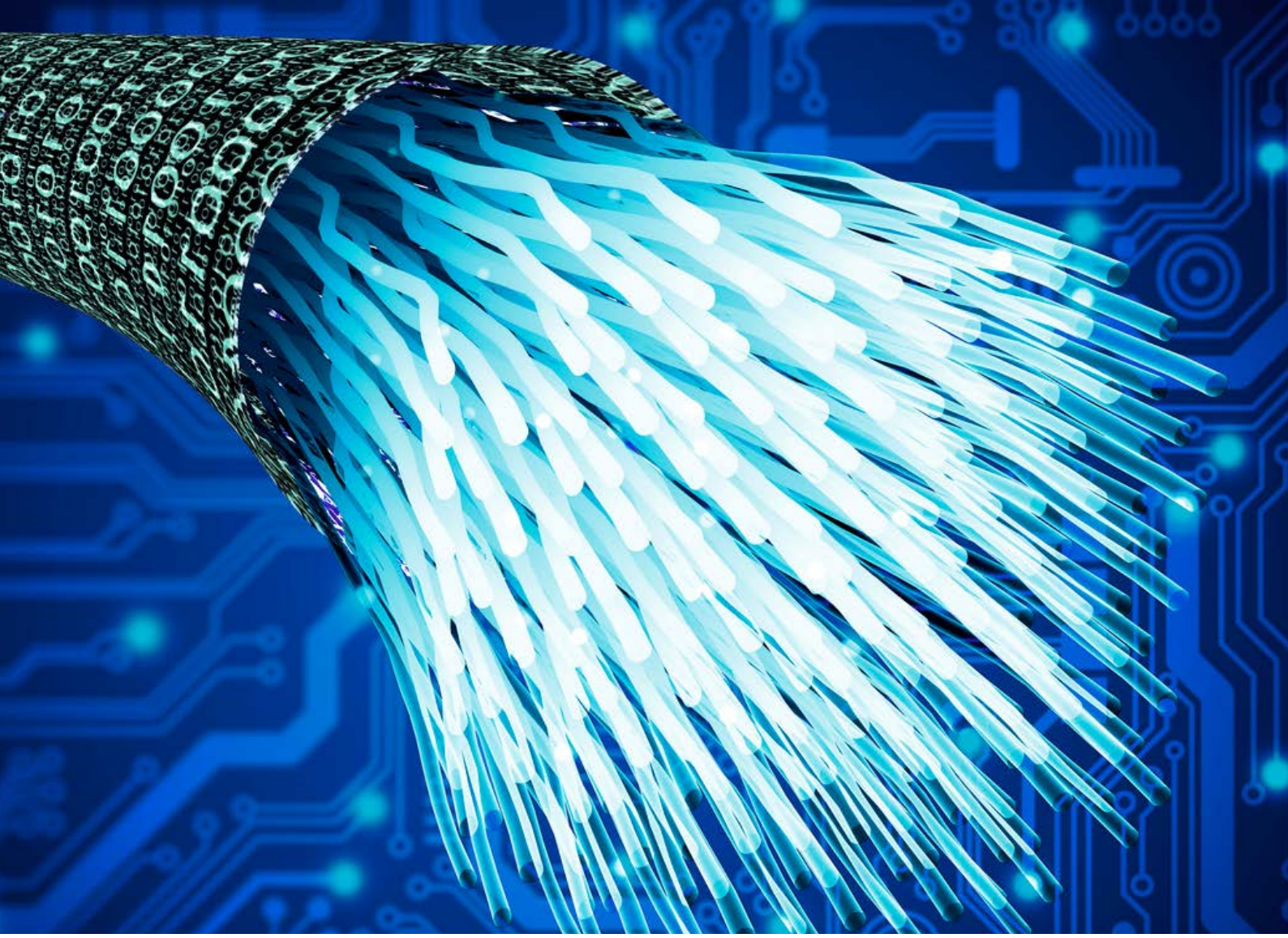

Race to Gigabit Fiber

Telecom incumbents pick up pace

December 2016

Arthur D Little

Content

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1. Fiber (FTTH/B) investments are more common now than ever before

Fiber[1] investments have become more common now than at any point in the past. Since we published the previous version of our Global Fiber Report in 2010 and 2013, the number of countries[2] with more than 95% fiber coverage[3] has increased from just one (in 2012) to seven countries (in 2016) and the number of households passed with fiber has increased by 20% percentage points since 2013 globally.

