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Working Party on Communication Infrastructures and Services Policy

INDICATORS OF BROADBAND COVERAGE

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FOREWORD

The Working Party on Communication Infrastructures and Services Policy discussed this paper at its meeting in June 2009. The Working Party agreed to recommend the paper for declassification to the ICCP Committee. The ICCP Committee agreed to the declassification of the paper in October 2009.

The paper was drafted by Mr. Agustín Díaz-Pinés, of the OECD's Directorate for Science, Technology and Industry. It is published under the responsibility of the Secretary-General of the OECD."

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MAIN POINTS

Comparing data on broadband coverage across OECD countries still faces some challenges because of the use of different metrics across countries. Coverage data are important to policy makers in that they indicate the extent to which businesses and residential customers have access to broadband, *i.e.* to what extent the population and businesses are able to subscribe to broadband if they wish, regardless of price, usage or speed constraints. That is the meaning of the terms availability and coverage/physical coverage along this report, which will use "availability" and "coverage" interchangeably.

The aim of this report is to assist policy makers in providing an overview of how broadband physical coverage and availability can be measured. It first summarises what data are available from official and non-official sources. The approach taken by the report is to consider coverage and availability related to different types of technologies. These include Digital Subscriber Line (DSL or xDSL), cable networks (*i.e.* cable modem), Fibre to the Premises (*i.e.* FTTH/B for homes and businesses), 3G (including W-CDMA and CDMA-2000), satellite and WiMAX technologies. This is because every technology capable of providing high speed Internet access involves specific issues when measuring coverage and availability. Accordingly, categorisation by technology is the most consistent way to approach this task. For every broadband technology, the available indicators will be presented, and this report discusses to what extent they are comparable.

This report does not address metrics on the actual take-up of broadband services or penetration rates which are based on different measures and for which cross-country data are much more consistent. The report is aimed at providing information on the advantages and pitfalls of existing indicators used to measure broadband coverage. There is not necessarily a single indicator which should be used when assessing broadband coverage since this depends on what measures policy makers require: for example measuring the digital divide which may exist in a country, measuring the availability of broadband access for business, measuring broadband availability for residential customers, *etc.* There is no attempt in the paper to draw a conclusion as to the ideal indicator which should be used. However, it is important that OECD countries try to ensure a better consistency in the use of indicators to measure availability of broadband.

The paper, in certain tables, lists all OECD countries even though they may be using different indicators to measure broadband coverage. The purpose in doing so is to show which indicators countries use and not to try and equate indicators that are by nature different.

DSL technologies are widely available in OECD countries, reaching on average 88% availability. DSL coverage might be measured in terms of household availability, population coverage, or by the percentage of telephone lines that may deliver DSL service. Each of these indicators may raise some issues and they may not be fully comparable to each other. A major challenge for assessing DSL availability is the fact that operators may not know the exact number of loops that are able to support broadband services.

The most widely used measure of cable coverage is assessing household accessibility. That is by measuring the number of households passed by an infrastructure that enables a cable modem Internet connection. While this enables a homogeneous set of indicators, some countries express cable coverage in terms of population. The main concern about using households or population indicators is that they do not provide any information regarding business access to broadband. Cable modem availability is mostly restricted to urban areas, with the exception of those countries that previously had a widely available cable-TV infrastructure, which has been upgraded in order to support broadband services. DOCSIS 3.0 technology is expected to significantly improve cable modem networks transmission capacities.

Fibre-to-the-home and fibre-to-the-building (FTTH-FTTB) deployments are starting to gain momentum in some OECD countries. While Japan and Korea already have widespread availability, network providers in other countries such as the Slovak Republic, the United States, Denmark, Finland, France and Italy are rapidly increasing their coverage. As for cable modem networks, coverage is measured in terms of “homes passed”.

3G coverage is widely available in most OECD countries, even though there may be large gaps for coverage in some rural areas. Much of the data are based on estimates, and actual measurements need a consistent methodology, that must be agreed upon between regulatory authorities and operators. When coverage milestones were included as a requirement for spectrum licensing, governments and/or regulatory authorities monitor their compliance.

Satellite technology generally provides the broadest coverage, being virtually available to 100% of the population in many OECD countries. The major drawback with satellite technology is that it cannot provide service comparable to the leading terrestrial alternatives. While satellites have some disadvantages (*e.g.* latency, higher price) they can be the most economic way to serve some areas particularly if no other alternatives are available. Fixed terrestrial wireless services, such as WiMAX, can also help fill the gap between rural and urban areas, but WiMAX has not to date significantly been deployed in sparsely populated regions. Under certain regulatory and economic conditions fixed wireless service may well become a viable broadband alternative.

Although a more enriched set of indicators could be produced if different technologies within a family taken into account to deliver different indicators (such ADSL, ADSL2+ or VDSL within the xDSL family, or DOCSIS 1.1, 2.0 or 3.0 for cable modem), data may be difficult to gather and the number of indicators would increase. Nonetheless, the development of technology-neutral, speed-based broadband coverage indicators could be helpful, but potentially challenging.

Business access to broadband is a key factor for economic and social development, and business digital divides should be adequately assessed. However, data on business broadband availability are rarely publicly available, and very few countries collect them. Their collection should be encouraged, in order to obtain a better picture of broadband coverage across the OECD.

The paper also provides some background information about broadband definitions and the thresholds above which an Internet access connection is considered as broadband. All thresholds and speeds are based on advertised values. When discussing broadband availability, this may help inform policy makers on the origin and evolution of the methodologies used for data collection in respect to broadband services.

Box 1: Summary of broadband coverage indicators

- **DSL**
  - Households:
    - Good for the analysis of residential segment availability. When based on DSL-enabled exchanges, it should take into account the percentage of eligible and ineligible loops related to a particular exchange.
    - Provides no information on business availability.
  - Population:
    - May provide a different level of penetration to households. While it is likely to be similar, variations will occur depending on the number of people per household.
  - Premises (households and businesses):
    - Similar to households, but includes business segment availability.
    - Mixes business and residential coverage.
  - Lines:
    - Relatively easy to collect.
    - May include business coverage (if a breakdown by segment is not available), and may therefore mix residential and business availability. Business coverage may differ from population coverage.
    - Excludes the population not covered by PSTN.

- **Cable modem**
  - Households:
    - Relatively easy to collect, based on the concept of "homes passed".
    - Good for the analysis of residential availability, but may lack information on businesses.
  - Population:
    - May provide a different level of penetration to households. While it is likely to be similar, variations will occur depending on the number of people per household.
  - Premises (households and businesses):
    - Similar to households, but includes business segment availability.
    - Mixes business and residential coverage.
  - Lines:
    - Mixes business and residential coverage, if data are not split by segment.
    - Excludes population not covered by cable TV service.

- **FTTH/B**
  - Households:
    - Relatively easy to collect, based on the concept of "homes passed".
    - Good for the analysis of residential availability, although it provides no information on businesses.

- **3G**
  - Population:
    - Good reflection of coverage where people reside.
    - It can be challenging to measure and needs to be regularly updated with accurate population location statistics.
    - Lacks coverage in areas where people do not reside but where they may access the service: transportation routes, national parks, *etc*.
  - Area:
    - May complement the population indicator by providing coverage information in non-residential areas.

INTRODUCTION

This report compiles the available data on broadband coverage, adopting a technology-based approach. The main challenge when carrying out a comprehensive analysis on broadband coverage, is that data for one technology might not be fully comparable to another. Availability of data might be based on population coverage, household coverage, percentage of homes passed or homes that would be able to subscribe in a short period of time, percentage of telephone lines that support broadband services, and so forth. That is why this document intends, after presenting the available data, to discuss what might be the advantages and disadvantages of using one or other coverage indicator. Some issues considered include how to compare the coverage of different technologies, and what could be the expected advantages or pitfalls if these available data are compared.

Broadband coverage is, of course, not the only factor that needs to be considered in order to assess potential digital divides. It is, however, a necessary indicator in determining whether some segments of the population are unable to participate in economic and social activities that require high speed Internet access. Knowledge of broadband availability is therefore a precondition in informing policies aimed at maximising the availability of services and the opportunities they present for economic and social development. The ideal situation would be having full (100%) residential and business broadband coverage, thus enabling each segment of the society to profit from the possibility of broadband access. Other indicators surrounding factors such as price, speed or usage are complementary in assessing the true availability of service. Availability of broadband clearly is a factor in the take-up of broadband services (number of subscribers), but not the only factor.

The measurement of broadband coverage is not without challenges, because subscribers may have a wide range of technological solutions from which to choose and each technology has different distribution patterns, coverage ratios or measurement aspects that have to be taken into account when delivering a coverage assessment. This document will adopt a technology-based approach when addressing the challenges of measuring broadband coverage, intending to explore the different aspects of the delivery of coverage indicators. It will first approach the issues inherent to producing coverage indicators for each broadband technology and it will analyse the complementarity, substitutability and mutual links between them.

Among wired broadband technologies, DSL (Digital Subscriber Line) technologies need prominent consideration because they account for the majority (around 60%) of fixed broadband subscriptions in OECD countries. The fact that DSL infrastructure is based on pre-existing PSTN networks involves a number of challenges for the delivery of data, since coverage figures may be expressed in terms of percentage of households, percentage of population or percentage of PSTN lines with DSL availability. Each of those indicators will be discussed, in order to flag the possible pitfalls when comparing them.

Cable modem Internet access is the platform with the second largest number of users across OECD countries, representing around 28% of the OECD broadband subscription base. Although cable networks in many countries have only been deployed in the previous two decades and are mainly deployed in urban areas, a number of OECD countries have widespread availability of high speed Internet access through upgraded cable TV networks. Cable coverage is mostly measured in terms of population or household coverage.

Fibre-to-the-home and fibre-to-the-building (FTTH/B) connections are still a minority in almost every OECD country, but an increasing number of telecommunications operators are starting to launch this service to the market, and coverage and penetration are expected to increase in the short to medium term. This will represent an important step towards higher transmission speeds and the opportunity for new services, which may bring into question the economic viability of some of the existing broadband technologies.

Fixed and mobile wireless solutions play a complementary role to the predominance of wired connections. Fixed terrestrial wireless broadband and satellites may be alternatives that help increase coverage in scarcely populated and remote areas, while mobile broadband take-up is rapidly growing in OECD countries. It can be regarded both as a complementary, as well as a substitute technology for fixed broadband. Mobile broadband relies on widespread availability of handsets and the current deployment of 3G access technologies by mobile providers. The intrinsic mobility of this type of broadband also poses new challenges to its measurement.

Finally, the definition of a broadband connection has to be discussed and mapped with actual technology options. The OECD's working definition of broadband has been to consider services enabling at least a 256 Kbps advertised downlink Internet access to be included. The capabilities of existing technologies and data speeds can be considered before carrying out an analysis of coverage. A number of countries deliver coverage statistics based on a different definition than the OECD and the potential effects of these differences are assessed in this report.

XDSL COVERAGE

xDSL[1], especially ADSL, is the most common technology used for high-speed Internet connections ("broadband services"). According to the OECD Broadband Portal December 2008 data, 60% of OECD fixed broadband connections are based on xDSL technologies. The key underlying factor is that xDSL reutilises an existing infrastructure, copper wire, which had been already extensively deployed. Policies surrounding universal service played an important role in the widespread availability of the PSTN, including in rural areas, making it the most widespread platform for Internet access in most OECD countries.

