-landscape-reports/tracker-uk-households-by-tv-platform/.

\(^{42}\) Ofcom (2019), Media Nations: UK 2019, p. 59 f., https://www.ofcom.org.uk/__data/assets/pdf_file/0019/160714/media-nations-2019-uk-report.pdf.

\(^{43}\) Ofcom (2018), Media Nations: UK 2018, https://www.ofcom.org.uk/__data/assets/pdf_file/0014/116006/media-nations-2018-uk.pdf.

\(^{44}\) https://yougov.co.uk/news/2017/05/19/vr-headsets-more-popular-tablets-and-wearables-wer/.

\(^{45}\) ONS (2018): Internet access – households and individuals, 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/.

\(^{46}\) See UK Commission for Employment and Skills (2014): The Future of Work, Jobs and Skills in 2030, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/303334/er84-the-future-of-work-evidence-report.pdf.

\(^{47}\) See ukie (2017): UK Video Games Fact Sheet, https://ukie.org.uk/research.

\(^{48}\) PWC (2017): The 2017 UK entertainment and media outlook, https://www.pwc.co.uk/industries/entertainment-media/insights/entertainment-media-outlook.html.

\(^{49}\) See Ofcom (2017): Adults’ media use and attitudes Report 2017, 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, https://www.ofcom.org.uk/__data/assets/pdf_file/0011/113222/Adults-Media-Use-and-Attitudes-Report-2018.pdf.
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. 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) 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.

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 2019 50% of individuals used cloud services in the UK. This is one of the highest percentages of cloud usage among Internet
users in comparison to other European countries. Cisco forecasts that by 2020, 59% of the consumer Internet population will use
personal cloud storage, up from 47% in 2015. 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). 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). 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%. More recent reports forecast the Internet of Things market to grow at 17% CAGR in 2017 and at 9% in 2021. The
share of user profiles using E-Home applications is estimated to be 33% in sum in 2025.

3.3.3. Flemish region

The user typologies in the model have also been critically reflected against specific data collected for the Flemish region 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 IMEC specifically for the Flemish region 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 justifi-
cation of their new approach is the fact that segmenting user profiles by only looking at usage and ownership no longer adds sig-
ificant value, as they report that only 2% of Flemish households did not have access to a smart device. Despite the rise of digitisation,
it is noted that the negative views and attitudes of the Flemish population towards digital technology has increased, the attitudes are

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

51 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, https://www.ofcom.org.uk/_data/assets/pdf_file/0022/117256/CMR-2018-narrative-report.pdf.

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

53 Eurostat (2019), Individuals – use of cloud services, http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_cici_us&lang=en.

54 In 2016 46% of Internet users used Internet storage space to save documents, pictures, music, video or other files. See Eurostat (2019), Indi-
viduals – use of cloud services, http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_cici_us&lang=en.

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

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

57 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.

58 https://www.alliedmarketresearch.com/smart-home-automated-building-market, accessed 16 January 2020.

59 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#.WnA76nkmos, accessed 16 January 2020.

60 User profiles: Disruptors, cumulator, struggler and resistor, see IMEC (2017): digimeter 2016, measuring digital media trends in Flanders,
https://www.imec-int.com/drupal/sites/default/files/2018-01/imec-digimeter-2016-report.pdf.
depicted in the new user profiles. 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 glasses.

Fig. 4. Internet user profiles in the UK in 2025.
Source: WIK.

Fig. 5. Use of the Internet for selected activities.
Source: ONS (2018): Internet access – households and individuals, https://www.ons.gov.uk/peoplepopulationandcommunity/householdcharacteristics/homeinternetandsocialmediausage/datasets/internetaccesshouseholdsandindividualsreferencetables.

61 IMEC (2019): IMEC.DIGIMETER 2018, Measuring Digital Media Trends in Flanders, p. 12, https://www imec-int.com/drupal/sites/default/files/inline-files/457015-IMEC-DIGIMETER-2018-ENG.pdf.
62 IMEC (2019): IMEC.DIGIMETER 2018, Measuring Digital Media Trends in Flanders, p. 94, https://www imec-int.com/drupal/sites/default/files/inline-files/457015-IMEC-DIGIMETER-2018-ENG.pdf.
As for video games, half of the Flemish population play digital games monthly. When it comes to social media usage, it is reported that nearly 87% use at least one social network monthly.

