



Learnings from international case studies in telecoms infrastructure



DCMS Review Annex | February 2018



1. Overview of case studies

- Implications for broader fibre rollout
- Implications for market models

2. Individual case studies

This international case study annex explores the implications of different international approaches for deploying fibre

1. The objective of the following annex is to provide the reader with background as to how other countries have chosen to deploy fibre.
2. We considered seven countries in detail including Germany, France, Spain, Portugal, Sweden, USA, and considered an additional six countries for reference.
3. This document focuses on fixed fibre deployment, specifically FTTP.

Glossary

ADSL – Asymmetric Digital Subscriber Line: the broadband technology used to deliver standard copper broadband products. It is designed to be able to run over long copper cable lengths, sacrificing speed for distance, allowing wider data coverage with fewer DSLAMs across the network

ARPU / ASPU – Average revenue per user / Average spend per user

CPs – Communications providers: A service provider is an entity that provides services to other entities. Usually this refers to a business that provides subscription or web service to other businesses or individuals. Examples of these services include internet access, mobile phone operator, and web application hosting. The term is more often applied to communication services than to other kinds of service industry

DSL – Digital Subscriber Line: Technologies that are used to transmit data over telephone lines

FTTC – Fibre to the cabinet: the term for the supply of data services over a fibre optic cable running between the local exchange and the local street cabinet, then using existing copper cable to deliver the data to the end user's premises. In FTTC, the device which translates the data into a signal that can be carried over copper wire, the DSLAM, sits in a local street cabinet, rather than in the local exchange

FTTP (FTTH/B) – Fibre to the premises (home/building): the term for the supply of data services over a fibre-optic cable running between the local exchange and the end user's premises. This technology replaces the need for copper cabling within the Openreach network. Sometimes referred to as 'full fibre'.

HFC – Hybrid Fibre-Coaxial: broadband network that combines optical fibre and coaxial cable

ISPs – Internet Service Provider: organisations that provide services accessing and using the Internet

MDF – Main Distribution Frame: A point in a telephone exchange where cables from outside can be connected to the exchange equipment

MDU – Multi-dwelling unit: multiple separate housing units for residential use are contained within one building

NEBA – Nuevo Servicio Ethernet de Banda Ancha (New Ethernet Bandwidth Service): Equivalent to VULA on a provincial level (NEBA Local = VULA)

NGA – Next generation access: wired access network which consist wholly or in part of optical elements and which are capable of delivering broadband access services with enhanced characteristics as compared to those provided over existing copper networks

ODF – Optical Distribution Frame: A rack or cabinet which either terminates or connects different optical fibre cables

OECD – Organisation for Economic Co-operation and Development

PON – Passive Optical Network: point to multipoint architecture which is able to serve multiple end-points e.g., customers

PPP – Public Private Partnership: cooperative agreement between two or more public and private sectors, typically of long-term nature

P2P – Point to Point: connection between two nodes or end points

VDSL – Very high bit rate Digital Subscriber Line: the broadband technology used to deliver the higher speeds associated with FTTC compared to standard copper broadband products which are delivered over ADSL. VDSL is designed to work on shorter lengths of copper cable

VULA – Virtual Unbundled Local Access: owner of the fibre line retains control over the physical line but provides rivals with management freedom over the connection

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Summary insights from examining at-scale FTTP rollout case studies

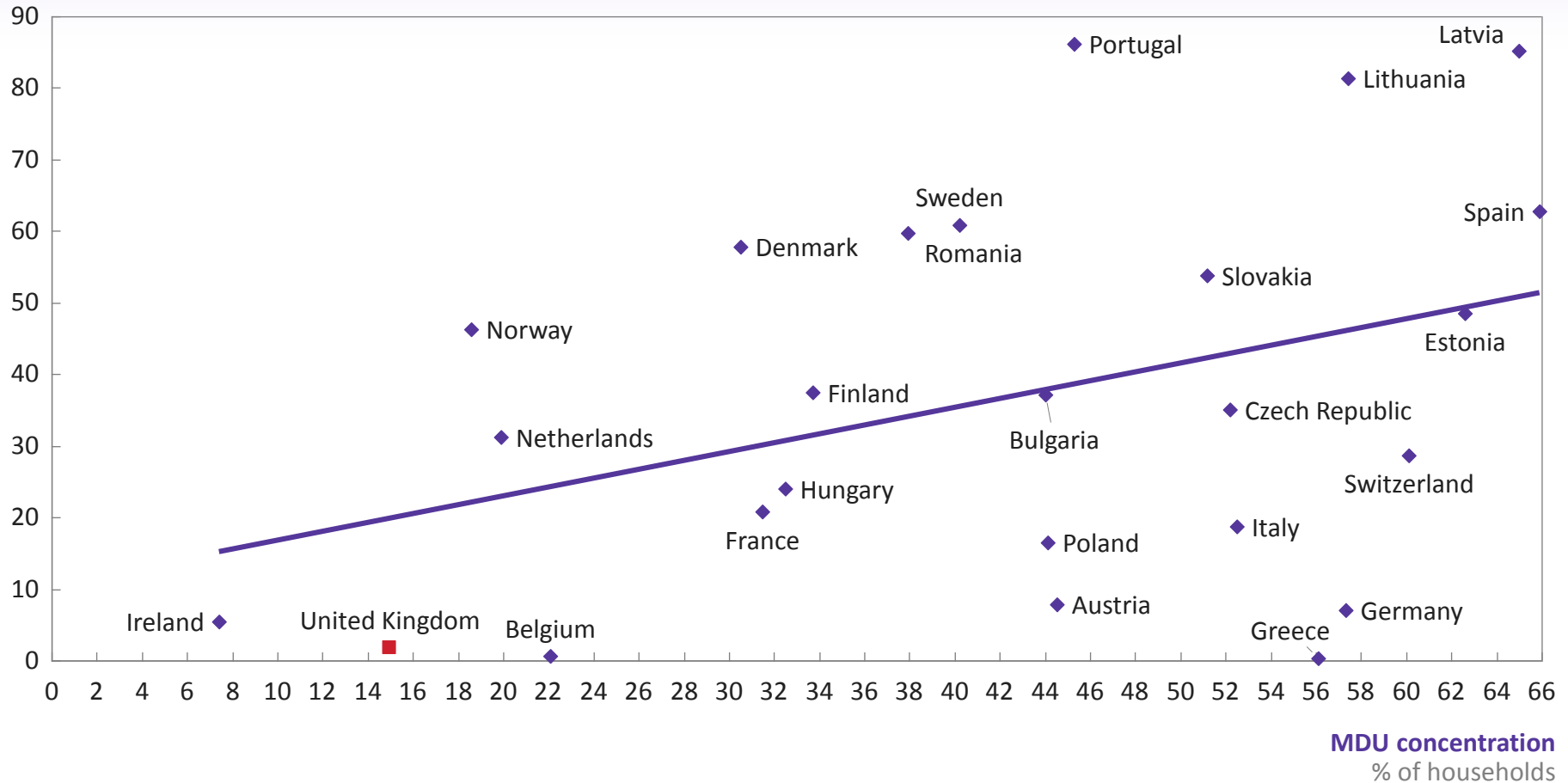
1. Countries that have undertaken at-scale FTTP deployment typically possess **favourable structural characteristics**: (i) the degree of Government funding (ii) network topology and housing density (iii) regulatory model; and (iv) market structure.
2. Evidence suggests that **FTTx investment is more likely when cable is a competitive threat to traditional broadband.**
3. In some countries where FTTP roll out has been extensive, high-speed internet cost may surpass the OECD average – this is typically **where rollout has been privately financed and reflects operators recouping their capital investments.**