Table 1 shows the different indicators used to measure coverage: 16 OECD countries use population, 10 use households and 4 use lines as indicator. Although they have been depicted below (Figure 1) for the sake of easier visual comparability, coverage figures for each country are measured using different indicators and have different reference dates. Some use the percentage of households with DSL availability, others refer to the percentage of the population while others deliver the percentage of lines that may be used for a DSL connection. This is why these data are not fully comparable.

1. The term xDSL refers to the full variety of Digital Subscriber Line (DSL) technologies, including ADSL, ADSL2, ADSL2+, SDSL, HDSL, VDSL, and any other variations that are based on the use of a copper-wire local loop to deliver data services.

Table 1: Indicators of DSL coverage

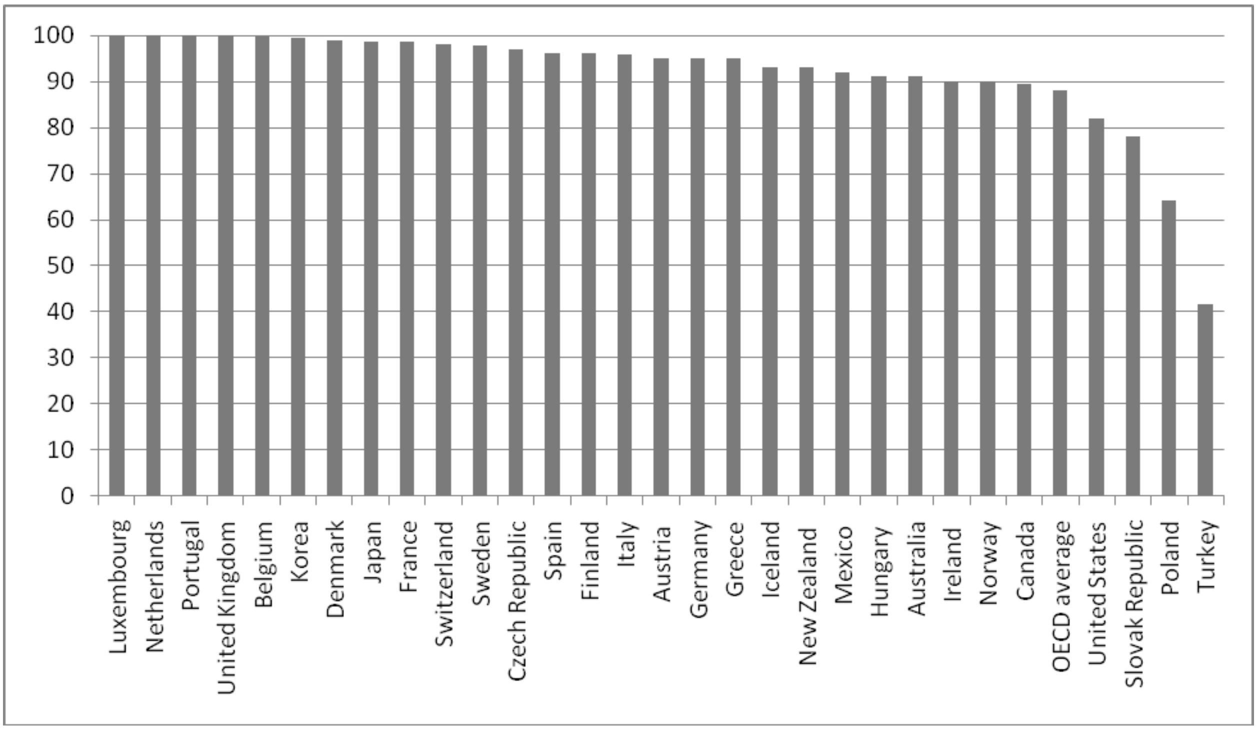
DSL	COVERAGE (%)	DATE	SOURCE[2]	INDICATOR USED TO EXPRESS COVERAGE	COMMENTS
Australia	91.0	June 08	Government	population	Australia also provides indicators based on premises (see text)
Austria	95.0	End 07	Government	households	
Belgium	99.7	Nov 07	Incumbent	households	
Canada	89.3	End 07	Government	households	
Czech Republic	97.0	End 08	Incumbent	population	
Denmark	99.0	End 08	Government	households	
Finland	96.0	End 08	Government	population	
France	98.5	End 08	Government	population	
Germany	95.0	End 08	Incumbent	households	
Greece	95.0	End 08	Government	population	DSL-enabled exchanges
Hungary	91.0	End 08	Government	population	
Iceland	93.0	Feb 07	Incumbent	population	
Ireland	90.0	Apr 09	Incumbent	population	DSL-enabled exchanges
Italy	95.7	End 08	Government	population	> 640 Kbps
Japan	98.6	Sep 08	Government	households	< 30 Mbps (all technologies, not only DSL)
Korea	99.5	June09	Incumbent	households	
Luxemburg	100.0	End 08	Government	population	
Mexico	92.0	End 05	Incumbent	lines	"capable of receiving broadband services"
Netherlands	100.0	End 07	Government	households	
New Zealand	93.0	End 08	Government	population	"subject to sufficient ports available at the exchange"
Norway	90.0	End 08	Government	population	
Poland	64.0	End 07	IDATE-EC	population	
Portugal	100.0	End 08	Government	lines	DSL-enabled exchanges
Slovak Republic	78.0	End 08	Government	population	
Spain	96.1	Apr 09	Government	population	
Sweden	97.9	End 08	Government	population	> 2 Mbps
Switzerland	98.0	End 08	Government	lines	
Turkey	41.4	End 08	Government	households	> 1 Mbps
United Kingdom	100.0	End 08	Government	lines	DSL-enabled exchanges
United States	82.0	End 07	Government	households	% of households within ILEC local-telephone service territories at which DSL service is available

Most OECD countries have extensive DSL coverage. Averaging across the different measures gives 88% (weighted by population), but it should be interpreted with caution, since different indicators are used. Based on that, most countries are between 90 and 95%. Japan, Korea, Belgium, the Netherlands, Denmark, Portugal, Switzerland, Luxemburg, France and the United Kingdom score above 98% coverage. The United States has DSL coverage below the average, but it has extensive cable networks. DSL coverage is

2. Under government a number of governmental agencies or bodies (such as regulators, public agencies, *etc*.), are also included, that may not be strictly considered as an official source.

low in significant areas of Poland (64% coverage), Slovak Republic (78%) and Turkey (41%), where it is likely to expand in the coming years.

Figure 1: Coverage of xDSL networks (% population or % households or % lines)



DSL coverage indicators

DSL coverage data are available in terms of percentage of population, percentage of households or percentage of lines with DSL availability. In addition, each of them may have some variations or specific additional factors to be taken into account. All three types, however, refer to physical availability, and are obtained from rollout data delivered by operators. Although Table 1 shows governments or operators as data sources, governments must ultimately obtain the data from broadband providers, mostly incumbent operators.

Measuring coverage in terms of population or in terms of households should not deliver very different results, since both data refer to the number of households/inhabitants where a DSL-enabled line reaches the end-user premises, thus always having a physical infrastructure (the local loop) as a reference. This enhances considerably the comparability of the data, while other indicators (for instance, Internet usage) may deliver completely different results when adopting a household- or a population-based approach. The only factor that could bias the household indicator, in relation to the population indicator, is the fact that households might have, on average, a higher or lower people-to-household ratio, which would result in a different population proportion. This could well happen in under-served areas, which are quite likely to be rural, where demographic characteristics of a household might vary in relation to the average, urban, served household. In general, therefore, in urban areas the population and household indicator are likely to be more comparable than in rural areas.

From the point of view of operators, the easiest indicator to provide is the percentage or the number of PSTN lines over which it is possible to deliver broadband services (*i.e.* where the lines have already been upgraded to provide DSL). At first glance, coverage data based on DSL-eligible lines are likely to be quite reliable but the fact that DSL lines reach both households and businesses needs to be taken into account. Therefore, figures based on lines would not show household or population coverage. It is arguable whether business density (business per inhabitant) is higher in unserved or under-served areas than a country's average. If business distribution were equivalent to population distribution, and if businesses without service were located where under-served residential users were located, the indicator would be perfectly valid. As mentioned, however, business distribution and coverage may be different from that of households/population. It is true that, as general rule, businesses should be located where the population is, but exact distribution patterns may be different.

According to a report published by the Swedish regulator PTS, coverage data vary slightly if referring to households/population or businesses. Thus, overall Swedish DSL coverage is 97.9% of the population, but only 94.5% of businesses, which suggests a higher business density in under-served areas. In any case, the number of business lines is normally smaller than the number of residential lines, so the eventual distortion of the population indicator, when using data based on lines, may be lower than in the case where both segments (business and residential) had a similar number of lines.

Data in Figure 1 and Table 1, regardless of whether they are based on population, households or lines, normally take into account the fact that not every line served by a DSL-enabled exchange can be upgraded to DSL (as shown in the following paragraphs). When this is the case, telecommunications operators estimate the percentage of households/population/lines that have availability, mostly by assessing the percentage of loops that are too long to deliver broadband (although length is not the only parameter to take into account). Alternatively, some countries, such as the United Kingdom and Greece, only provide an indicator based on the population/households/lines served by a DSL-enabled exchange. A third group of countries does not specify whether they have taken into account the fact that not every line served by a DSL-enabled exchange may be used to provide broadband services. These particularities have been added to Table 1 (column "Comments"), when identified by the country's data source.

In addition to the fact that coverage data based on lines include those servicing businesses, there is another factor that may be relevant for some countries where a population/household coverage figure is to be obtained. As the IDATE broadband coverage report[3] states, some OECD countries such as Poland and the Czech Republic do not have 100% coverage for copper-based telephone service, which means that, if broadband coverage statistics based on the percentage of lines are used (regardless of the issues previously raised), they must be corrected in order to reflect that lack of coverage. The same would apply for Mexico or Turkey. Some of the existing universal service policies (such as the European Union's) guarantee universal access to publicly available telephone service at a fixed location, but this does not imply that access is based on copper wires, so the assumption of 100% copper-based telephone service coverage may be wrong.

The main advantage of coverage indicators based on households or population is that they are more relevant when addressing digital divide issues, since it is the population who ultimately may not be able to access broadband services. From this point of view, it is also relevant to look at the share of businesses that

3. IDATE Consulting & Research – *Broadband Coverage in Europe – Final Report, 2008 Survey – Data as of 31 December 2007* (page 6) – Study for DG INFSO (European Commission) - December 2008, http://ec.europa.eu/information_society/eeurope/i2010/docs/benchmarking/broadband_coverage_2008.pdf

are not able to access broadband. Measuring coverage in terms of population or households allows for a better understanding of access possibilities for families or residential locations, despite not providing any information about business access to broadband. Nevertheless, most businesses are located in or near populated areas, so there is an assumption that where population or households have access to broadband, so do businesses. Coverage figures based on lines, on the contrary, include both businesses and households, but may distort coverage figures since they may not make a distinction between household and business lines.

Lastly, it is worth mentioning the case of Japan, which only provides service-based (up to 30 Mbps or from 30 Mbps on data), thus not splitting them by technology. This means that the data provided refer to both cable and DSL technology (for connections up to 30 Mbps) and mainly fibre for connections above 30 Mbps (although some VDSL and DOCSIS 3.0 might be included). This service-neutral approach is desirable as a general rule, since it reports broadband availability regardless of technology, but this excludes full comparability with most other OECD countries that do not use this approach. As a sample of the relative importance of DSL and cable technologies in the Japanese broadband market, by June 2008 there were[4] around 12.7 million DSL lines (strongly decreasing), 4 million cable modem lines (slightly increasing) and 12.1 million fibre lines – ultra-high speed broadband – (strongly increasing), making Japan one of the top-ranked countries in terms of broadband availability, speed and pricing.