Successful fiber rollout is independent of the size of the country or its GDP per capita. Fiber rollout has been successful in both in smaller high GDP, countries like Singapore & Qatar, in medium size high GDP countries like Spain, Portugal and New Zealand, as well as a large but lower GDP country like China. In all these countries fiber rollout was primarily driven by the incumbent, with or without government support and in some cases, the challenger TelCo has also actively rolled out fiber. In the first edition of this 'Global FTTH Report – Double squeeze of the incumbent' we highlighted that the incumbent was getting squeezed by CableCos and alternative operators in order to roll out next generation broadband. In this report we observe the comeback of the telecom incumbent – incumbents are taking the lead (in some cases also the challenger TelCos) in countries that are successfully rolling out nationwide fiber.

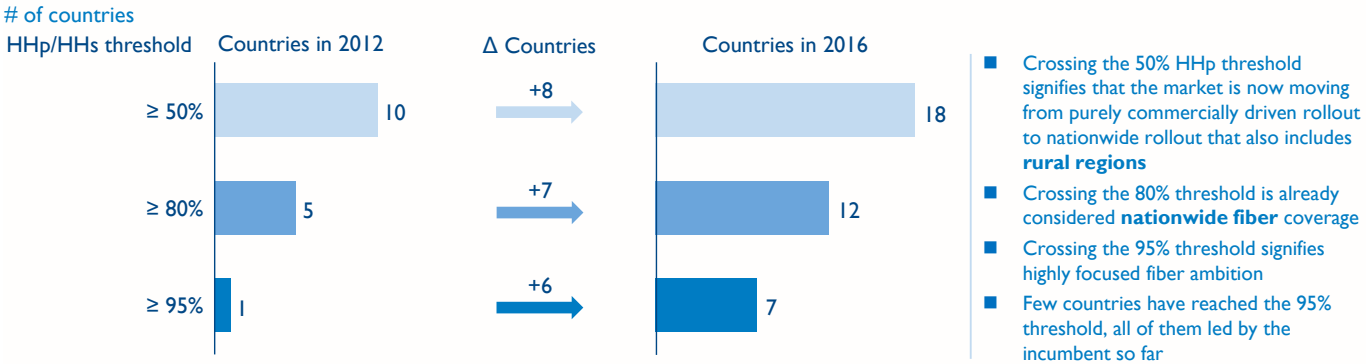
In countries that have seen slow rollout, the incumbent did not, or is still not taking the lead. We have seen fiber rollout programs being paused in countries Australia & USA. Some other countries like Austria, Germany & UK have yet to start nationwide fiber rollout programs. It is interesting to note that irrespective of the size of the country or its GDP per capita, a large developing country such as China is successfully rolling out fiber, while India has not yet started. Similarly a high GDP country like Spain already has more than 80% fiber coverage, while comparable Germany is yet to start nationwide fiber deployment.

The incumbent driven fiber rollout model is becoming the most common rollout model for fiber. In the previous edition of this report, we had introduced five fiber rollout models, and had predicted that the best model is when the incumbent takes the lead with graded government support. We observe that this model is still the most successful and common model used.

Commercial[4] take-up of fiber has followed rollout, albeit sometimes with delays. We have not yet seen an example of low fiber take-up following rollout. Some countries like Singapore has seen successful take-up, but with a gap of 3-4 years after rollout, while other countries like Qatar has seen faster take-up success within a span of 2 years after rollout. In most cases the main driver for success of take-up is migration of customers from legacy technologies to fiber, while competition and launch of innovative products further aids it. In a dozen countries with strong fiber rollout programs in place, innovative products like gigabit broadband and 4k TV have been successfully launched.