1 MDU concentration appears to influence FTTP coverage; the UK is more urban than peers but has low MDU concentration

FTTP coverage vs. MDU (multiple dwelling unit) concentration

FTTP coverage

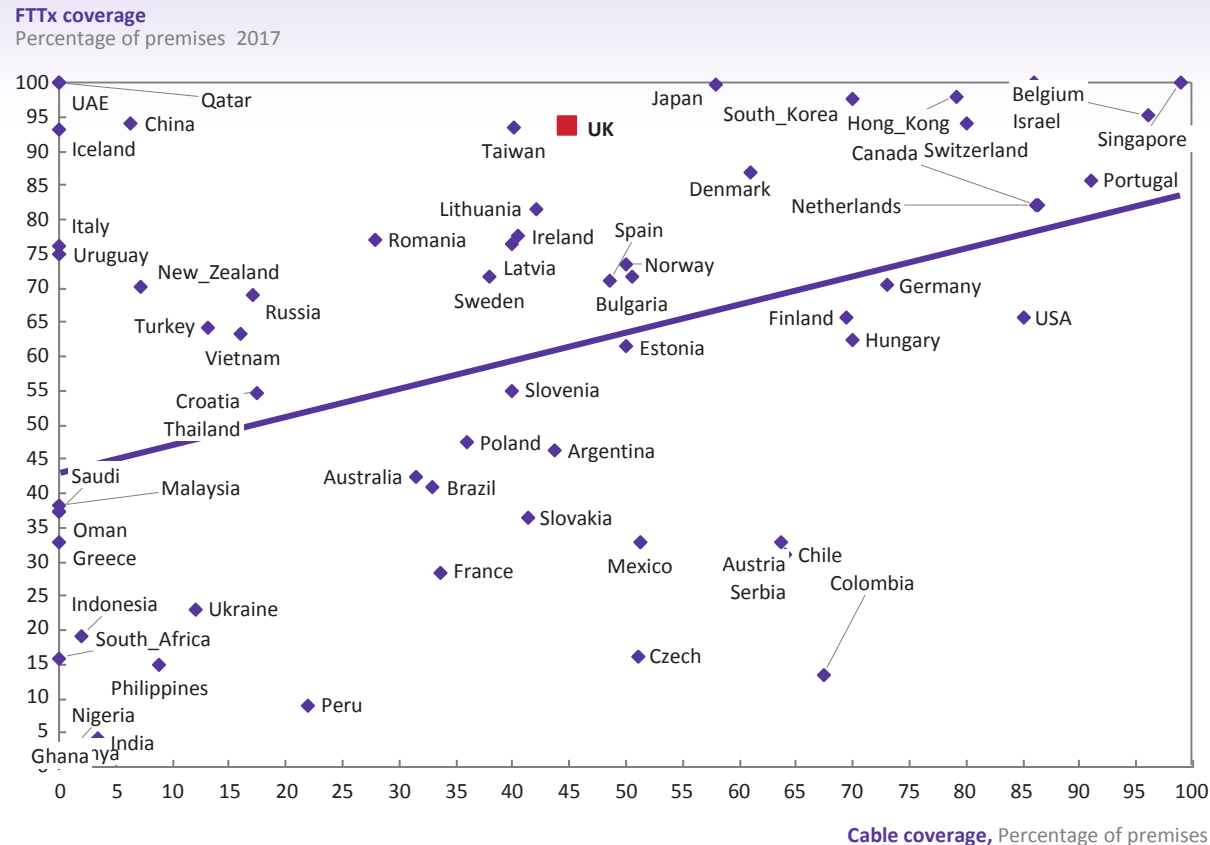
% of households, 2016



SOURCE: Eurostat (Mean income by degree of urbanisation, population according to three zones, surface area in three zones); European Commission, 'Broadband Coverage in Europe 2016' (September 2017)

The presence of cable as a competitive threat stimulates investment from fixed providers, but whether it's FTTP or FTTC depends on country characteristics

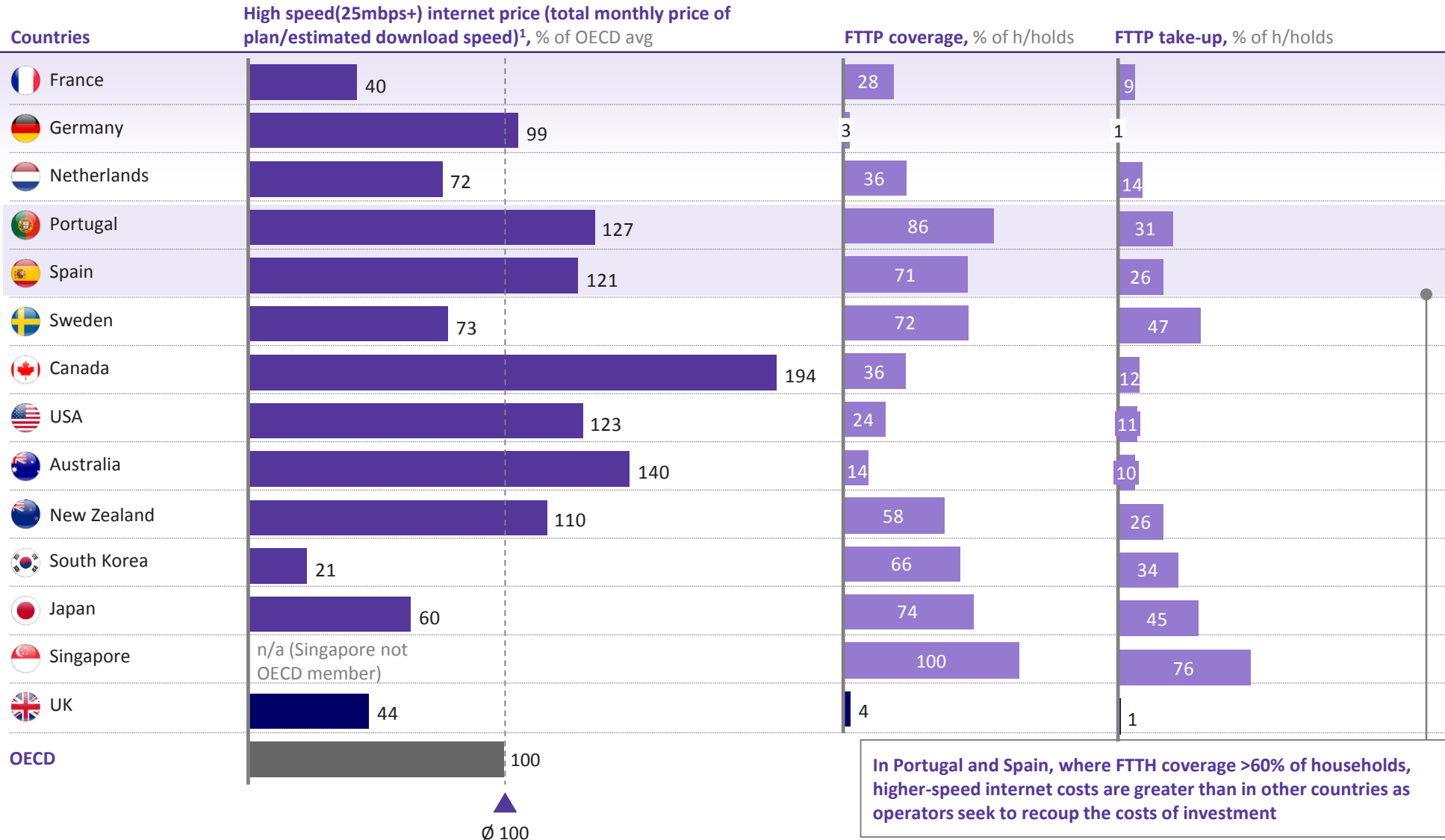
Comparison of FTTx (incl. FTTP and FTTC) coverage rates with cable penetration rates Observations



- The presence of cable stimulates investment in FTTx but this can take the form of FTTP or FTTC
- Countries with higher levels of FTTP coverage have often embraced FTTP due to the presence of other 'nudge' factors:
 - high levels of MDUs,
 - High-quality duct
 - regulatory policy favourable to investment (see next section on levers and market models)
 - significant government aid to accelerate the deployment of FTTP nationally
- Countries with lower levels of FTTP coverage but higher levels of FTTx coverage (Germany, Netherlands, Belgium) have focussed on non-FTTP technologies and share similar structural characteristics to the UK (lower MDU share, lower quality ducting, underground cabling, higher labour costs)
- The UK has high levels of FTTC coverage which lifts overall FTTx coverage to 93% of premises (91% - FTTC + 2% - FTTP)

SOURCE: Analysys Mason, 'FTTx roll-out and capex worldwide: forecasts and analysis 2017–2022'. The number of households for Spain in this graph excludes 7m holiday properties and empty villas (including them would increase coverage to about 90%). Please note the disclaimer in the Annex.

3 In some countries where FTTP roll out has been extensive, high speed internet cost is higher than the OECD average



1 OECD, Fixed Broadband basket, High user, June 2017 ((set of broadband price plans by country >25mpbs, min 200g usage/month, prices normalised on a PPP basis)

SOURCE: OECD Broadband Portal, Analysys Mason, 'FTTx roll-out and capex worldwide: forecasts and analysis 2017–2022' (2017 data) The number of households for Spain in this graph includes 7m business sites, holiday properties and empty villas (excluding them would bring coverage to about 90%). Please note the disclaimer in the Annex.