Availability of more granular technology-based indicators

Ideally, in compiling a comprehensive and meaningful set of broadband coverage indicators, it would be useful to take into account the service capability of broadband. In particular a benchmark access speed would need to be set and data made available on the number of users who can access broadband at that access speed (*i.e:* DSL coverage at 2 Mbps or higher, cable modem coverage at 10 Mbps or higher, *etc*.), as some OECD countries already do. Such indicators would allow for a better understanding of service capabilities and coverage. In addition to speeds, other factors involved in service equivalence are the use of hidden proxies, static vs. dynamic addressing, protocol restrictions and other aspects of Internet provisioning. However, these aspects are difficult to map to availability figures and do not affect coverage, since an ISP is normally able to offer them to all customers, although it may well market customers with different offers delivering different service capabilities. Another useful quality indicator could be the percentage of population/households that are able to access audiovisual services over DSL (which needs a minimum line speed and requires a certain infrastructure deployed by operators). The public availability of such granular data is, however, rare.

The more usual approach in coverage data has been technology-based, or rather physical-media based, since the data are specific to cable modem, xDSL or 3G technologies. It could also be argued that within each of these technologies (or families of technologies, or physical media groups), a more granular analysis could be performed. This would mean delivering a more enriched set of indicators within each technology family:

- xDSL: not only ADSL, but also ADSL2, ADSL2+ and VDSL coverage indicators could be delivered.
- Cable modem: Docsis 1.1, Docsis 2.0 and Docsis 3.0 could be taken into account.
- FTTH/B: FTTH, FTTB, GPON, P2P, and so on.
- 3G: UMTS, HSPDA, *etc*.

4. Source: Japanese Ministry of Internal Affairs and Communications.

Accordingly, if a technology-neutral indicator were developed, it would have to take into account the data speeds of each technology and cross-check technology-based coverage figures, as Japan has done when delivering figures on broadband availability above a speed threshold (in the case of Japan, above 30 Mbps).

Nevertheless, although the approach described could eventually lead to a more granular and enriched set of coverage indicators, it has two drawbacks: on the one hand, OECD countries cannot always deliver such granular coverage data, since actual coverage figures are not always available and mapping two or more technology-based indicators to a technology-neutral one is not evident. On the other hand, it would unnecessarily multiply the number of indicators, which would imply a lot more complexity when assessing a country's broadband coverage. That being said, it should be acknowledged that developing a technology-neutral, speed-based indicator, such as Japan has done, is a good way forward that indeed reveals a country's broadband availability.

Business coverage data

Some of the indicators that this report deals with address residential access to broadband, and some address business coverage as well. Namely, households and population indicators just refer to the residential segment (citizens' digital divides) while lines, premises and area indicators include to some extent business coverage. Although ideally both components should be reflected in this report, business coverage data are scarce and less frequently collected and published by governments or operators. As noted above, Sweden is one of the few OECD countries which publishes broadband coverage data for businesses (in terms of percentage of businesses with broadband availability), and the figures are slightly different from those addressing residential broadband coverage. Even though business access to broadband in terms of take-up or use is approached in a number of surveys conducted in OECD countries and by some data published by operators, coverage data collection is rare across the OECD.

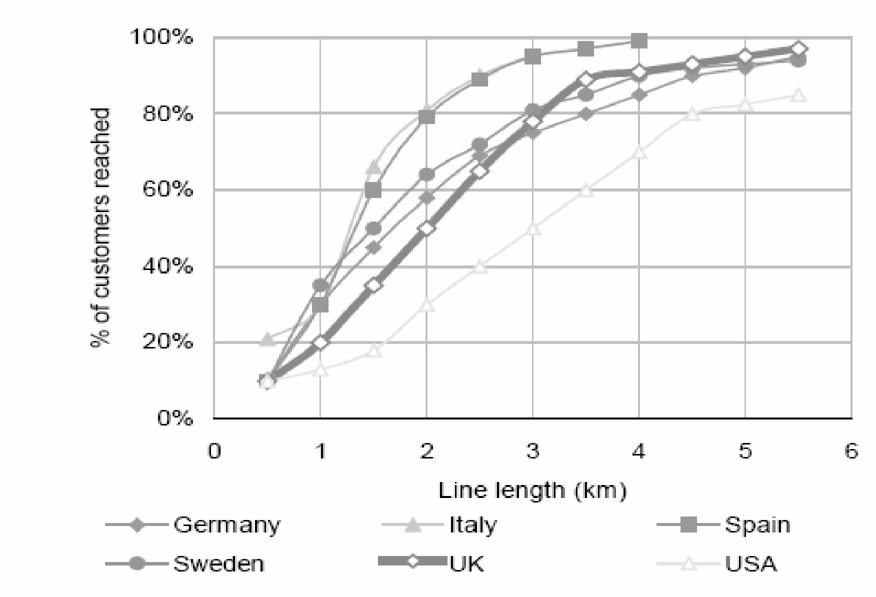
Business coverage data should also play a prominent role when assessing broadband availability, since it is a key aspect for the development of the information society and the economic and social opportunities associated with broadband access. Thus, it should be recommended that countries start compiling and publishing data on business broadband availability, in a way that can be compared across OECD countries, in order to allow for better comparability.

Estimating coverage: local loop length

If copper-based local loops are available, telecommunications operators can upgrade local exchanges and core networks to deliver a broadband service through a xDSL connection, provided that the local loop length is short enough to allow for a broadband connection bit-rate (among other characteristics). Local loops shorter than 5.5 km are normally adequate for xDSL transmission although, depending on loop conditions, this distance might be shortened to 4 km. In rural areas a large share of the population may live at particularly long distances from the local exchange. This means that, even when the serving exchange has been upgraded, these telephone lines would still not be able to connect to broadband services. The exact percentage of unserved users for an upgraded local exchange is however hard to assess, strongly depending on population and local loop length distribution patterns.

For DSL networks, it is mostly difficult to assess what percentage of loops would not be served. According to BT estimates, this percentage lies around 0.3% of the population in the United Kingdom (out of 99.98% of lines that depend on a DSL-enabled exchange), but it may not be relevant to other countries with a higher proportion of rural populations or lower population densities. Countries with a lower population density or higher population dispersion are likely to have a higher share of unserved population. As an example, Figure 2 shows the distribution by length of copper-based local loops across selected countries. The pattern greatly varies across countries, depending on population density/dispersion and network topology, which is highly likely to result in varying eligibility ratios for users depending on a DSL-enabled local exchange.

Figure 2: **% of customers reached as function of local loop length**



Source: New Zealand's Ministry of Economic Development (elaborated by Azimuth Consulting): Broadband Services and the Local Loop Network – April 2006.

The Australian joint ACMA-ACCC report on "Communications Infrastructures and Services Availability in Australia 2008" states that DSL-enabled exchange service areas (ESAs) cover 98% of homes and businesses. However, there are customers within these ESAs who are not able to access DSL, since they are located too far from the exchange, or they have another technological barrier such as the use of pair gain systems (LPGS) on their line, or they are not connected to a copper phone line. ACMA-ACCC estimates that 89% of homes and businesses lying within a DSL-enabled ESA are close enough to an exchange to obtain a DSL service. Therefore, 11% of homes and businesses within an ESA are too far to connect to broadband services, in contrast to the UK 0.3 % estimate. The Australian estimate, however, is based on a threshold distance of 3.4 km to the exchange (radial distance), and the Australian population pattern is totally different from that of the United Kingdom which has a much more densely and evenly distributed population. Sweden's PTS estimates that 0.2% of the population has a loop length longer than 5 km, so they cannot receive broadband at at least 2 Mbps. Australia also provides population-based DSL coverage data, which are included in Figure 1 and Table 1.

Factors affecting coverage: population density and dispersion and geography

Population distribution patterns, both in terms of density and dispersion, and difficult terrain are among the most important factors affecting broadband coverage. Scarcely populated areas may be more challenging in terms of profitability for market players, because the cost of deploying some types of infrastructure may be high compared to the expected return on investment. Additionally, it is in rural areas where PSTN loop length is a particular factor affecting the delivery of broadband services, that a larger share of loops may be too long. Countries having low DSL coverage also have large rural areas within their territory. Low population density and high dispersion can encourage the use of terrestrial wireless or satellite technology (and/or a hybrid of these) rather than wired infrastructure that may be relatively more expensive and less timely to deploy. As a result, rural areas are frequently a potential target for broadband subsidies and deployment plans that address their specific issues.

Of course, granularity of the territory division when elaborating coverage statistics also plays a role. Some counties may have a very low population density (and might be considered as largely rural areas), but if the population is quite concentrated in a particular part of the county, this would enable almost every telephone subscriber to upgrade to DSL, since household's distance to the exchange is very likely to be short. The European Commission supported IDATE study on broadband coverage uses NUTS[5] 5 granularity level, which normally refers to districts or municipalities, but which may also be uneven across European countries.

The United States Federal Communications Commission, when publishing statistics regarding broadband coverage, has up to now aggregated data by 5-digit geographical ZIP Code, of which there are around 30 000 in the country. In June 2008, the FCC adopted a new order for collecting data about broadband connections and phone service. Most facilities-based broadband providers are required to report numbers of subscribers at the census-tract level (of which there are about 66 000 in the country). Up to now, ZIP codes having only one connection were reported as having access available, and ZIP codes may cover a considerable geographical area in some parts of the United States. The Broadband Data Improvement Act (signed in October 2008) requires the FCC to compile a list of geographical areas that are not served by any provider of advanced telecommunication capability, to collect demographic data for those geographical areas and to make certain international comparisons. The American Recovery and Reinvestment Act states that up to USD 350 million may be used to implement the Broadband Data Improvement Act and to develop and maintain a broadband inventory map.

Using one country's population density to measure the difficulty of deploying broadband may yield incorrect indications for others, as stated in OECD's "Broadband growth and Policies in OECD countries", if other variables, such as population dispersion or geography, are not taken into account. Iceland, having one of the lowest population densities across OECD countries, has 50% of its population living in just 1.4% of its territory, which means that DSL networks may reach a very high proportion of population with relatively low investment expenditure. Using population dispersion as a variable results in the Slovak Republic and Poland being the OECD countries with most dispersed population (38.7% and 33.6% respectively).

Even though these indicators are useful to indicate how difficult network deployment is, their adequacy when analysing the digital divide is arguable. As DSL networks have already been widely deployed, bridging the digital divide mostly refers to extending the network to the last 5-10% of the population that is not covered. As a consequence, a more suitable indicator of the difficulty of extending coverage would probably be one indicating the extension of the area where this 5-10% under-served population resides. For example, according to IDATE's rural population indicator (those residing in a municipality under 100 inh/sqkm), Norway would have the highest figure, with 48.8% of its population living in rural areas. However, Norway has 50% of its population living in only 11% of its geographical territory, which is a relatively highly concentrated population.

5. NUTS: Nomenclature of Territorial Units for Statistics, established to provide a single uniform breakdown of territorial units for the production of regional statistics for the European Union.

Difficult terrain is another important factor in the difficulty to deploy DSL networks. Countries with flat terrains, like the Netherlands or Belgium, undoubtedly have an advantage, in addition to their high population densities. By way of contrast, countries like Switzerland, Norway or Greece, with more challenging terrains may need higher levels of investment. Again, not only the difficult terrain should be taken into account, but also the percentage of population living in those under-served areas with challenging terrains.