Countries with 95% fiber coverage (FTTH/B)

# of countries by penetration rate (HHp/HHs) – 2012 & 2016e



Deployment has been accelerated by multiple factors – IPTV, 4k TV, Gigabit BB and expected to further accelerate with 5G

Source: Arthur D. Little Analysis, Euromonitor, IDATE World FTTx market June 2016
HHs – Households in the country, HHp – Households passed by FTTH/B HHc – Households connected by FTTH/B

1 Fiber refers to FTTH/B in this report
2 In this report we assessed fiber (FTTH/B) rollout in more than 80 countries globally covering Europe/ Americas/ Asia-Pacific/ Middle East
3 Coverage is defined as the ratio of Households passed (HHp) with fiber (FTTH/B) to the total Households (HHs) in the country
4 Commercial fiber take-up is the ratio of households connected to house passed. A take-up of above 30% is usually considered successful

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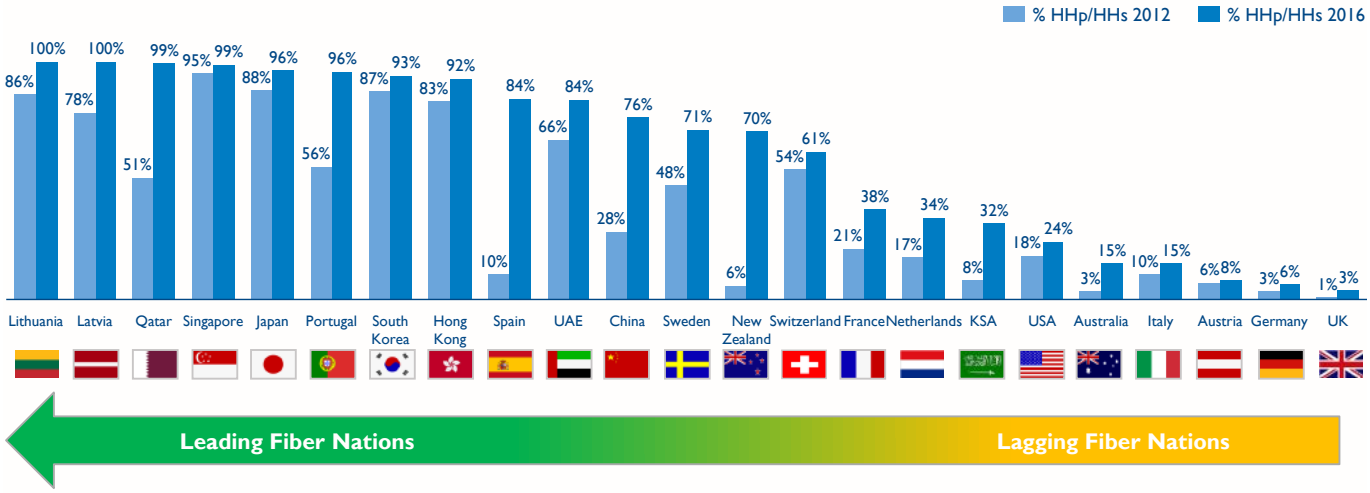
2. Telecom incumbents are driving most nationwide fiber rollout programs

Benchmarks of fiber (FTTH/B) coverage

HHp/HHs in country ratio – 2012 & 2016e



Global fiber HH passed increased by 20% points from 2012 to 2016

Source: Arthur D. Little Analysis, Euromonitor, IDATE World FTTx market June 2016
HHs – Households in the country, HHp – Households passed by FTTH/B HHc – Households connected by FTTH/B