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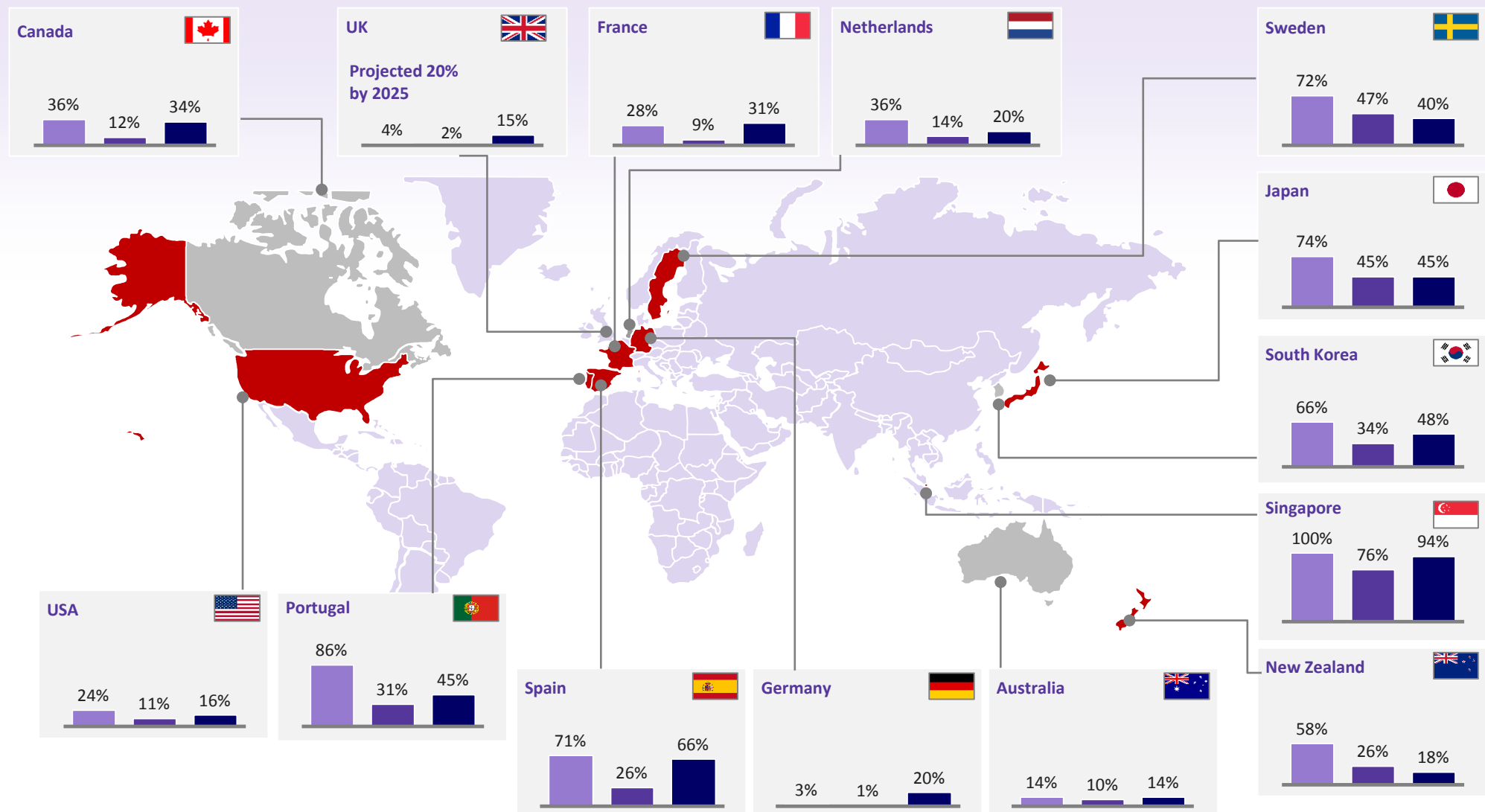
International case studies summary

A comparison of a representative set of developed countries reveals several clear themes to inform the goal of at-scale FTTP deployment in the UK:

1. the market models correlated with **the highest levels of FTTP coverage have typically involved the nominated provider** (model #2), **Government-led** (model #5) or the **market-driven** model (#3)
2. there are no **clear examples of countries adopting either franchising** (#4) or **regulated infrastructure competition** (#1) while also **achieving high FTTP coverage**
3. countries with high FTTP coverage have typically adopted **geographically differentiated regulation** to reflect different competitive conditions and also provide sufficient incentives to invest in FTTP deployment (France, Spain, Portugal). Geographic markets were identified prospectively on the basis of existing and prospective levels of fibre competition and dwelling density and were refined during rollout
4. **in some countries in prospectively competitive areas no wholesale access obligations even on anchor products (except for duct access) were imposed** to incentivise migration and allow returns from new build infrastructure; these have often been **complemented by policies introducing lighter touch regulation (symmetric, ex post and dispute-based) in prospectively competitive areas** (see below) to give sufficient comfort that consumer choice is maintained in the transition
5. especially in countries with nominated provider models (Singapore, Australia) there has been **significant demand side stimulus in the form of direct public subsidy which has aided coverage rollout**
6. countries with **market-driven models do not appear less competitive at retail level than the UK** (France, Spain, Portugal)
7. **national FTTP coverage rarely means universal FTTP coverage** - even in countries with high levels of national FTTP coverage, extending FTTP to rural areas has been limited (Spain, Sweden).

We have compared a representative group of developed countries to determine applicable lessons for at-scale FTTP deployment for the UK















■ FTTP coverage¹ ■ FTTP uptake² ■ MDU % ■ Focus country ■ Included in group



1 Percentage of households with FTTP connection 2 Premises using FTTP as a proportion of total premises

SOURCE: European Commission, 'Study on Broadband 2016' (21 September 2017); Eurostat and relevant national statistical agencies [MDU share]; CRTC (Canada); NBNCo (Australia); Ofcom (Korea, Japan); MBIE (NZ); Netlink Trust (Singapore); Fiber Broadband Association (USA); Analysys Mason (take-up statistics); Analysys Mason, 'FTTx roll-out and capex worldwide: forecasts and analysis 2017-2022'. The number of households for Spain in this graph includes 7m businesses, holiday properties and empty villas (excluding them would bring coverage to about 90%). Please note the disclaimer in the Annex.

Overview of key Fixed/FTTP metrics

Countries	Household density	Infrastructure		Internet quality, cost and coverage			
	MDU share of households, % of h/holds	Dominant transmission conduit, aerial vs underground	High duct quality and ease of access ²	Avg. broadband download speed mbps	High speed (25mbps+) internet cost ¹ % of OECD avg	FTTP coverage, % of h/holds	FTTP take-up, % of h/holds, 2017
 France	32	Aerial	✓ (Local utilities)	11	40	28	9
 Germany	57	Underground	✗	15	99	3	1
 Netherlands	20	Underground	✗	17	72	36	14
 Portugal	45	Aerial	✓	13	127	86	31
 Spain	66	Aerial	✓	13	121	71	26
 Sweden	40	Underground	✓ (Local utilities)	23	73	72	47
 Canada	34	Aerial	✓	16	194	36	12
 USA	16	Aerial	✓	19	123	24	11
 Australia	14	Aerial		11	140	14	10
 New Zealand	18	Aerial	✓	15	110	58	26
 South Korea	48	Aerial	✓	29	21	66	34
 Japan	44	Aerial	✓	20	60	74	45
 Singapore	94	Underground	✓	20	n/a	100	76
 UK	15	Underground	✗ (Access available but lower quality)	17	44	4 Projected 20% by 2025	1