CABLE MODEM COVERAGE

Cable networks were initially deployed in OECD countries, to support cable TV service, but have been extensively upgraded in order to provide cable modem broadband access to the Internet. A number of countries have only deployed cable networks during the past 20 years. Even though cable modems only account for 28% of broadband connections in OECD countries, some countries, such as Canada, the United States, Belgium and the Netherlands, have cable modem coverage reaching close to or more than 90 % of the population. OECD cable modem coverage is at an average of 59% of households/population (population-weighted average that does not include Japan and Mexico).

Unlike DSL coverage, where operators mostly know whether a DSL exchange has been upgraded but do not necessarily have data on how many customers actually have broadband services available, cable providers normally count the number of homes passed by cable. Since cable networks need cable infrastructure to be deployed to every customer's home, it is easier for cable providers to provide data on availability and/or eligibility.

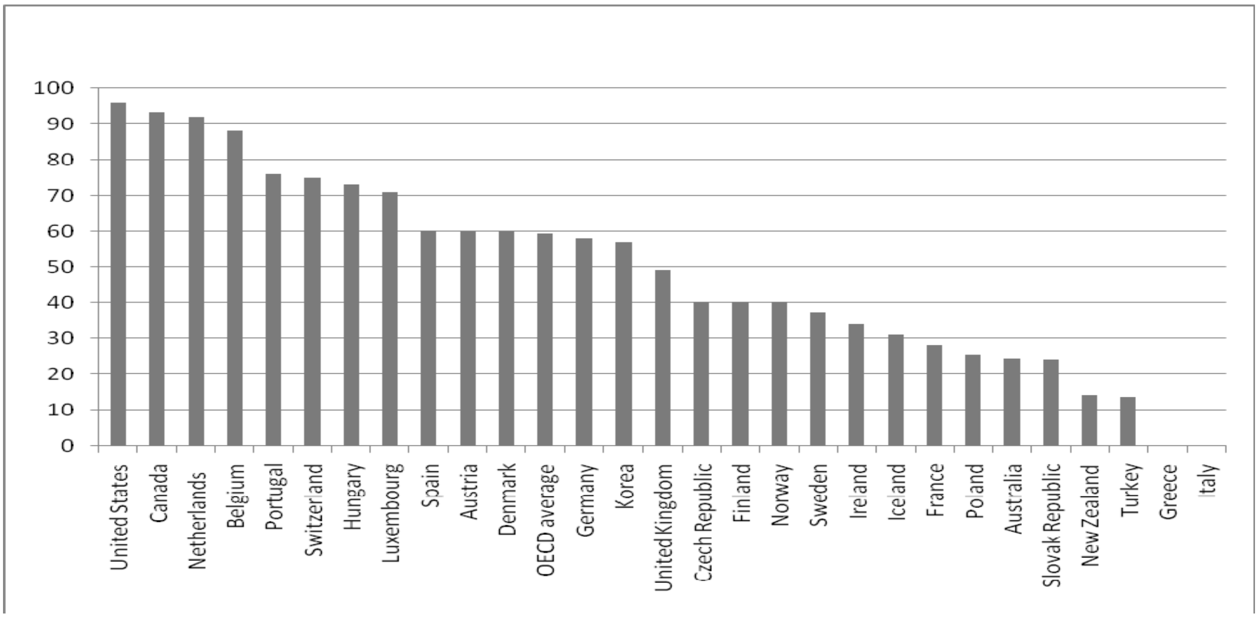
Table 2 shows data sources, reference dates and indicators used to deliver a coverage figure. Nineteen countries use households, six population, and one premises as their indicator.

Table 2: Indicators of cable broadband coverage

	Coverage (%)	Date	Source	Indicator used to express coverage	Comments
Australia	24.3	End 08	Government	premises	Official data: 2.6 million premises – percentage has been drawn based on an estimate of the number of premises
Austria	60.0	End 07	Government	households	
Belgium	88.0	End 08	Government	population	
Canada	93.4	End 07	Government	households	
Czech Republic	40.0	End 08	Government	households	
Denmark	60.0	End 08	Government	households	
Finland	40.0	End 08	Government	households	
France	28.0	End 08	Government	households	Numericable's FTTH/B footprint (12 %) has been excluded
Germany	58.0	End 08	Government	households	
Greece	0		Government		
Hungary	73.0	End 08	Government	population	
Iceland	31.0	End 07	IDATE/EC	population	
Ireland	34.0	End 08	Government	households	
Italy	0		Government		
Japan					
Korea	57.0	End 03	Government	households	
Luxemburg	71.0	End 08	Government	households	
Mexico					
Netherlands	92.0	End 07	IDATE/EC	population	
New Zealand	14.0	End 08	Government	households	
Norway	40.0	End 08	Government	households	
Poland	25.4	End 07	IDATE/EC	population	
Portugal	76.0	End 08	Government	households	
Slovak Republic	24.0	End 08	Government	population	
Spain	60.2	End 08	Government	households	
Sweden	37.3	End 08	Government	households	
Switzerland	75.0	End 04	Government	households	Incumbent does not report statistics thereafter
Turkey	13.5	End 08	Government	households	
United Kingdom	49.0	End 08	Government	households	
United States	96.0	End 07	Government	households	% residential premises passed by cable TV plant and also offered cable modem service(Cable TV coverage is 99% of population, according to the FCC)

Data have been depicted in Figure 3 for easier visual comparability. They reflect the percentage of households with availability of cable modem services (percentage of homes passed by cable enabling broadband access), or the percentage of population living in households with such availability, and have different reference dates.

Figure 3: **Availability of cable modem services (% households / % population/ % premises – see Table 2)**



Indicators of cable broadband coverage

It is noticeable that cable modem coverage indicators are more homogeneous than those of DSL. They are almost exclusively based on households and population and do not include business segment coverage, which allows for a better comparability. When it comes to adequacy for analysing the digital divide, they are more adapted to delivering an image of household digital gap, in terms of unserved households. However, information is generally not provided on businesses, which does not assist in informing analysis on business digital divides. The United States delivers figures based on the percentages of households passed by cable TV and also offered cable modem service. Cable TV service is available to 99% of US population, according to the FCC. Australia states cable modem coverage in terms of the number of premises passed by cable, which means that business coverage is also included in the indicator, but no stand-alone business indicator is developed, since premises include both households and businesses. There is no official data for the number of premises in Australia, although an estimate has been drawn from existing household and business statistics.

The same problems that arose when comparing households and population DSL indicators may be mentioned again. This time, as cable modem is more limited in terms of coverage than DSL, and is mostly restricted to urban areas, the socio-economic differences (namely, the number of people to a household), might be reinforced. In the event that rural and urban household sizes differ, the inconsistency between household and population indicators might be greater than that of DSL. However, this assumption has to be checked on a case-by-case basis, and may not be true, or be insignificant, in most OECD countries.

Using the premises indicator has the advantage that business coverage is also reflected, thus it is not limited to assessing household digital divides. However, if the premises indicator is used, both business and household broadband availability are put together, making no distinction between these two types of coverage. Although, as previously said, data might not be available; it is convenient to be able to separate business and citizen's coverage figures.

Household-based, cable providers provide statistics based on "homes passed". However, this term is not defined by OECD when collecting statistics, since it is only mentioned as "*The number of households which are passed by a cable network enabled to provide cable modem services, as a percentage of the total number of households*.", in the Communications Outlook Questionnaire. The term "homes passed" is further discussed in the FTTH/B section, when dealing with fibre coverage, and there is a fibre-related definition produced by the FTTH Council. Nevertheless, when using the term "homes passed" or "households passed", the reference is to a household that could subscribe to the service if it wanted to, even though it may be necessary to deploy additional elements, such as wiring from the activated node to the subscriber's home.

Japanese data, as explained in the previous section, provide information on availability of Internet access below and above 30 Mbps, and do not split data by technology. Finally, despite the lack of recent data, Korean cable broadband coverage is supposed to be quite high, since it already reached 57% in 2003, and cable subscribers outnumber DSL customers, although the market is quickly switching to FTTH/B technology.

Cable modem coverage in OECD countries

The situation is again uneven. Italy and Greece have no cable modem the availability as historically they do not have cable television. Coverage in Turkey and New Zealand is also limited, under 15%. In contrast, the United States, Canada, Belgium, Netherlands and Portugal enjoy a quite high household coverage. As stated in OECD's report "Broadband Growth and Policies in OECD countries",[6] high cable TV coverage normally corresponds to high cable Internet coverage. Historically, countries with more developed cable networks and TV service delivered by cable have higher cable TV and cable Internet coverage. The prevalent situation in OECD countries is, on the contrary, that most countries have recently developed their cable networks, mainly covering urban areas, although cable providers are still extending their networks. OECD population-weighted average availability for cable Internet services accounts for 59.3%. Again, averaging across different indicators should be taken with caution, since some countries did not report in terms of households (six countries reported in terms of population and one country in terms of lines). Only Canada and the United States have higher cable modem availability than DSL availability.

The development of cable Internet coverage is very closely related to pre-existing cable TV infrastructures and to the regulatory approach taken by governments and regulators. The issues involved in these decisions are complex, but one of the main concerns of governments taking such an approach (*e.g.* Spain) has been to ensure that there was an incentive for infrastructure competition, encouraging third parties (other than the incumbent provider) to invest, or as a tool to guarantee the viability of the investment (many regulators did not expect more than one cable network to be viable). The most important regulatory measures to provide incentives for investment were: setting a period during which the incumbent telecommunications operator was restricted from providing video services or exclusivity licences (either regional or national) awarded to the new cable operator. Many cable operators target their audience through triple-play packages (including fixed telephony, Internet access and cable TV). Regulatory approaches greatly differ across OECD countries: sometimes cable TV regulation is dominated

6. OECD (2008) *Broadband Growth and Policies in OECD Countries:* www.oecd.org/sti/ict/broadband/growth

by priorities such as delivery of public TV services, encouraging a diversity of programming, promoting national culture – or local interests, and other social and political priorities. In some countries, like the United States, law or policy prevented the entry of cable operators and telecommunications operators into each others' markets. In other countries, telecommunications operators were the cable operators.

Cable broadband providers are starting to upgrade their HFC infrastructure to adopt DOCSIS 3.0, the new version of DOCSIS that will enable download speeds around 150 Mbps, which may well provide significant competition to fibre deployment in areas where there is infrastructure competition. The main concern about the future of cable networks is how they will face competition from fibre infrastructure, and if DOCSIS 3.0 standard developments will be able to face FTTH/B competition, which in principle can reach higher transmission rates. However, DOCSIS 3.0 upgrade is less resource demanding than fibre deployment in terms of cost, since it relies on an existing infrastructure. So far, few DOCSIS 3.0 commercial offers have appeared on the market: major United States operators such as Comcast and Cablevision have already launched commercial services - Comcast claims to have reached 20 % of its customer base with DOCSIS 3.0, offering coverage in ten cities, planning 65% coverage by end 2009 (at 50 Mbps and bitcap). The United Kingdom's Virgin Media has to date upgraded 6 million homes to DOCSIS 3.0, expecting full completion (12 million homes) by Q3 2009. UPC has launched a 120 Mbps broadband service in the Netherlands using EuroDocsis 3.0 and French Numericable claims that it has already upgraded 2.7 million homes, offering 100 Mbps connection, while the largest cable operator in Spain, ONO, has also started offering 50 Mbps DOCSIS 3.0-based service and ZON, the largest Portuguese cable operator, had already passed 1 million homes by May 2009, offering 100 Mbps broadband services.