Table 4 shows the 4 user profiles identified in the 2016 IMEC report and the characteristics per user profile followed by Table 5 showing the mapping of these four user profiles on the user profiles of the demand model.

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 the Flemish region, had access to internet in their households. In 2016, 76% of the Flemish population used internet on a daily basis. 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 2021. In 2018, 43% of the Flemish population streamed music monthly, while 49% watched internet television or other online material.

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. Fig. 6 shows that the use of cloud computing is constantly growing in Belgium (34% of population in 2018).

In 2016 5.5% of the population in the Flemish region owned a VR headset while in 2018 the percentage grew to 10%. The use of virtual reality applications in 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 (see Fig. 7).

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.

Table 6 shows the household structure in Germany, the UK and in the Flemish region.

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 households 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 the Flemish region. This is shown in the next section.

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.

Table 4
Description of IMEC user profiles.

| User profiles (% of Flemish region population) | Characteristics per user profile |
|-----------------------------------------------|----------------------------------|
| Disruptor (24,1%)                            | • 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%)                             | • 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%)                             | • 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%)                              | • 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 (2017); digimeter 2016, measuring digital media trends in Flanders, https://www.imc-int.com/drupal/sites/default/files/2018-01/imc-digimeter-2016-report.pdf.
4.1. Forecasts

4.1.1. Germany

By 2025 it is predicted that approximately 30.6 million households, which presents 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. Fig. 8 demonstrates the bandwidth demand forecast for fixed broadband access in 2025 in Germany.

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 (see Fig. 9).

4.1.3. Flemish region

In the Flemish region, 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 (see Fig. 10).

4.1.4. Comparative analysis, sensitivity and conclusions

The comparison of future demand in the different regions shows an ambiguous picture. In the Flemish region, 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. In sum, this seems to point at an increasing digital divide in the Flemish region.

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

| 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%)    | Digital avantgardist (8%)                                      |
|                                | - Profile match, this group prominent in Flemish region         |
|                                | according IMEC report-                                          |
|                                | Sceptical outsider (4%)                                         |
|                                | - profile match, same as in other EU countries -                |
|                                | Occasional user (19%)                                          |
|                                | - profile match-                                                |
| Struggler (10,9%)              | Denier (9,8%)                                                  |

Source: IMEC (2017): digimeter 2016, measuring digital media trends in Flanders, https://www.imec-int.com/drupal/sites/default/files/2018-01/imec-digimeter-2016-report.pdf., WIK.
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 (see Table 7).

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

Table 6
Household structure in Germany, the UK and in the Flemish region.

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

Source: Statistisches Bundesamt (2011): Bevölkerung und Erwerbstätigkeit, Entwicklung der Privathaushalte bis 2030, Ergebnisse der Haushaltsvorausberechnung; https://www.destatis.de/GPStatistik/servlets/MCRFileNodeServlet/DEHaft_derivate_00012544/5124001109004.pdf; jsessionid = 1F6F7176E99BFCCE7657FE7AE47E9F70; ONS (2016): Families and households in the UK: 2016, 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, https://www.statistiekvlaanderen.be/sites/default/files/docs/proj2018kleinere-huishoudens.pdf.
The results of the sensitivity tests are shown in Table 8.

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,\(^70\) 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 the Flemish region. However, the majority of households is expected have demands calling for top level bandwidths (above 500 Mbit/s) in this scenario as well.

Naturally, increasing the simultaneous use of applications 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

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\(^{70}\) 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.
The different household structures and allocation of user profiles explain the regional differences in our forecast on future bandwidth demand. The UK and Flemish region 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/Flemish region 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/Flemish region 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 the Flemish region 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 the Flemish region 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 the Flemish region than in the UK and Germany (see Table 9).

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 because they do not use E-Learning, E-Government and other digital applications.

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 Flemish region 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 deal with those 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 that 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.

Declarations of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Source: WIK.

Table 9

Geographical differences in user profiles.

| Country/User Types | Occasional | Sceptical Outsider | Home Office User | Trend User | Avant-gardist | Professional | Denier |
|--------------------|------------|--------------------|------------------|------------|--------------|--------------|--------|
| Germany            | 12%        | 4%                 | 14%              | 30%        | 17%          | 16%          | 8%     |
| UK                 | 12%        | 4%                 | 14%              | 30%        | 16%          | 17%          | 7%     |
| Flemish region     | 19%        | 4%                 | 10%              | 23%        | 8%           | 25%          | 10%    |

Source: WIK.
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