1 Total cost per month of benchmark plan/estimated download speed

2 Empty ticks reflect reduced need for high quality ducts due to presence of aerial cabling

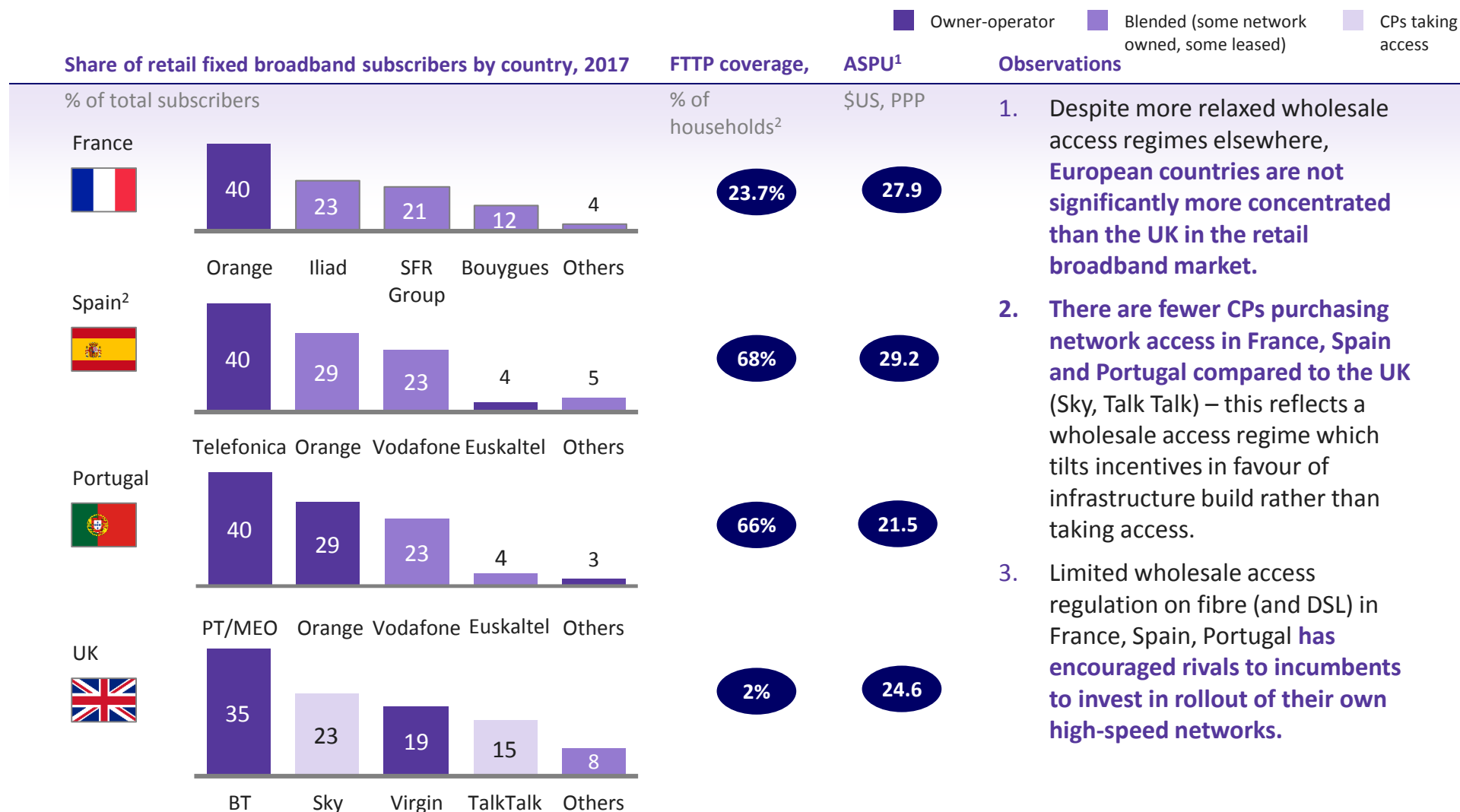
3 HFC/D3.0 covers cable operators coaxial-based networks where either optical fibre has been deployed to a node outside building and/or the D3.0 standard has been implemented in central node (ldate)

SOURCE: Akamai State of the Internet Report, OECD Broadband Portal, European Commission, 'Study on Broadband 2016' (21 September 2017); Eurostat and relevant national statistical agencies[MDU share]; Analysys Mason (FTTP coverage and take-up, '. The number or households for Spain in this graph includes 7m businesses, holiday properties and empty villas (excluding them would bring coverage to about 90%)., see disclaimer in the Annex.

There are some clear lessons for each market model when considering the case studies of at-scale fibre deployment

1	2	3	4	5
Regulated infrastructure competition	Nominated provider with regulatory pricing	Market-driven	Franchising	Government-led
<p>A. There are no notable examples of the regulated infrastructure competition model at a national level resulting in at-scale full fibre rollout</p>	<p>A. Countries that have opted for nominated provider models who have achieved coverage gains have also made steep public investments to assist the nominated providers (NZ, Singapore)</p> <p>B. Temporary deregulation of pricing has been an additional spur to invest (NZ)</p> <p>C. Some countries who have adopted the nominated provider model have failed to achieve desired coverage gains on time (Australia)</p> <p>D. Sometimes, nominated providers have been de facto, still with positive consumer outcomes (NTT in Japan)</p>	<p>A. There are multiple examples of countries successfully employing market-driven models in prospectively competitive areas to incentivise high levels of fibre rollout (France, Spain, Portugal)</p> <p>B. Infrastructure competition often regulated on a region-specific basis (France, Spain, Portugal)</p> <p>C. Countries often provide temporary forbearance on wholesale access requirements (especially active access) (France, Spain, Portugal) with adjustments in implementation of the regulatory approach as markets evolve</p> <p>D. Commercial arrangements for supporting investment include risk sharing through two-part tariffs/volume discounts between the incumbent and access seekers (Germany) and collaboration to minimise asset duplication (France, Spain); asset sharing achieved in the UK through duct and pole access</p> <p>E. Countries with the market-driven model do not appear less competitive at retail level</p>	<p>A. There are no notable examples of successful deployment of franchising to incentivise at-scale FTTP deployment (or equivalent NGA technology) in developed countries</p> <p>B. We have not come across examples internationally where local franchising has been used as an approach, except in circumstances of retail supply to, eg, public sector tenants which could be considered a form of franchising.</p>	<p>A. Demand-side Government stimulus has been a powerful driver of rollout in countries with high FTTP coverage whether direct (Government-owned wholesalers as in Sweden) or indirect (Government-subsidised wholesalers as in New Zealand)</p> <p>B. Government subsidies are especially required for commercially unviable rural areas (France)</p>

Countries with market-driven infrastructure competition models are broadly as competitive as the UK



1 Average spend per user per month, industry-wide for broadband services 2017

2 2016 figures (as for 2017 only estimates available at this time); coverage for Spain includes businesses, holiday villas and empty properties. Excluding them would bring coverage to about 90%.

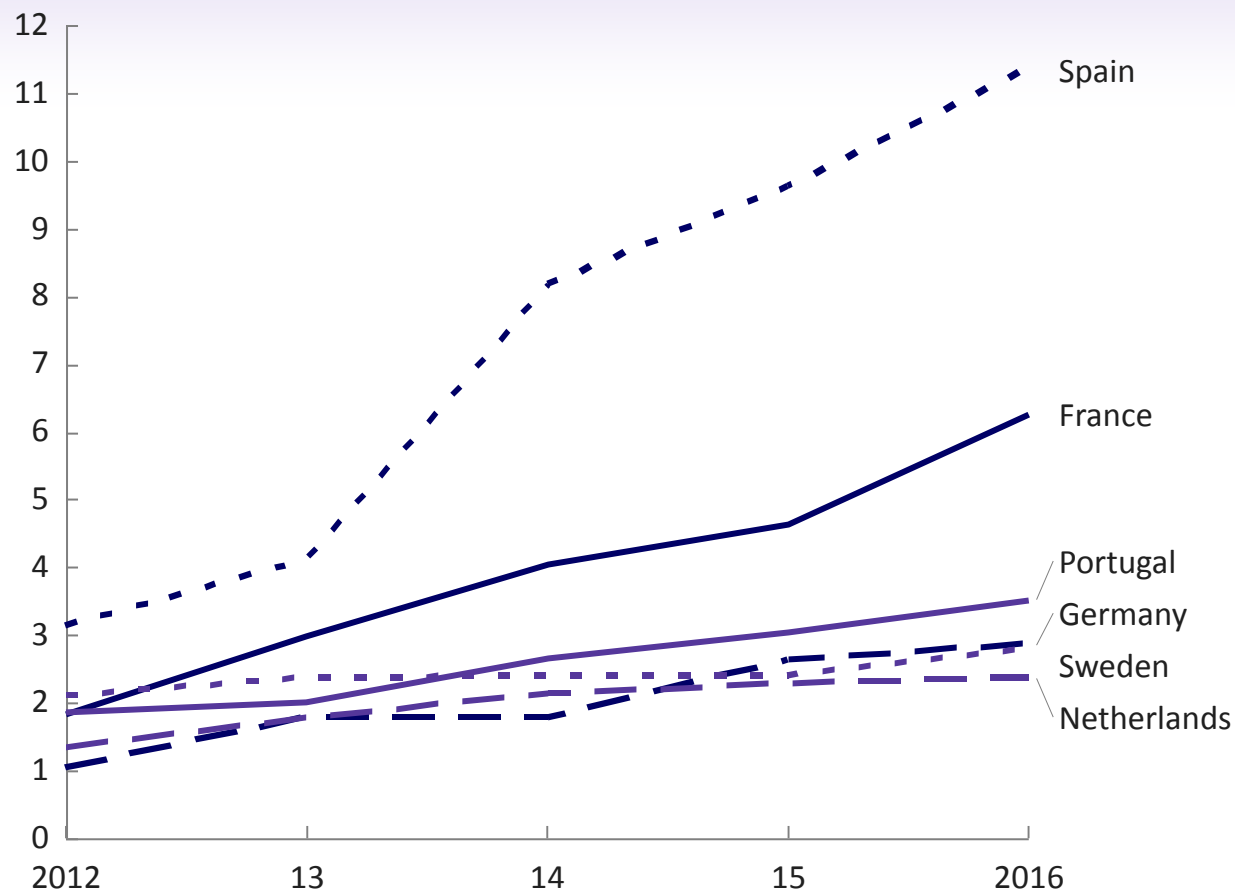
SOURCE: Analysys Mason; : European Commission, 'Study on Broadband 2016' (21 September 2017); please note the data disclaimer in the Annex.