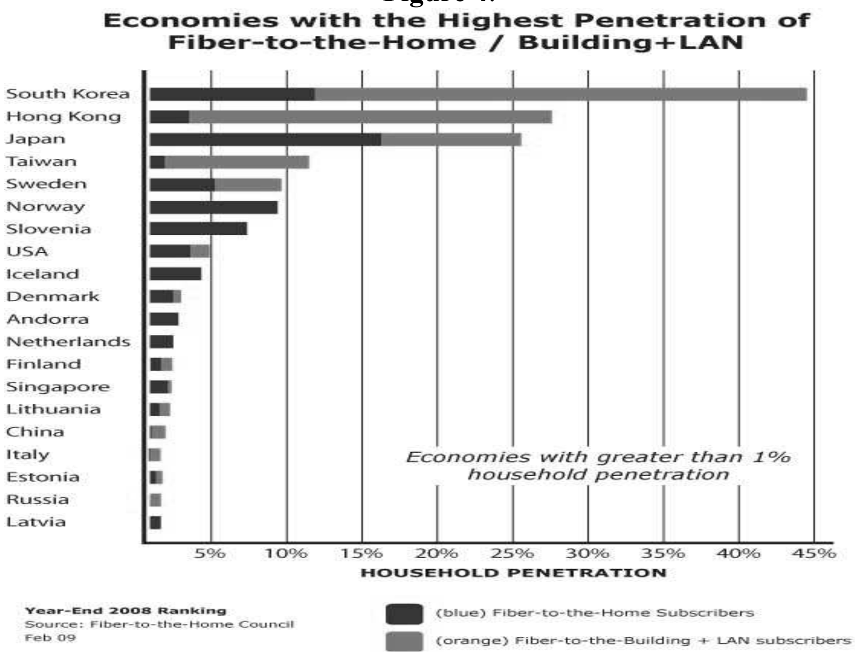
FTTH/B COVERAGE

Next Generation Networks (NGNs) deployment is an important issue for the telecommunications sector across OECD countries. All stakeholders including operators, regulators, policy makers and consumers have a keen interest in the regulatory approach and economic impact of deploying fibre to the home, or close enough to allow for data connection rates of several hundreds of Mbps. The regulatory approach to be taken greatly varies across countries but tackles the same issues and challenges: how to incentivise investment while enhancing or at least not hindering competition, and how to take into account risk and protect consumer choice. While some market players have already committed resources and some countries have already benefitted from increasing availability of fibre, especially in urban areas, others have modified their investment roadmap, due to the current economic crisis.

This section addresses (Fibre-to-the-home and Fibre-to-the-building FTTH/B) the state of deployment and availability of not covering Fibre-to-the-node or Fibre-to-the-curb infrastructure (FTTN-FTTC), which is usually based on a VDSL or HFC topology. Under FTTB, Apartment-LAN deployments are included. However, taking a technology-neutral approach, some FTTN-FTTC infrastructure projects might enable very high transmission rates (although lower than FTTH), depending on how far from the end-user the fibre loop is located. Remarkably, some VDSL/VDSL2 and DOCSIS settings, with very short copper or coaxial cable loops, may enable speeds higher than 100 Mbps. FTTH/B is likely to support similar levels of service (at least in its first stages of development).

Nevertheless, the current state of deployment in most OECD countries may sometimes be difficult to assess, since telecommunications operators do not always make their deployments public, nor report the availability of a particular high-speed offer throughout a country. Additionally, coverage and availability data are rapidly evolving. One source of statistics is the FTTH Council, which periodically publishes the list of economies enjoying FTTH/B household penetration (number of subscribed households divided by the total number of households) higher than 1%, but does not yet report on availability.

Figure 4:



Source: FTTH Council.

FTTH Council Europe also published estimates on the number of homes passed by fibre (FTTH/B) in European countries, provided by IDATE (Table 3). Additionally, according to the same IDATE-FTTH Council Report, in Eastern Europe, Russia has taken the lead in fibre deployments and accounts for 630 000 FTTB subscribers. Figure 5 and Table 4 summarise the compiled data on fibre availability, showing the household coverage, reference date and sources.

Table 3: **Significant FTTH/B rollouts in Europe, end 2008**

COUNTRY	PROVIDER		NUMBER OF HOMES PASSED
DENMARK	DONG Energy	Power utility	150,000
	Energie Midt	Power utility	75,000
	TRE FOR	Power utility	60,000
FINLAND	TeliaSonera	Incumbent carrier	400,000
FRANCE	France Telecom	Incumbent carrier	500,000
	Illiad/Free	Alternative operator	300,000
	SFR	Alternative operator	250,000
	Numericable	Cable Operator	3,400,000
GERMANY	Wilhelm Tel	Public	100,000
	M-Net	Public	80,000
ITALY	Fastweb	Alternative operator	2,000,000
NETHERLANDS	Reggefiber	Infrastructure operator	350,000
NORWAY	Lyse	Power utility	170,000
SLOVAK REPUBLIC	T-COM	Incumbent carrier	200,000
	Orange Slovensko	Alternative operator	215,000
SLOVENIA	T2	Alternative operator	200,000
SPAIN	Telefónica	Incumbent carrier	250,000
SWEDEN	B2	Alternative operator	390,000

Source: IDATE for FTTH Council Europe.

Figure 5: **FTTH/B Household availability**

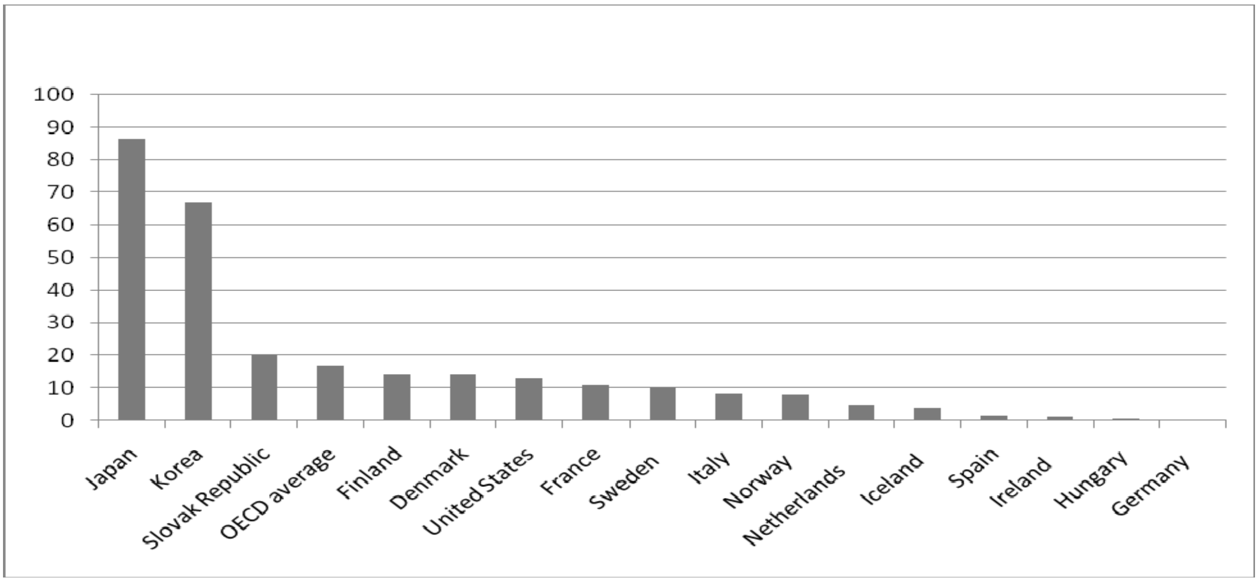


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Table 4: FTTH/B availability

	Coverage (%)	Source	Date	Indicator used to express coverage	Comments
Australia	N/A				
Austria	N/A				
Belgium	N/A				
Canada	N/A				
Czech Republic	N/A				
Denmark	14.0	Government	Mar 09	households	
Finland	14.0	Government	Mar 09	households	
France	11.0	Government	Apr 09	households	
Germany	0.4	IDATE-FTTH Council Europe	Apr 09	households	
Greece	N/A				
Hungary	1.3	Government	Apr 09	households	
Iceland	4.0	IDATE-FTTH Council	Jan 09	households	Penetration (availability must be higher)
Ireland	1.4	Government	End 08	households	
Italy	8.6	IDATE-FTTH Council	End 08	households	
Japan	86.5	Government	March 08	households	
Korea	67.0	Incumbent	End 08	households	Coverage forecast
Luxemburg	N/A				
Mexico	N/A				
Netherlands	4.8	FTTH Council Europe IDATE	End 08	households	
New Zealand	N/A				
Norway	8.3	FTTH Council Europe IDATE	End 08	households	
Poland	N/A				
Portugal	N/A				
Slovak Republic	20.0	Government	End 08	households	
Spain	1.5	FTTH Council Europe – IDATE	End 08	households	
Sweden	10.0	FTTH Council Europe - IDATE	End 08	households	
Switzerland	N/A				
Turkey	N/A				
United Kingdom	N/A				
United States	13.1	FTTH Council – RVA	Mar 09	households	

Again, Korea and Japan show high availability of fibre broadband. Some 86.5% of Japanese and 67.0% of Korean households have FTTH/B coverage. Sweden, Denmark, Finland, France and the United States reach FTTH/B availability above 10%. Slovak Republic's availability is 20% and Norway's is close to 9%, which is also reported as fibre penetration. Therefore, Norway's availability must be actually higher than 9%. On the other hand, 14 OECD countries have no availability and 4 other OECD countries have less than 2% of households passed. However, this situation might rapidly change if some of the largest telecommunications operators start to launch their fibre offers on a broader scale, as Verizon in the United States, Numericable in France or Fastweb in Italy have already done.

Figure 5 and Table 4 show the available indicators of FTTH/B coverage, specified in terms of what each figure measures. Many countries have reported no availability or lack of reliable data, while others have a household-based indicator. Figure 5 uses the sources indicated in Table 4. When governments have not reported data on fibre availability, figures from FTTH Council Europe on significant rollout have been used. It may well be that some existing deployments have not been included in this table. Countries listed as "N/A" have either reported no availability or lack of available data. The total number of households that has been used to draw an availability indicator dates from end 2007.

It should be noted that fibre data are based on household availability. As the indicator is dealing with a new infrastructure that must be deployed to each of the end-user premises, as well as cable Internet technology, the coverage indicator will always be the percentage of "homes passed", as it was mostly the case for cable modem coverage. FTTH Council has issued a recommendation on Definitions and Terms, that intends to define some coverage and technological concepts, with which it remains consistent when publishing fibre statistics. For the sake of clarity, FTTH, FTTB and "Homes passed" FTTH Council definitions are included below.

Box 2: FTTH Council – Definition Of Terms

FTTH: "Fibre-to-Home" is defined as a communications architecture in which the final connection to the subscriber's premises is Optical Fibre. The fibre optic communications path is terminated at or in the premise for the purpose of carrying communications to a single subscriber.

In order to be classified as FTTH, the access fibre must cross the subscriber's premises and terminate:-

- inside the premises, or
- on an external wall of the subscriber's premises, or
- not more than 2 metres from an external wall of the subscriber's premises

FTTB: "Fibre to the Building" is defined as a communications architecture in which the final connection to the subscriber's premises is a communication medium other than fibre.

The fibre communications path is terminated on the premises for the purpose of carrying communications for a single building with potentially multiple subscribers.