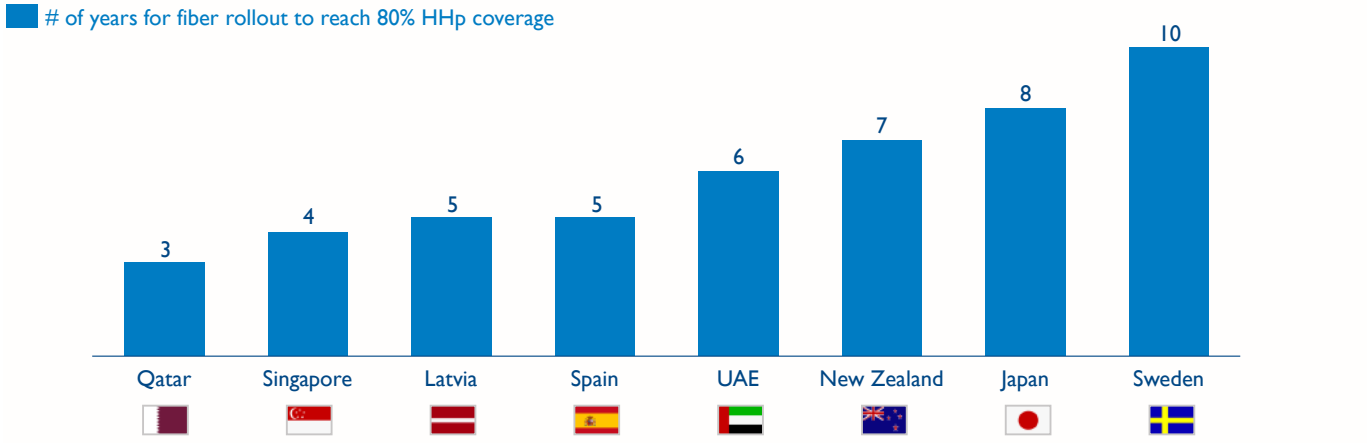
The incumbent has played a leading role in most countries that have seen successful fiber rollout. Qatar, Portugal, Spain, China and New Zealand have seen the biggest delta growth in fiber homes passed. There is no one recipe for success - each of these countries scripted their own path for fiber rollout.

However they all had one common theme – the incumbent TelCo took a leading role in the last four years.

We observe four hot spots for fiber rollout – South East Asia, Middle East, Baltics and Iberia. In Qatar, the incumbent Ooredoo

Time taken to deploy nationwide (FTTH/B) fiber

Duration of fiber rollout in years

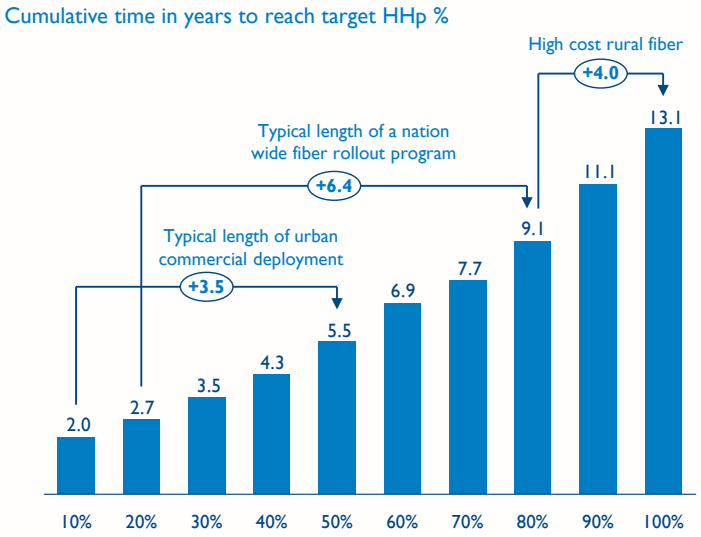


Qatar, Singapore, Latvia, Spain have proven effectiveness of focused fiber programs

Source: Arthur D. Little Analysis, Euromonitor, IDATE World FTTx market June 2016
HHs – Households in the country, HHp – Households passed by FTTH/B HHc – Households connected by FTTH/B
Note: Nationwide refers to achieving at least 80% coverage of HHs. Duration calculated as the time taken to rollout fiber from the 20% percentile to 80% of HHs
Note: New Zealand expected rollout from 2013 to 2019, Sweden started in 2006, and expected to reach 80% coverage by 2017

Time taken to deploy (FTTH/B) fiber by percentile

Years needed to rollout out fiber broken down by percentile of HHp/HHs %



- On the left hand side we plot the cumulative time taken in years to roll out fiber to the given HHp coverage of HHs in the country
- The typical length **urban commercial deployment** is **3.5** years (from 10% to 50%)
- The typical length of full **nationwide fiber deployment** is **6.4** years (from 20% to 80%)
- The typical length of covering the last 20% percentile **rural fiber** is **4.0** years – as this is the most difficult high capex rollout