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In Europe, only Spain (1.6m homes/year) has managed to deploy fibre to more than 1m homes/year – this indicates the difficulty of rapid, at-scale deployment

FTTP coverage by EU country, 2012-16, homes passed (m)



FTTP homes passed per year,
000s of homes, 2012-16

	Spain	1,644
	France	883
	Portugal	330
	Germany	366
	Sweden	140
	Netherlands	208

SOURCE: European Commission, 'Study on Broadband Coverage in Europe, 2016' (September, 2017)

In countries with at-scale FTTP deployment, there has been significant demand side stimulus in the form of direct public subsidy

Commercial operators can struggle to justify FTTP capex

“

Altice-SFR ready to deploy very high speed throughout the territory, without public money

LesEchos 11 July 2017

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“

Altice abandons effort to lay its own fibre technology across France

REUTERS 13 December 2017

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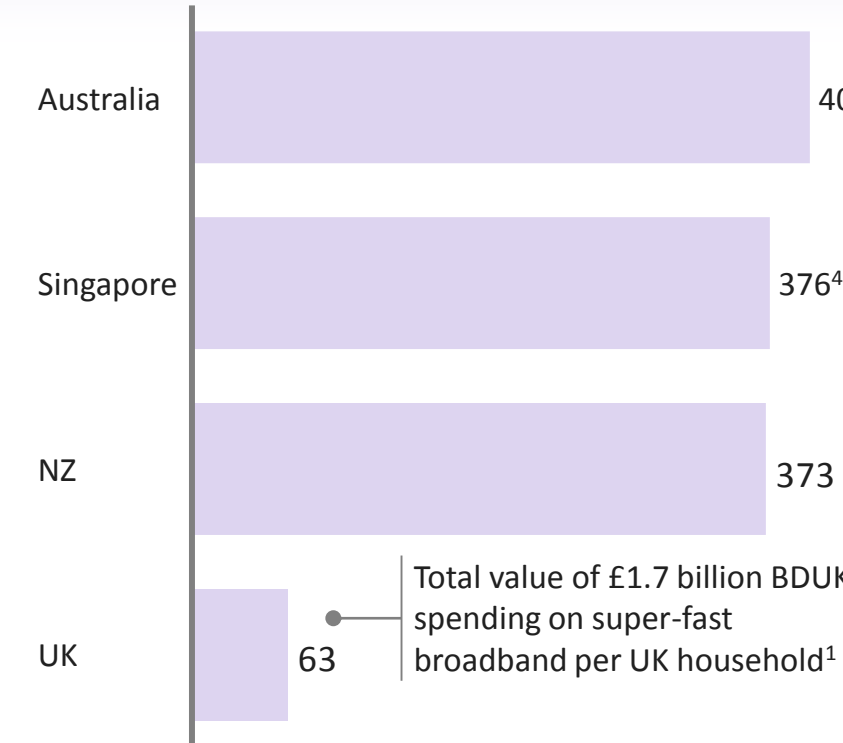
Why Google Fiber is no longer rolling out to new cities

The Washington Post 16 October 2016

”

The sums invested by Government-led national provider models represent a steep premium to existing UK spending

Average level of public subsidy for fibre broadband per household, £GBP

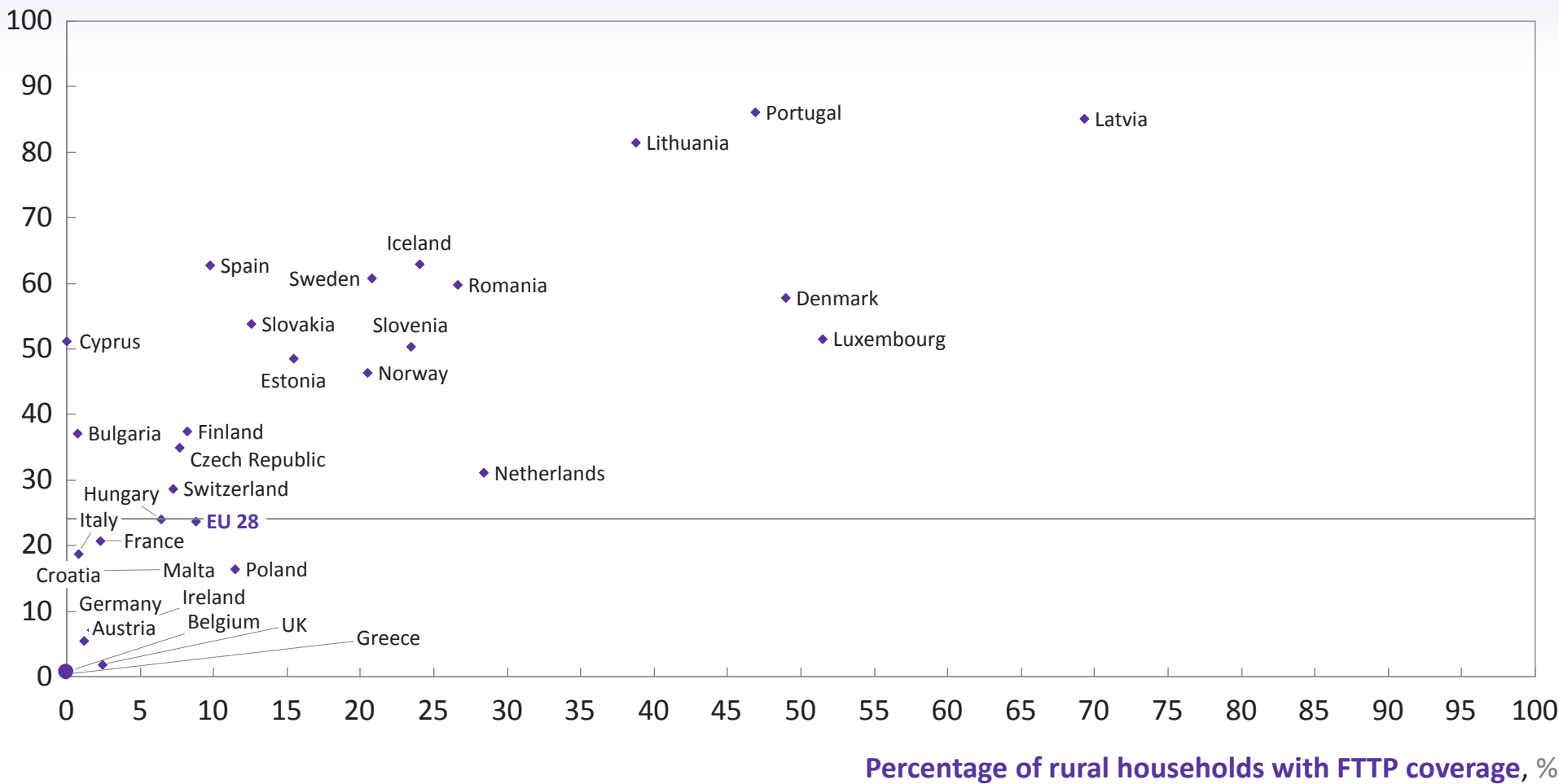


1 House of Commons, ‘Superfast Broadband in the UK’ (March, 2017) | 2 Estimated by WikConsult at 560 euros in 2015 (exchange rate to GBP of 0.8 - £402) | 3 Estimated total public subsidy of £475m divided by 1,263m households in Singapore [Ofcom, International Case Studies (July 2015), p. 166] | 4 Estimated total public subsidy of £690m divided by 1.85m households [Ofcom, International Case Studies (July 2015), p. 44]
SOURCE: Analysys Mason (for Ofcom) 'International Case Studies' (July 2015) [NZ and Singapore figure]; Wik Consult, ‘Competition and Investment’ (July 2015) [Australia figure]; National statistical authorities (household figures)

Even countries with high levels of national FTTP coverage struggle to extend FTTP to rural areas

FTTP coverage by EU country

Percentage of national households with FTTP coverage, %



SOURCE: European Commission, 'Study on Broadband Coverage in Europe, 2016' (September, 2017)

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Spain – Overview of fibre regulation and insights for UK

Timeline

2009

- CMT (the then Spanish telco regulator, now 'CNMC') ex-ante excludes fibre in urban areas from wholesale access requirements, limited active remedies imposed on fibre in non-competitive regions in order to stimulate competition

2010

- Telefónica deploys FTTH on a large scale in Barcelona and Madrid (completed in 2012)