It is implicit that in order to be classified as FTTB, the fibre must at least

- enter the building, or
- terminate on an external wall of the building, or
- terminate no more than 2m from an external wall of the building, or
- enter at least one building within a cluster of buildings on the same property, or
- terminate on an external wall of one building within a cluster of buildings on the same property, or
- terminate no more than 2m from an external wall of one building within a cluster of buildings on the same property.

The number of **"Homes Passed"** is the potential number of premises to which an operator has the capability to connect in a service area, but the premises may or may not be connected to the network (typically new service activation will require the installation and/or connection of a drop cable from the homes passed point to the premises, and the installation of subscriber premises equipment, including an ONT (Optical Network Termination) device at the premises.

This definition excludes premises that cannot be connected without further installation of substantial cable plant such as feeder and distribution cables (fibre) to reach the area in which a potential new subscriber is located.

As previously stated, household-based coverage indicators are a good way to assess the lack of coverage within the residential segment of the market. They are also consistent with most usage indicators that provide telecommunications services usage data based on surveys. According to FTTH Council definition, data on household availability deliver statistics on the number of premises that may potentially connect to fibre networks, although installation of further equipment might be needed. As a main drawback of a household–based coverage indicator, we could mention the lack of data on business coverage. When assessing telecommunication infrastructures, business coverage should also be considered. Even though business coverage is mostly addressed by usage surveys, it would be desirable that operators provide figures on the number of business that may potentially connect to fibre broadband.

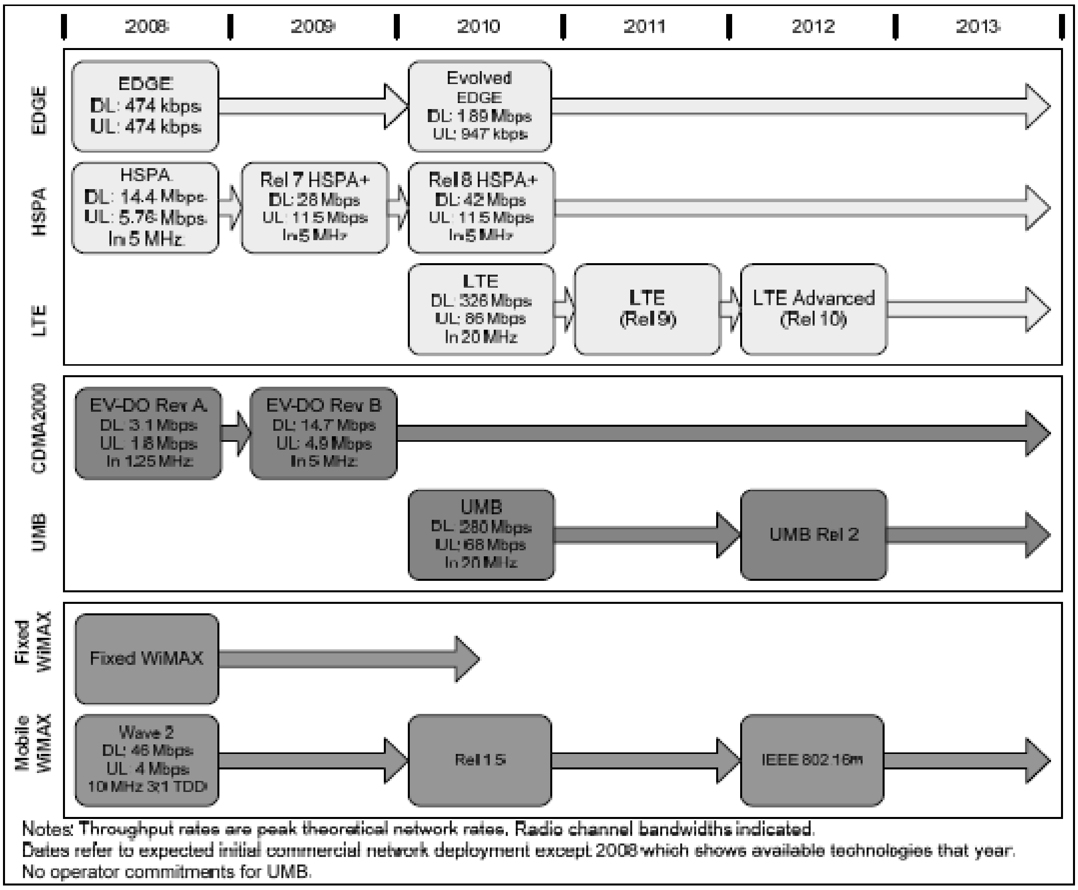
Fibre is starting to gain importance in OECD countries, although coverage is still low for most of them, operators are expected to increase their rollouts in the short-medium term, although information about rollouts is not always disclosed by market players. As it is already harmonised by the FTTH Council, households/homes passed remains the most effective way to assess coverage.

3G COVERAGE

Mobile broadband technologies

High speed mobile technologies are becoming increasingly important in the broadband landscape particularly as services and applications are developed to take advantage of higher transmission rates. While technologies associated with the second generation or its improved versions of mobile communications, such as GSM and GPRS (2.5G), could not be considered broadband (with download rates reaching 60/80 Kbps), EDGE/Evolved EDGE could well be above the 256 Kbps threshold. Besides, there are other mobile wireless technologies that may also deliver speeds higher than 256 Kbps (such as TD-SCDMA – Chinese national standard – or the Japanese XGP). In general most of OECD countries are more focused on rolling out 3G networks than investing in upgrades to 2G systems, such as EDGE. Its coverage data and those belonging to TD-SCDMA and XGP technology are, however, difficult to compile. This section focuses on W-CDMA (UMTS) and CDMA-2000 3G coverage. The following chart provides guidance on the speeds that 3G technologies (following IMT-2000 standard), and enhancements such as 3.5G HSPA or the future LTE Advanced (currently experimental) may offer, and their possible evolution. In addition, 3G coverage assessment and measurement faces a number of challenges summarised below.

Figure 6: **Evolution path of selected mobile broadband technologies**



Source - 3G America.

An additional technology providing mobile broadband is WiMAX, an evolution of Fixed WiMAX (IEEE 802.16d – 2004), adding on features to the standard to support mobility in 2005 (IEEE 802.16e-2005) or mobile WiMAX. Some operators have announced that they will deploy mobile WiMAX solutions, and deployments have started in Korea (WiBro), France, United States, Japan and Spain. However, in terms of coverage, mobile WiMAX is much less available than other 3G technologies and its coverage will not be discussed in this paper.

Mobile broadband can be regarded as a complementary or substitute technology for wired broadband. For urban areas, where wired technologies are highly prevalent, mobile broadband is usually a complementary technology that intends to provide end-users with mobility. Thus, in urban areas, mobile broadband solutions may be mainly addressed to users wanting to access broadband when they are away from their homes, such as travellers or users at any particular moment when fixed broadband is not available. However, mobile broadband may also be a substitute technology specifically addressed to areas where it is not economically efficient to deploy wired broadband technologies, such as rural, remote or scarcely populated areas. For these situations, mobile broadband may address (together with fixed wireless technologies) specific access problems and act as a substitute for wired technologies.

3G coverage indicators in OECD countries

Table 5 compiles data on population coverage (except for one country, which uses area coverage), but some countries report availability in different terms or refer their data to different dates, which makes them not fully comparable to each other. When the population coverage indicator is used, it is based on population's residential location, regardless of the methodology established to measure coverage.

Table 5: 3G coverage indicators

	Coverage (%)	Date	Source	Indicator used to express coverage	Comments
Australia	99.0	End 08	Operator	Population	Most widely deployed
Austria	84.0	End 07	Government	Population	National
Belgium	89.9	End 08	Government	Population	Most widely deployed
Canada	78.0	End 07	Government	Population	National
Czech Republic	89.8	End 08	Government	Population	Most widely deployed
Denmark	97.0	End 08	Government	Area	National
Finland	80.0	End 08	Government	Population	National
France	72.5	End 08	Government	Population	National (70-75%)
Germany	80.0	End 08	Government	Population	National
Greece	88.0	End 08	Government	Population	Most widely deployed
Hungary	56.1	End 08	Government	Population	Most widely deployed
Iceland	63.0	End 07	Government	Population	National
Ireland	89.0	Sep 08	Government	Population	Most widely deployed
Italy	92.0	End 08	Government	Population	National
Japan	100.0	End 08	Operator	Population	Most widely deployed
Korea	99.0	June 09	Government	Population	National
Luxemburg	90.0	End 08	Government	Population	National
Mexico					
Netherlands	90.0	End 07	IDATE/EC	Population	National
New Zealand	97.0	End 08	Government	Population	National
Norway	90.0	End 07	IDATE/EC	Population	National
Poland	25.5	End 07	Operator	Population	Most widely deployed
Portugal	98.0	End 08	Government	Population	Coverage obligation Actual coverage data are confidential
Slovak Republic	81.0	End 08	Government	Population	National
Spain	83.0	End 08	Government	Population	National
Sweden	100.0	End 08	Government	Population	National
Switzerland	91.0	End 07	Government	Population	National
Turkey	0.0	End 08	Government	Population	National
United Kingdom	90.0	End 08	Government	Population	Population living in a postcode area with at least 75% area coverage
United States	92.3	May 08	Government	Population	National

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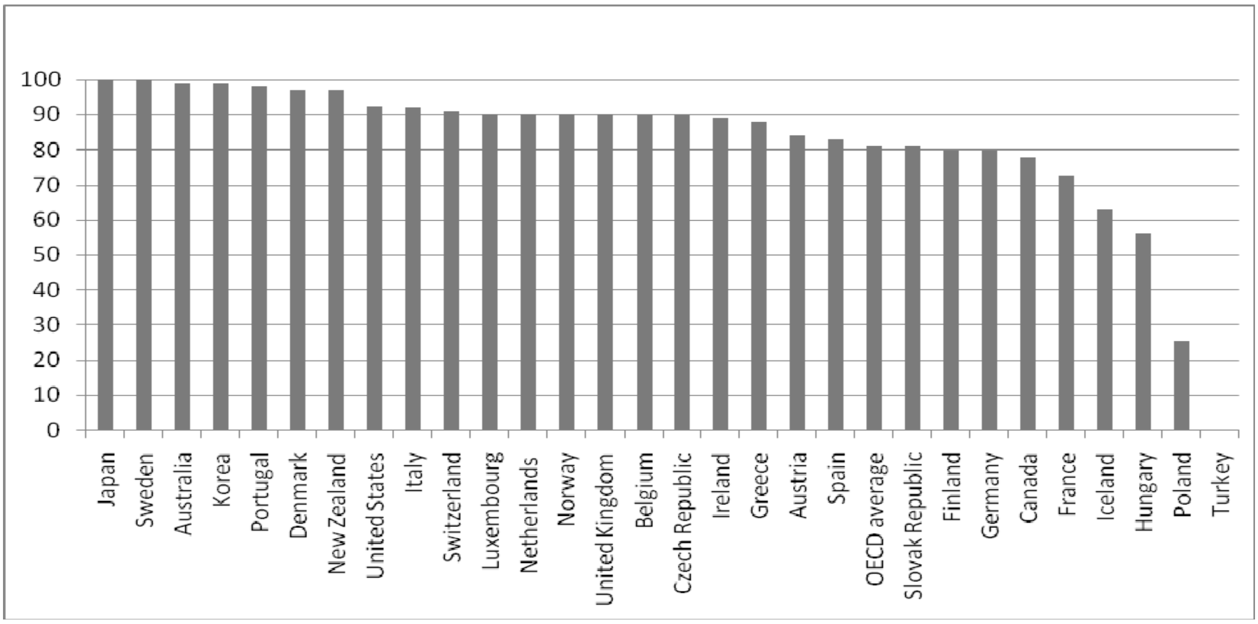
Figure 7 charts 3G population coverage across OECD countries. If not specified, data refer to the overall coverage of 3G technologies in terms of population percentage, that is, what percentage of population (according to their residential location) has 3G coverage of at least one operator. However, for some countries (showing “most widely deployed” in the comments column), the data provided is the coverage of the operator with the broadest deployment. In these cases the overall or national coverage is not specified, but would be higher than the given figure (unless no other operator has deployed its 3G network outside the area covered by the most widely deployed). Denmark uses area coverage, not population coverage. Since mobile operators normally deploy their networks in highly populated areas, actual population coverage should be higher than reported area-based figures. Portugal only refers to the mandatory requirement set on one operator to cover 98% of the population, without specifying whether this figure has actually been attained. Finally, the United Kingdom states that 90% of its population lives in a postcode area where 75% of the population has 3G coverage. The United States also provides data on the percentage of population and territory covered by one or more, two or more, and three or more mobile broadband providers, thus also giving one indication of the available choice for consumers.