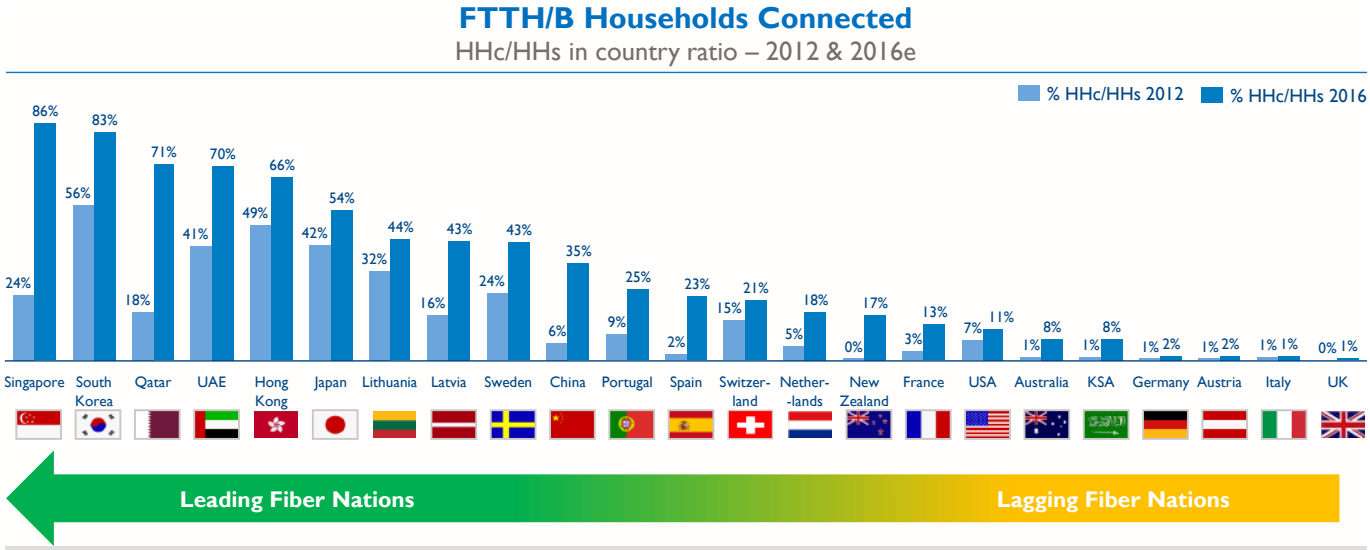
When supported by a government program, achieving nationwide fiber coverage (reaching the 80% threshold) usually takes around 6.4 years

Source: Arthur D. Little Analysis, Euromonitor, IDATE World FTTx market June 2016
HHs – Households in the country, HHp – Households passed by FTTH/B HHc – Households connected by FTTH/B

rolled out nationwide fiber without government subsidy. In Portugal and Spain, the incumbent TelCo – Portugal Telecom and Telefonica respectively, began nationwide fiber rollout programs. The government also contributed with rural subsidies for commercially unattractive areas. Meanwhile the other challenger TelCos, Vodafone & NOS in Portugal and Vodafone & Orange in Spain also began fiber rollout or large scale cable upgrade programs, also competing for rural fiber subsidies. This in turn led to faster fiber deployment as well as healthy competition for fiber rollout. It is estimated that more than one third of the areas in these two countries have access to fiber from at least two providers. In New Zealand, the incumbent spun-off its infrastructure into a separate entity called Chorus. Chorus (with two other regional TelCos) partnered with the government to roll out nationwide fiber with the government contributing an estimated 30% of the total funding. This has resulted in rapid rollout of fiber in New Zealand, reaching 70% of the households by 2016 and estimated to reach 95% of the households by 2019. This is one of the most successful case studies worldwide of an incumbent successfully partnering with the government to roll out nationwide fiber in a country with a difficult terrain.