2013

- Vodafone and Orange sign JV to roll out fibre to 6m homes across Spain by 2017
- Telefónica, Orange and Vodafone reached agreement on sharing of vertical infrastructure within buildings, ask CMT to set prices for services (prices set in 2014)

2014

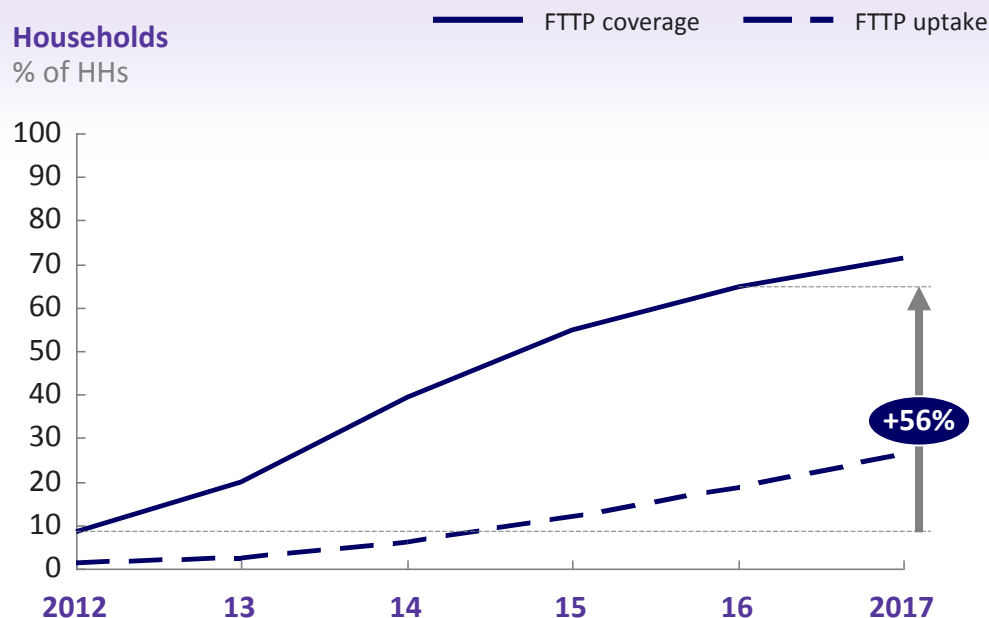
- Vodafone acquires ONO (cable operator) and Orange acquires Jazztel (broadband company) – consolidation leads to further FTTP investment due to improved scale economics of deployment

2016

- VULA at all speeds (including >30Mbit/s) mandated for the first time in 65% of country deemed non-competitive
- Change introduced to secure downstream competition in 'non-competitive areas'

Overview of Spanish FTTP deployment and uptake

Households % of HHs



Insights for UK

- FTTP rollout in Spain was aided by **physical structural conditions not present in UK**: high density (66% of population in flats vs 15% in UK), quality duct and pole access (constructed in 1970s), and a lower cost of deployment (due to lower labour and construction costs)
- **Market conditions not present in UK also aided the speed and scale of rollout**: (i) limited wholesale access requirements for retail re-sellers created incentives for operators to invest, (ii) operators allowed to agree areas of collaboration to avoid asset duplication, and (iii) geographic deregulation

SOURCE: Analysys Mason: 'International Case Studies'; Wik Consult: 'Regulatory approaches to risky bottleneck assets'; BEREC: 'Challenges and drivers of NGA rollout'; Analysys Mason, 'FTTx roll-out and capex worldwide: forecasts and analysis 2017–2022'. The number of households for Spain in this graph includes 7m business sites, holiday properties and empty villas (excluding them would bring coverage to about 90%). Please note the disclaimer in the Annex.

Timeline

2008

- French parliament sets out economic modernisation law (LME) determining that high-speed broadband (incl. fibre) and broadband were substitutable markets. Law empowered ARCEP (regulator review) to withhold mandating active remedies for fibre access and minimal passive requirements (duct access only)

2009-10

- ARCEP develops regulatory framework to govern fibre rollout
- Zones identified by ARCEP for different regulatory oversight levels (adjusted again in 2014):
 - 106 cities identified as 'very dense' and regulated on deliberately 'light touch' basis (all cities with >250 000 inhabitants – 17% of premises ('black areas'))
 - Less densely populated areas covered by private initiative rollouts ('grey areas') and commercial co-investment
 - Sparsely populated areas where public-initiative networks are being deployed ('white areas')

2013

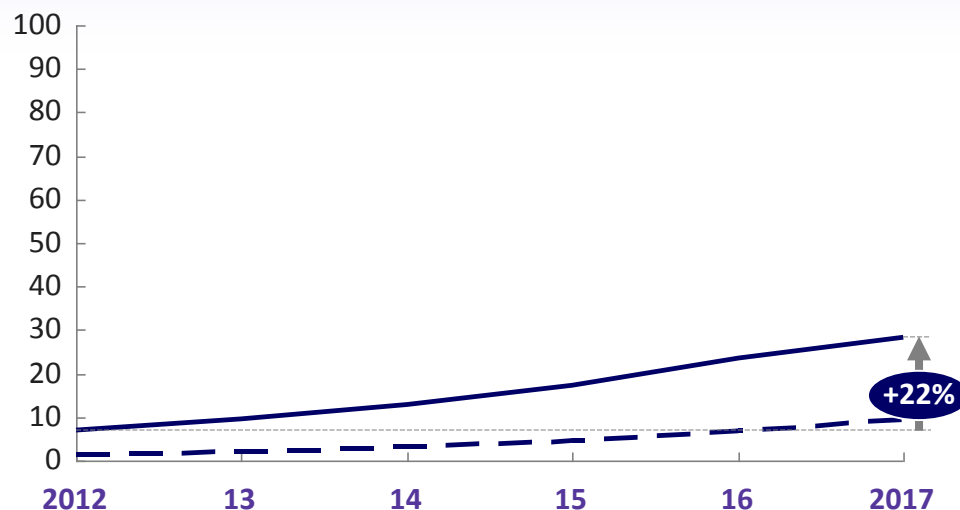
- New national broadband plan (Mission Très Haut Débit) announced which involves joint investment by local and central government and network operators, with proposed joint investment of €20 billion (€13.3bn of state funding)

2017

- France's audit office - the "Cour des comptes" - estimated that the cost would be closer to €35bn if it wanted to achieve its target for 80% of households by 2022. It thought a more realistic target was 80% by 2030

Overview of French FTTTP deployment and uptake

Households % of HHs



Insights for UK

- FTTTP rollout in France was aided by **physical structural conditions not present in UK**: high density (31% of population in flats vs 15% in UK), high quality duct access, limited scope for VDSL – due to long length of copper loop on distribution side which limited the ability of VDSL upgrade of existing infrastructure to a speed that would compete with cable networks
- Market and regulatory conditions not present in UK also aided the speed and scale of rollout**: (i) limited wholesale access requirements (especially in high density zones) created certainty for multiple operators to invest in rollout (ii) regionally-differentiated deregulation and (iii) significant public subsidy from government and municipalities has aided rollout in commercially uneconomic areas



Sweden – Overview of fibre regulation and insights for UK

Timeline

2000

- Swedish Government and telco firms agree co-ordinated national plan for national fibre network (*An Information Society for All*), underpinned by \$US1 billion government subsidy
- Svenska Bostader (Stockholm housing authority) rolls out duct and dark fibre across its buildings (all MDUs) renting out passive infrastructure and network infrastructure to commercial providers – other government entities and municipalities begin to follow suit

2007

- TeliaSonera begins deployment of FTTH to new buildings and running services over some of the muni-fibre network (networks from municipalities)

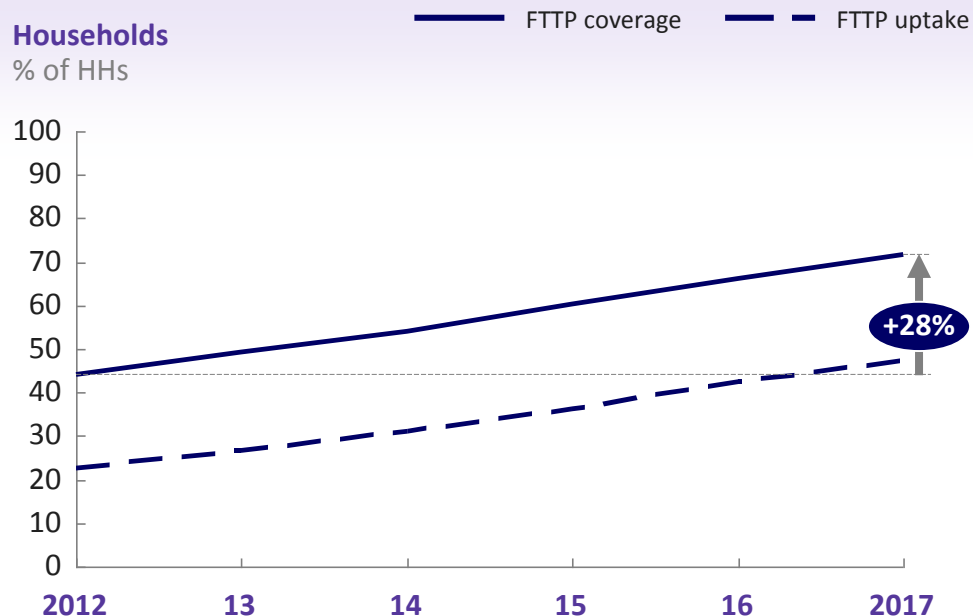
2009

- Government broadband strategy commits to target of 90% of population with broadband connection >100Mbps by 2020 and continued financial support for rural areas where no commercial build out is expected in 3 years