Figure 7: **3G population coverage (%)**



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As shown by Figure 7, the situation across OECD countries is uneven. While some countries have almost achieved universal coverage, such as Japan (reaching 100% coverage already in March 2007, according to NTT Docomo), Korea (99%), Sweden (100%) and Australia (99%), Turkey has not started its 3G deployment yet, and other countries such as Poland are in their early stages. It has not been possible to gather data about coverage in Mexico. Since 3G networks have been rapidly deployed in most of the OECD area, if this occurs in the lagging countries an important increase in coverage will take place. The population-weighted average coverage across OECD countries already attains 81%, with 16 countries reaching at least 90%.

In order to look into the size of the digital divide, which is one of the aims of gathering broadband coverage data, the most representative indicators should be the percentage of population that is able to access mobile broadband services, no matter which type of network is covering them. That being said, it is also useful to know the number of service providers they can access as the potential for competition can be expected to affect areas such as affordability. While operators are aware of their own coverage the overall coverage may be hard to ascertain.

3G coverage data submitted by most countries capture only the residential population covered by the network. This has limitations or can be inaccurate for mobile broadband networks since subscribers use mobile broadband services outside of their homes, especially those who use mobile broadband as a complementary service to fixed broadband. Therefore, the extent of geographic area coverage, rather than residential population, might be more relevant for mobile broadband networks. This is also why some coverage deployment requirements also take into account coverage along highways, railways and so forth. The availability of these data, while important, will not be taken into account when assessing 3G coverage in OECD countries, due to the difficulty in obtaining them.

The utility of coverage calculations is reliant on data that can assist in informing policy makers about the location and distribution of the population (normally census or postal code data). Unlike fixed broadband coverage, a 3G connection is not associated with a physical location or a household, but to an area covered by one (or more) base station. Therefore, it is very important to develop a consistent methodology to map coverage against physical locations and households. Another factor for 3G coverage can be the different levels of reception for measurements carried out indoors or outdoors. Finally, as it has been stated in the sections dealing with DSL and cable coverage, basing indicators on population does not necessarily inform policy makers on business access to 3G broadband services. Some examples of these issues will be given below.

Coverage assessment and measurement

Coverage data are normally provided by operators, whose databases may mostly be based on estimates. Many telecommunication regulatory authorities independently test and assess coverage developments of mobile operators, but these data, which are mostly considered as having a commercial and marketing value, are not always made public. This monitoring is generally undertaken to check coverage obligations compliance and to assess the quality of service. Measuring 3G coverage needs to take into account factors such as cell size and traffic load (*e.g.* "cell breathing", diminishing the size of the 3G cell when it is heavily loaded).

In France, mobile operators publish coverage maps, with an accuracy of about 250 metres in rural areas, and 50 metres in urban areas. In order to check the compliance of actual coverage with the published maps, the three French 2G operators had coverage of 250 cantons within 11 different regions checked, audited and sent to the regulator ARCEP, who found that coverage maps were coherent in more than 96.5% of the cases, but it had to be improved for some cantons. In 2009, audits will be carried out by the operators in another 11 regions. The measurement methodology needs to be agreed upon in advance by the operator and the regulator. Even though this procedure has only been carried out in France for 2G, a similar one might be envisaged for future 3G measurements. In Belgium, a theoretical coverage was calculated in 2007 based on data provided by operators. In order to carry out field measurements, a harmonisation of technical standards has been achieved, through joint working groups, involving operators and the European Radiocommunications Office (ERO). Further, Belgium's regulator, IBPT, has elaborated a statistical method to keep error rate below an established threshold. Finally, 1 350 locations have been tested to check whether a UMTS link could be established from a laptop.

When the 3G licences were auctioned in the United Kingdom they contained an obligation requiring a 3G licensee to roll out their networks to enable the provision of 3G services to at least 80% of the population from 31 December 2007. The United Kingdom's Ofcom published in 2006 a consultation on how 3G roll-out should be measured, which resulted in a final statement including a methodology to measure compliance with rollout obligations. Four of the five UK operators passed the obligation with O2 only reaching 75.69%, a shortfall of approximately 2.5 million people. In February 2008 Ofcom issued O2 with a notice which proposed to shorten O2's licence (an equivalent loss of at least GBP 40 million) if it had not met the rollout obligation by the end of June 2008. O2 installed additional base stations and when the rollout obligation was rechecked in May 2008 they had passed the 80% threshold. The UK 2001 Census was used to check the accomplishment of the obligation, by means of the concept of Output Area, each representative of a residential population of around 300 people. Each Census output area has a centroid position which is representative of the location of where most of the population resides within the Output Area. Accordingly, the 80% threshold is assessed by checking the output area's centroid points within the 3G coverage to a signal level of -110dBm. The propagation model ITU-R P1546-2 was used with an additional factor of 8dB which was calculated during a benchmarking exercise comparing Ofcom's prediction results with those of all five operators and a series of test drives carried out in a 100 x 100 km area of the United Kingdom.

The United States FCC uses census blocks deaggregation to obtain mobile broadband coverage data (provided by American Roamer, corresponding to May 2008), and only includes WCDMA/HSDPA and EV-DO/EV-DO Rev. A technologies, leaving EDGE out of the assessment. It is remarkable that United States estimates are based on census blocks (of which there are around 8 million in the country), allowing for a very high level of detail.

How to improve 3G coverage: UMTS 900, digital dividend and infrastructure sharing

Following the burst of the dotcom bubble at the turn of the century, deployment of 3G radio technologies was considerably delayed. Due to the inability of licensees to comply with coverage obligations set in the licence grants, the related obligations were withdrawn or reduced in some cases, and reviewed in others. As a whole, 3G rollout was generally delayed and did not start commercially until 2004 in most OECD countries, except for Japan and Korea, where 3G networks started operation around 2000. Since coverage requirements are one of the pillars of any 3G rollout, they are carefully monitored by governments as one of the most important conditions to be fulfilled by 3G network operators.

In the context of the current economic crisis, where mobile operators are facing decreasing revenues and financing difficulties, infrastructure sharing is viewed as an option for a more economical way to improve coverage. By end March 2009, Telefonica and Vodafone agreed to share mobile phone infrastructure in Germany, Spain, Ireland and the United Kingdom, and this might be extended to the Czech Republic. The companies expect to save hundreds of millions of dollars over the next decade. This agreement will allow both mobile providers to expand coverage while minimising expenditure on masts and their sites.

To improve the 3G networks footprint in metropolitan France, notably in areas where profitability is a major concern, the regulator issued in April 2009 a decision enforcing a timetable for drawing upinfrastructure sharing agreements. Thus, mobile operators have to determine the conditions and the extent to which 3G network infrastructures will be shared while meeting regulatory objectives (land settlement, promotion of infrastructure competition notably). Market players should thereby define what are the best technical solutions, from passive sharing to radio access network (RAN) sharing, including local roaming. They also have to identify the areas where infrastructure will facilitate the extension of existing and expected 3G coverage. In particular, they must share 3G networks in areas where they already share 2G networks and should examine thoroughly the interest of network sharing in “grey zones”, that is, areas where not all 2G operators operate.

The use of low frequencies (below 1 GHz) will play a crucial role in enhancing coverage. Indeed, they are much better adapted than higher frequencies (above 2 GHz) to provide extended coverage, as well as better indoor reception. By using this part of the spectrum, notably in under-served areas where capacity is not a major requirement, operators can cut investment and expenditures, since fewer base stations are needed to provide coverage, compared to the use of higher frequencies. Two main bands can be used to improve current 3G coverage: first, the 2G lower band, and second, the so–called digital dividend. The reuse of the former frequencies for the rollout of 3G equipments on existing infrastructure has been authorized in several countries, including France. Some UMTS 900 MHz networks are already in operation. The attribution of the latter frequencies is on the way worldwide and initial rollouts are planned in the coming years.

In the United States, the increase in 3G coverage has been facilitated by the use of flexible spectrum allocations. Under this approach, spectrum licensees have not been required to utilise a specific generation of mobile air interfaces within a particular licensed band. Rather, they have efficiently upgraded services provided with their licensed band from 1G to 2G to 3G as competitive market forces have dictated.

The 3G mobile broadband market is experiencing rapid growth, which is stimulating mobile operators to increase its availability by improving coverage, already around 80% of populations, with more than half of OECD countries above 90 %. Coverage is expected to increase in the short-medium term. However, due to the intrinsic mobility of the service, coverage data are not easy to obtain, and are mostly based on estimates, which sometimes need to be audited by a third party. An additional factor to be taken into account is the need for measuring the coverage on transportation routes or at places where people do not reside but where they frequently access the service.

COVERAGE OF SATELLITE, WIMAX AND OTHER TECHNOLOGIES

In addition to xDSL, cable modem, 3G and FTTH/B technologies, fixed wireless broadband needs to be considered to round out the primary available options. Up to now fixed wireless has generally been used by users without a "wired" alternative. As such the number of users is relatively small compared with wired alternatives. In fact less than 2% of current broadband subscribers use technologies other that xDSL, cable modem and FTTH/B, by June 2008 (note: mobile wireless broadband technologies are not covered in these data). In this section, WiMAX is considered to be a fixed wireless technology, even though some types of WiMAX may enable considerable mobility.[7] Satellite and fixed terrestrial wireless solutions (such as WiMAX) may be used to address coverage issues in scarcely populated areas, as an alternative solution to high-cost wired broadband rollouts.

Satellite broadband has traditionally provided a lower speed service when compared to other technologies. Initially, satellites required a PSTN return path as the wireless channel provided no bi-directional communications. Nowadays, while having a bidirectional broadband service, satellites can still have major drawbacks, such as the delays (inherent latency impedes the effective use of some applications, such as real-time communications) or decreasing performance under some weather conditions (*e.g.* periods of heavy rain). An additional drawback of satellite broadband services is affordability. Even though this document focuses on coverage and availability aspects of broadband technologies and, in principle, does not deal with pricing and speed issues, these must be taken into account when dealing with satellite technology, which has traditionally been more expensive than wired solutions.

Satellite broadband solutions using Ka band are starting to be deployed by providers, and the future is promising in terms of performance, as bit-rates between 10 and 20 Mbps are expected. Ka band technology reduces the required dish size, resulting in a lower equipment cost to consumers. It employs "spot beams", rather than regional or hemispheric transponder coverage, allowing for a more efficient use of bandwidth. As an example, ViaSat has received a USD 18 million contract from Skylogic, the broadband subsidiary of Eutelsat, for broadband gateway earth stations for the previously announced high-capacity KA-SAT Ka-band satellite systems, scheduled for mid-2010. The total foreseen investment for this project is USD 472 million. Although these improvements will to a large extent increase the capacity and speed of satellite solutions, it is clear that in the long run, their performance will be lower than wired technologies, not only in terms of bit-rate, but also taking into account latency and price.