Fiber rollout is a multi-year, long term investment. But we also see successful and quick fiber rollout programs in small countries like Qatar, Singapore and Latvia, as well as in larger countries like Spain and the UAE. In all these countries, the incumbents took the lead to deploy fiber. We analyzed fiber rollout speeds in more than 50 countries and observed that the average time for a nationwide fiber rollout program – time taken to roll out fiber from 20% of the HHs to 80% of the HHs - is 6.4 years. But from 80% to reach 95% rollout, it takes a further 4.0 years, as the incremental effort is higher to reach the last decile of households.

3. Commercial take-up of fiber mostly follows, even if it is sometimes delayed



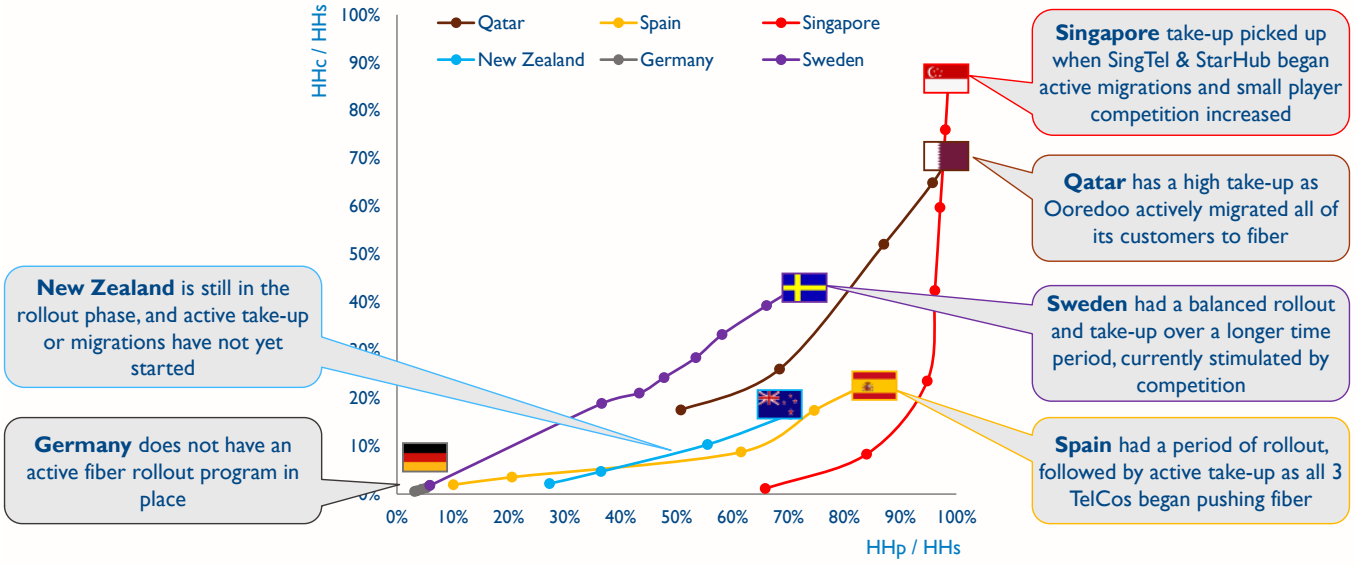
Source: Arthur D. Little Analysis, Euromonitor, IDATE World FTTx market June 2016
HHs – Households in the country, HHp – Households passed by FTTH/B HHc – Households connected by FTTH/B

Commercial success of fiber – measured by speed and extent of take-up has always followed fiber rollout, sometimes within a couple of years as in Qatar, and sometimes longer, as in Singapore. Some countries like Singapore, Qatar and UAE have seen high take-up rates, primarily driven by migration of legacy customers to fiber. SingTel (Singapore) and Ooredoo (Qatar) have both announced that they plan to move their entire legacy base of customers to fiber. In Singapore, given that there is open access, competition between the smaller players and the incumbent, has also played an important role in pushing innovative fiber based products to the market. Other countries like Switzerland and Sweden, which have open access, but where fiber was already rolled out a few years ago, competition between players is now driving fiber take-up.