2013

- TeliaSonera and Telenor make substantial acquisitions to enlarge their fibre coverage and increase market share

Overview of Swedish FTTP deployment and uptake



Insights for UK

- Demand-side levers present in Sweden are not currently (or likely to be) present in UK, limiting applicability of case study**
 - Extensive municipality-owned wholesale networks funded through direct government spending and PPPs (currently 180 separate municipal networks providing 58% of fibre lines¹) forcing the incumbent (Telia) to react
 - Higher revealed willingness to pay on part of Swedish consumers (mark-up on rent for every apartment fitted with fibre)
- Other demand-side levers (e.g., government utilising FTTP itself via public e-services) may be powerful accelerator to FTTP deployment**

¹ Berec, Challenges and drives of NGA rollout and infrastructure competition (2016)

SOURCE: Analysys Mason, 'FTTx roll-out and capex worldwide: forecasts and analysis 2017–2022'. Please note the disclaimer in the Annex.



USA – Overview of fibre regulation and insights for UK

Timeline

2002 -04

- FCC begins to gradually reduce legacy wireline regulations to allow telecom companies to effectively compete against cable companies with a fibre optic network (and in response to litigation)
- Verizon begins to deploy FTTH technology called FiOS

2006

- AT&T begin to deploy FTTC in order to compete against cable companies

2009

- Announcement of National Broadband Plan, aiming to enhance broadband coverage throughout the whole country, in particular in rural areas.

2010

- Google announces it will begin to deploy FTTP on an open access model
- Kansas City chosen from more than 1100 towns and cities become the first city to have Google Fiber

2014

- AT&T deploys FTTP network in Austin, Texas in order to provide connection speeds of up to 1Gbps

2015

- AT&T and DirecTV merger approved on the condition an additional 12.5million customers will be passed via FTTP within four years

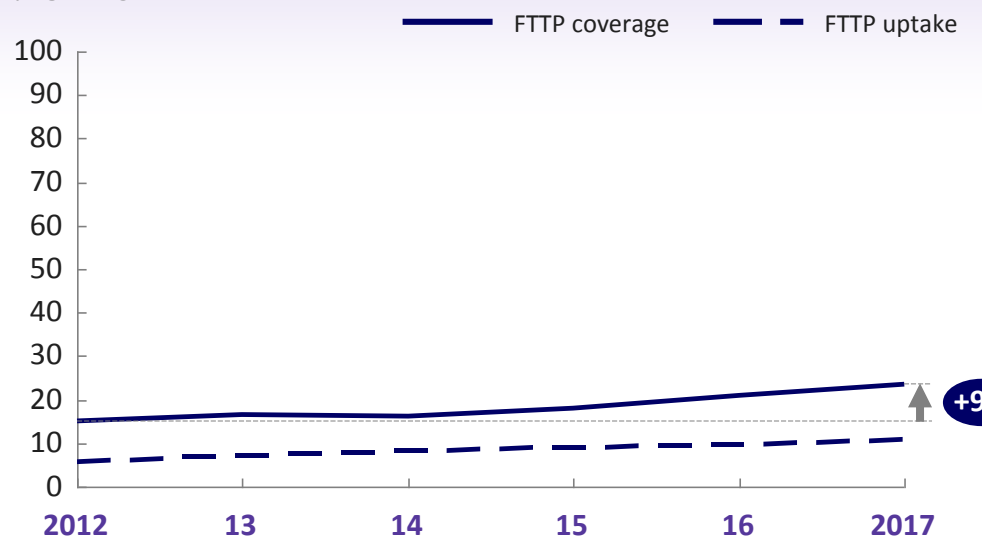
2016

- Google puts all expansion plans on hold due to installation cost of fibre but remains operational in 20 cities

Overview of USA FTTP deployment and uptake

Households

% of HHs



Insights for UK

- **Higher retail internet costs in USA** partly a product of higher costs, e.g. due to geography and input costs) and partly due to less regulation have given US cable and telecom companies sufficient **cash to make the capital investments in FTTP (telecom) or DOCSIS 3.0 (cable)** – lower prices in UK may not lead to similar investment
- **Intense competition from cable companies** drove heavy investment in competing technologies by telecom companies but this did not lead to universal coverage (telecom companies' FTTP now covers the most attractive ~20-25% of US households)
- **Significant public investment** (~\$9-10bn annually across all programs;) through the National Broadband Plan and Universal Service Fund has been required to significantly improve broadband coverage and speeds across the USA in rural areas that present a commercially unattractive investment



New Zealand – Overview of fibre regulation and insights for UK

Timeline

2009

- NZ government launches national programme: Ultra Fast Broadband (UFB) to deploy FTTH to 75% of the country by 2019

2011

- Telecom NZ splits into Chorus (wholesale) and Spark (retail) as a pre-condition for deploying FTTP and accepting government support for FTTP deployment
- Four commercial partners selected with each allocated a specific number of municipalities in which to deploy FTTP: Chorus (69% coverage), Enable Services (15%), WEL Network (13.7%) and Northpower (1.6%)

2012

- Market consolidation as Vodafone (2nd biggest retail provider) acquired TelstraClear (3rd biggest)

2016

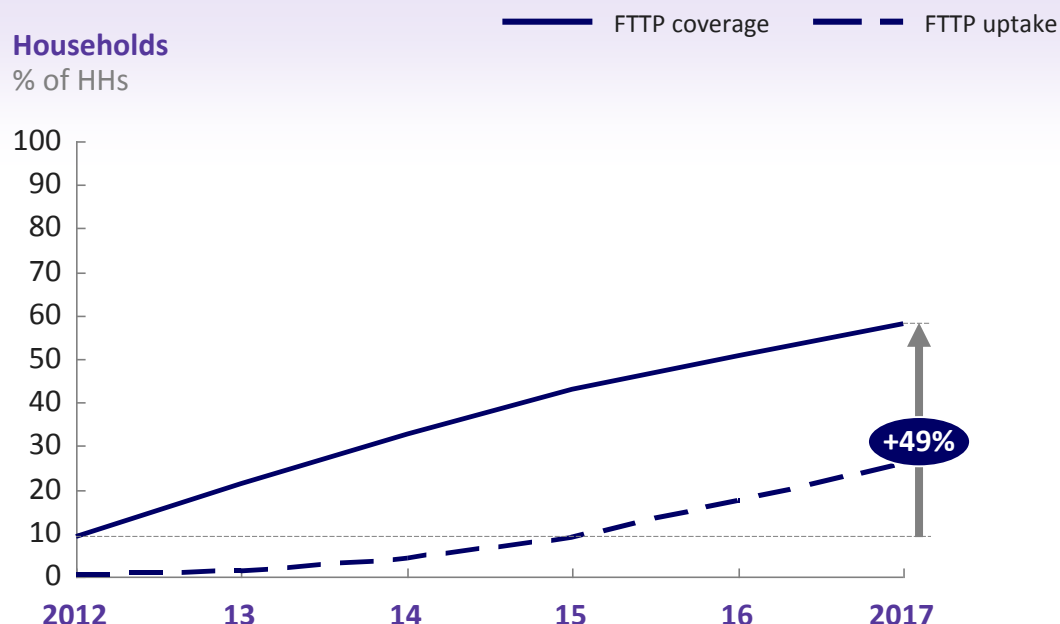
- 97% of businesses and 100% of schools connected to FTTP network
- Entire footprint of Chorus network receiving gigabit services for an introductory price of \$60 per month following successful trial in Dunedin in 2015

2017

- Regulation of fibre network from 2019/20 proposed by New Zealand government as it has replaced copper as the dominant network in most parts of the country
- Proposed deregulation of copper from 2020 except in areas which do not have UFB coverage

Overview of NZ FTTP deployment and uptake

Households % of HHs



Insights for UK

- Even with a **nominated provider model**, large public funding (around £500 per premise passed) has been required to enable the deployment of FTTP across New Zealand. Nationwide deployment has been defined as 87% of all premises and is due for completion at end 2022.
- FTTP programme will have taken **over 10 years** and is being **supplemented by a rural broadband programme** where cost of FTTP makes it impractical and **mix of technologies is being used**.
- RAB based, utility style regulation is to be applied from 2020 on nominated local fibre monopolies; copper switch-off is planned** (by 2017, Chorus had achieved fibre take-up of 39% in deployed areas).