WiMAX technology (based on IEEE 802.16 family) has been regarded as a key technology to provide broadband services in rural areas, belonging to fixed wireless technologies. Compared to satellite access, WiMAX enables higher speeds and lower cost, but it needs a rolling out of necessary base stations. WiMAX has been seen as a possible substitute for other mobile broadband technologies (W-CDMA, CDMA-2000) and fixed wireless broadband (satellite, or LMDS/MMDS). However, while WiMAX rollouts have taken place in a growing number of OECD countries, many deployments have only focused on urban areas. Economic feasibility and spectrum licence granting are two critical issues in any WiMAX deployment project.

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7. IEEE 802.16d (2004) is considered as a fixed, nomadic wireless standard (Fixed WiMAX), while IEEE 802.16e (2005) was accepted on 18 October 2007 by ITU as part of the IMT-2000, that is, members of the 3G family. In addition IEEE 802.16m will be considered part of the IMT Advanced evaluated technologies (to be discussed by ITU).

In July 2006, France awarded new spectrum licences for WiMAX (3.4-3.6 GHz band). The successful candidates committed to deploy 3 500 stations as of June 2008, 70% outside urban areas. Although some sites have been deployed (around 500), due to some equipment-related problems (delays and device immaturity) the committed numbers have not been reached, so ARCEP has begun to monitor the licence holders, who must report their progress every six months. In the United States, Clearwire, a wireless broadband operator, has launched a service in a growing number of smaller markets across different states. In Spain, 1% of the population will have access to broadband at subsidised prices via WiMAX technology (as part of the National Broadband Extension Scheme - PEBA). Since WiMAX broadband projects are mostly developed on regional or local basis, based on spectrum licensing, coverage improvements can be difficult to monitor.

Lastly, Broadband over Power Lines (BPL) have not yet been used for delivering extended broadband coverage, although the ubiquity of power networks would in principle suggest its use as an important technology for rural areas. However, BPL technology faces a number of technological and regulatory challenges that have hindered its development. It only accounts for less than 30 000 subscribers across OECD countries.

The United Kingdom-based satellite broadband supplier Tariam Satellite Communications targets the residential market with 2048/384 Kbps offer at USD 61 monthly fee, with a 1.2 GB download allowance. Installation costs are around USD 1,163. While these charges are lower and speed higher than regular satellite offers from some years ago, it is clear that satellite suppliers will hardly reach the price to speed ratio that wired broadband suppliers offer unless the are subsidised. This is actually the case in some rural broadband deployment plans, where satellite connections are offered at comparable prices to those of wired-broadband.

The “Digital France 2012 Plan”, presented by the French government on 20 October 2008 includes the certification of “Universal broadband Internet service provider”, that is, one offering at least 512 Kbps at an affordable tariff (max. USD 47 per month). At the time the French Government announced its intention to launch a call for proposals to guarantee broadband access for 100% of the population. However, currently at least two providers are offering broadband services through satellite technology. Both Eutelsat and Orange have announced satellite broadband offers at 2 Mbps for USD 47/month. Orange’s offer, however, has a download limit of 2 GB per month. Every household in metropolitan France and Corsica is eligible for Eutelsat’s satellite solution.

Australian satellite operators offer coverage to roughly 100% of the Australian population. This is a solution very well adapted to a vast continent like Australia, where terrestrial technology cannot provide broadband services to all the population particularly in remote areas. In July 2008, approximately 48 satellite broadband service providers were operating, most of which were regional ISPs reselling satellite broadband to regional, rural and remote customers. Some 11% of Australian broadband subscribers use wireless solutions (either satellite- or WiMAX-based, not counting 3G subscribers). As ACMA and ACCC acknowledge in their Communications Infrastructure and Services Availability in Australia 2008 Report, satellite broadband requires expensive customer premise equipment (including a satellite dish), and it is more expensive than other access technologies (except for rare exceptions). It suffers from a high latency, and its performance may be seriously affected by wet weather.

Spanish Rural Broadband Deployment Plan (PEBA), which ran from 2005 to 2009, and helped deploy broadband coverage to rural and remote areas by subsidising private investment, includes as technology options both WiMAX and satellite, providing coverage to around 3% of the Spanish population (13.5% of PEBA’s target population) by these technologies. Download rates are 256/128 Kbps with a monthly fee USD 53 plus USD 53 one-off sign-up charge plus USD 175 one-off installation fee. This offer is limited to 36 months.

In the United States, satellite broadband provides near ubiquitous coverage and downstream data rates between 512 kbps and 5 Mbps. Satellite broadband provides much-needed connectivity in rural and remote areas of the United States, where other broadband technologies are not available or currently uneconomical. At present, three licensed satellite operators provide satellite-based broadband Internet access services, namely, HughesNet, WildBlue Communications, and Starband Inc. Recognising the importance of satellites as a critical technology for supplying broadband access to rural areas in the United States, the National Rural Telecommunications Cooperative (NRTC) recently announced a subsidised leasing programme addressing the costs of customer premises equipment (CPE), which can be a barrier to broadband implementation and adoption by rural customers. For example, WildBlue satellite service customers can now gain satellite broadband access for just USD 99, which includes CPE and installation. Under this program, the actual CPE cost of USD 400 is subsidized by NRTC and its members. Other programs focus on stimulating broadband adoption and sustainability among targeted groups, including rural customers. Traditionally slow upstream speeds – with offerings often below the broadband threshold – have been improved in recent years but typically remain slower than the downstream mode.

Satellite and fixed terrestrial wireless technologies are often potentially good solutions for improved coverage, since deployment costs are far less than wired solutions. However, while satellite technologies mostly reach around 100% population coverage, WiMAX needs base station deployments, which may hinder its success in rural areas not reached by wired technologies. Cost must also be considered when including these technologies as broadband coverage alternatives, since they might still remain relatively expensive, in spite of the scale economies that further take-up may bring.

BROADBAND DEFINITION, THRESHOLDS AND THEIR RELATION TO AVAILABILITY

This section will provide some information on thresholds and broadband definition that OECD countries use to deliver information on broadband coverage. Coverage data might be influenced by thresholds or broadband definition used by each country, as availability or eligibility ratios might vary if one or another definition/threshold is used. The eventual impact will be discussed below. All thresholds used in this report are based on advertised speeds.

Broadband service is usually understood to be a connection providing high-speed Internet access, that is, a communication service that enables access to the Internet at data transmission rates above a specific threshold. As this approach deals with a service and not a technology, it must remain independent of the latter, through which it is provided. However, as technologies rapidly evolve, technical features of broadband services can quickly change, and as a result a service definition review may sometimes be required. Data transmission rate is among the most dynamic characteristics of broadband services. Telecommunication providers have always based their marketing strategies on advertised transmission rates, and some governments which produce and deliver broadband statistics monitor service speeds. This is to acknowledge that they are a key factor for service usability and customer experience, as well as expanding the possibility of application use. Undoubtedly, services such as real-time video applications or peer-to-peer audiovisual content sharing would not be possible at dial-up bit rates.

A threshold itself only plays a role if a government/institution wants to guarantee that broadband technology can be used for a specific service (such as video-telephony), and they want to establish a minimum quality requirement for that service or range of services. It may also be useful to set a specific threshold if a particular technology needs to be excluded for the purpose of measurement (although it may provide an equivalent service), based on its predicted evolution. Such would be the case of a technology that may meet the threshold level, but is being replaced by a technology with greater scope for performance improvement. In this case it may not make sense to include that technology if its presence in the market will only be limited in terms of number of users and timeframe. In short, setting up a threshold may make data gathering considerably easier. Of course, the choice of a particular threshold would only have an impact if there are a considerable number of connections at data rates between the alternative possibilities. For most wired broadband subscribers today, setting broadband threshold at 256 Kbps, 144 Kbps or 200 Kbps would make no difference, because connections below 1 Mbps are decreasing, and reported availability data would not be affected. That being said some countries may have a relatively large share of lower speeds.

Historically, for the purpose of data collection, the OECD has considered broadband as a service providing Internet access at speeds higher than 256 Kbps. The OECD Broadband Portal data are based on that threshold. It is used to report broadband data of all technologies (xDSL, cable modem, fixed wireless, *etc.*), except mobile broadband, whose measurement methodology is currently being developed. In the early stages of DSL technology, the OECD chose 256 Kbps as the broadband threshold because that was the base threshold for the vast majority of commercial DSL and cable modem offers and, at that point in time, data rates were only expected to increase. Subsequently, operators in a small number of countries, such as Denmark and Poland, introduced some offers at lower speeds though these are rarely offered across the OECD area today. ITU also publishes broadband statistics based on the 256 Kbps threshold, both for fixed wired and wireless broadband access.

European Union Member States periodically report to the European Commission broadband statistics (mainly the number of broadband lines existing in every EU Member State, to produce a broadband penetration ranking). Their data collections are based on the 144 Kbps download capacity threshold. This threshold, while lower than the 256 Kbps one, is still high enough to leave ISDN BRI access out of the scope. However, it is worth mentioning that the main EC contractor for broadband coverage studies, France-based company IDATE, uses a 128 Kbps threshold to deliver its coverage analysis (except for 3G coverage data, where it uses a 384 Kbps threshold). Its data have been often mentioned throughout this paper, since in recent years it has elaborated a yearly report for the European Commission on broadband coverage data (including DSL, cable modem, fibre and 3G), analysing the 27 Member States plus Iceland and Norway.

As stated already, while the 256 Kbps broadband threshold was set, based on existing commercial DSL and cable modem offers, wireless technologies also play a role in broadband developments, although they have only attained a significant part of the market once mobile broadband (based on 3G) had been launched. Previously, wireless solutions (such as satellite or LMDS/MMDS) were only addressed to niche markets. Therefore, whether they fit in the broadband definition (based on a bit-rate threshold) should be carefully analysed too, both for mobile wireless (GPRS, EDGE, 3G technologies) and for fixed wireless (satellite, WiMAX, *etc*.).

The FCC has up to now used a slightly different terminology in the United States. “High-speed lines” are connections to end-user locations that deliver services at speeds exceeding 200 Kbps in at least one direction (either enabling the end-user to send information to – upstream – or receive information from the Internet – downstream), while “advanced services lines”, which are a subset of high-speed lines, are connections that deliver services at speeds exceeding 200 Kbps in both directions. For the purpose of information collection, the FCC has used “broadband connections” as a synonym of “high-speed lines”. In June 2008, the FCC modified its requirements for reporting broadband lines. Specifically, it established eight download speed tiers and nine upload speed tiers, which providers must employ in reporting broadband subscriber lines.

In Norway, NPT defines wireless broadband (mobile broadband and nomadic, wireless broadband), as “access capacity in which the end user, wirelessly connected to a public mobile network or public fixed network, has access to data transmission services with a perceived bit-rate of at least 640 Kbps downstream and 128 Kbps upstream”, thus considerably increasing the 256 Kbps threshold. This definition is consistent with the Norwegian definition for fixed broadband, which also sets a 640/128 Kbps threshold. Italian coverage data used through the document were reported based on a broadband definition enabling at least 640 Kbps downlink, Sweden reports broadband coverage above 2 Mbps downlink and Turkey uses 1 Mbps downlink to deliver coverage data.

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