Portugal – Overview of fibre regulation and insights for UK

Timeline

2007

- Portuguese Telecom (PT/MEO) began tests on FTTH but awaited regulation clarification before initiating rollout

2012

- Merger announced between Zon (No 1 cable operator) and Optimus creating NOS. Consolidation happened to improve both of their relative positions against PT/MEO
- Regulatory review which resulted in VULA being selected as regulated solution until a passive fibre product became economically viable

2014

- Altice acquires PT/MEO from Oi allowing it to further expand its FTTH offering
- PT signs 25 year network their fibre networks across Portugal (900,000 households)

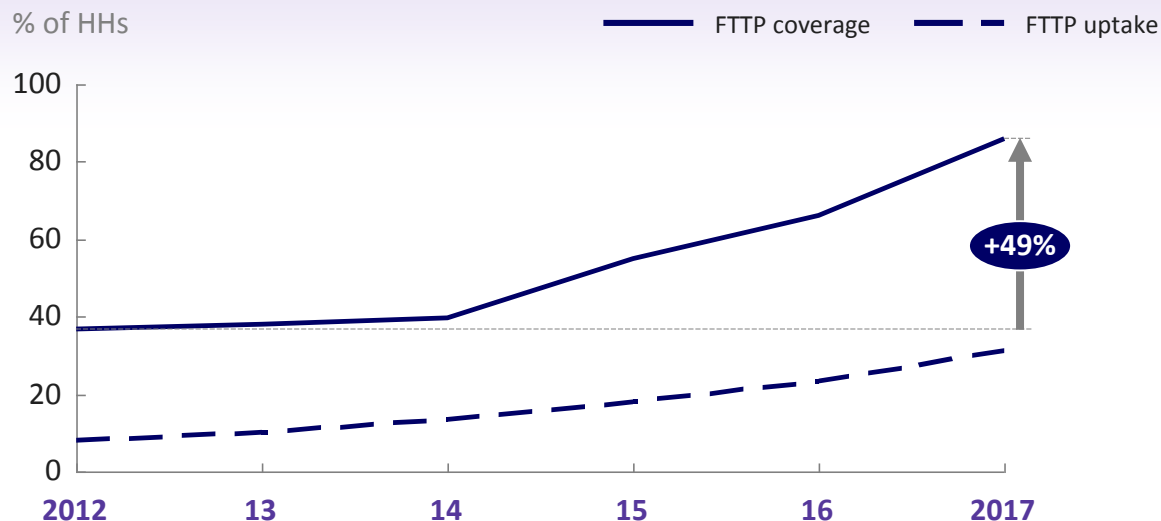
2016

- PT announces plans to replace its legacy copper infrastructure with FTTH technology by 2020
- Vodafone purchases FTTH network from Zon/NOS

Overview of Portuguese FTTP deployment and uptake

Households

% of HHs



Insights for UK

- Fibre rollout in Portugal was aided by **physical structural conditions not present in UK**: high density (45% of population in flats vs 15% in UK), quality duct and pole access (constructed in 1980s), and a lower cost of deployment (due to lower labour and construction costs)
- Light touch regulatory regime (light touch wholesale access remedies applicable in most areas) incentivised investment by incumbent** and did not harm competition as regulatory authority was able to influence the market through directives following consolidation
- Competitive cable market** in Portugal heavily influenced PT/MEO decision to deploy as it had to react to regain market share against cable competitor selling bundled services. PT/MEO used FTTH to future proof its business strategy

SOURCE: Analysys Mason: 'International Case Studies'; Wik Consult: 'Regulatory approaches to risky bottleneck assets'; BEREC: 'Challenges and drivers of NGA rollout'; Analysys Mason, 'FTTx roll-out and capex worldwide: forecasts and analysis 2017–2022'. Please note the disclaimer in the Annex.



Germany – Overview of fibre regulation and insights for UK

Timeline

2006

- Deutsche Telecom (DT) begin to upgrade local loop from ADSL to VDSL. Areas which are upgraded had street cabinet and local exchanges connected via fibre

2009

- Federal government set-up the Broadband programme with the aim to cover 75% of German households with at least 50mb/s by 2014, but this ambitious goals has not been reached

2010

- Incumbent (DT) announced plans to connect up to 10% of households via FTTP. Rollout plan was not completed after lower than expected take-up of FTTP in those households (30,000 households)

2015

- DT announce strategy to upgrade access network to VDSL and implementation of vectoring at street cabinets

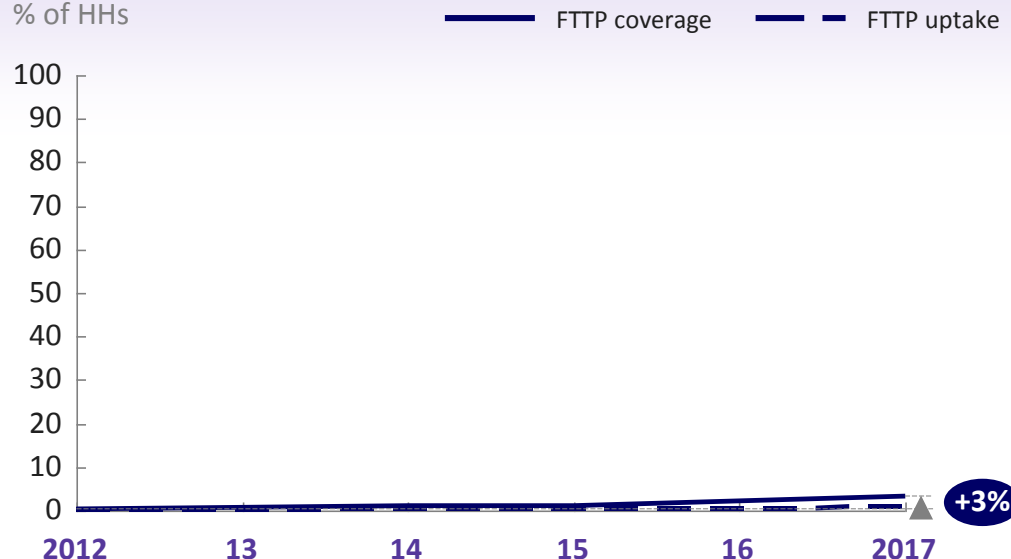
2016

- German regulator permits vectoring on a first come, first serve basis for all operators at street cabinets. Local loop suspended where vectoring is deployed
- Launch of “Digital Strategy 2025” to improve connectivity across Germany. The programme includes deployment of fibre with an investment fund of €10bn for rural areas

Overview of German FTTP deployment and uptake

Households

% of HHs



Insights for UK

- Low fibre take-up** (even in areas with fibre) driven influenced by **high cable speeds** (above 300mb/s in towns and cities) and **lower cable prices** (vs DSL and Fibre) due to wholesale regulatory regime on incumbent
- Large-scale targeted subsidies are required to deploy fibre in rural areas**; empowering local government and municipalities can help deployment, especially in areas where trenches and roads need to be dug up

INDUSTRY AND MARKET DATA

Where the slides above contain statistics, data and other information from Analysis Mason relating to markets, market sizes, market shares, market positions and other industry data pertaining to our business and markets, market data and statistics are inherently predictive and subject to uncertainty and not necessarily reflective of actual market conditions. Such statistics are based on market research, which itself is based on sampling and subjective judgments by both the researchers and the respondents, including judgments about what types of products and transactions should be included in the relevant market.

We have generally obtained the market and competitive position data in this document from industry publications and from surveys or studies conducted by third party sources that we believe to be reliable. While we accept responsibility for the accurate extraction and summarization of such information, we cannot assure you of the accuracy and completeness of such information, and we have not independently verified such market and position data.

In many cases, there is no readily available external information (whether from trade associations, government bodies or other organizations) to validate market-related analyses and estimates, requiring us to rely on our own internally developed estimates regarding our industry, our position in the industry, our market share and the market shares of the various industry participants based on our experience, our own investigation of market conditions and our review of industry publications, including information made available to the public by our competitors. We and the Initial Purchasers cannot assure you of the accuracy and completeness of, and take no responsibility for, such data. Similarly, while we believe our internal estimates to be reasonable, these estimates have not been verified by any independent sources and neither we nor the Initial Purchasers can assure you as to their accuracy or the accuracy of the underlying assumptions used to estimate such data. Our estimates involve risks and uncertainties and are subject to change based on various factors.