4. Success is measured by achieving the right balance between rollout & take-up

Achieving the right balance between rollout and take-up

HHp/HHs vs. HHc/HHs from 2010-2016



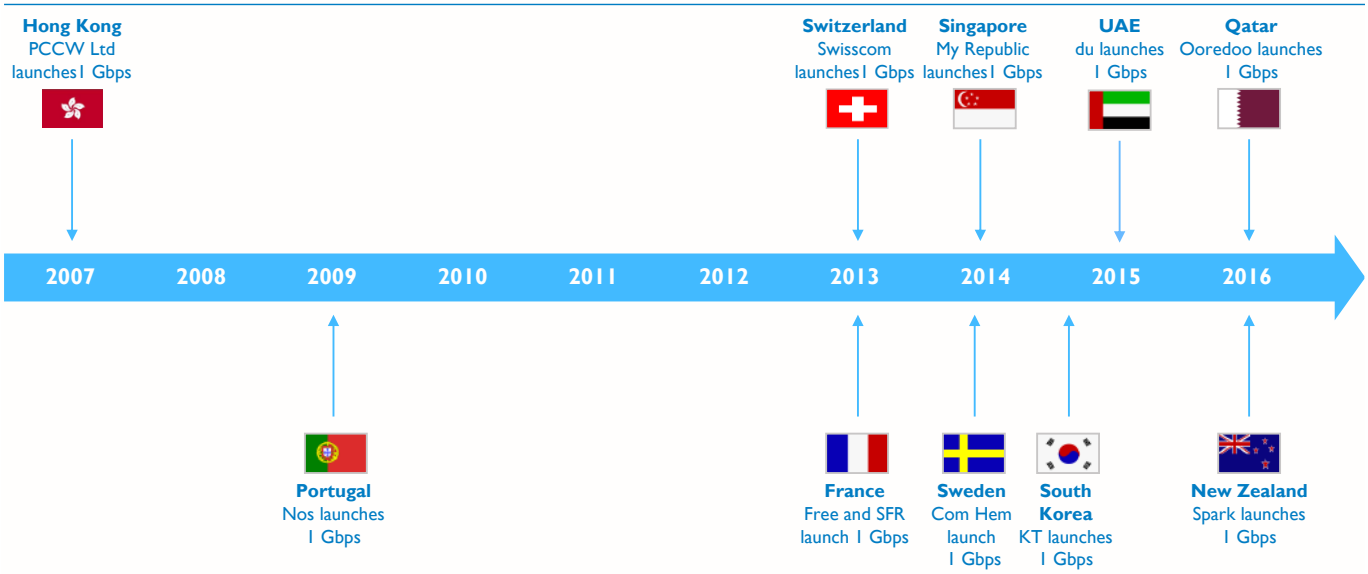
Source: Arthur D. Little Analysis, Euromonitor, IDATE World FTTx market June 2016
HHs – Households in the country, HHp – Households passed by FTTH/B HHc – Households connected by FTTH/B
Note: Data points for Qatar and New Zealand cover only 2012-2016

A successful fiber rollout program is measured not just by rollout success but also by take-up success. In the chart below we plot the ratio of household passed vs. household connected to the total households in the country during the period 2012-2016.

Two big movers appear with this analysis – Singapore and Qatar. Singapore rolled out fiber fairly quickly, but there was a gap of a few years before take-up started to pick up. Since then, take-up has been very rapid as seen in the chart. This was due to two reasons - migration of customers to fiber as well as competition between the players - SingTel, StarHub, and smaller operators - M1, MyRepublic, ViewQuest, etc. Qatar has also seen a fairly fast rate – both of rollout as well as take-up - driven by a nationwide fiber program by Ooredoo. Countries like Spain and New Zealand, have effective rollout programs in place as seen in the quick rate of increase in households passed, but strong take-up is yet to start. Sweden has had a balanced rate of rollout and take-up - as competition between operators Telia, Telenor, local players such as Stockab and even the CableCo (ComHem) – is driving both rollout as well as take-up. In contrast, a large country, like Germany, that does not, as yet, have a nationwide fiber program in place, has a low rate of both fiber rollout as well as fiber take-up.

5. Gigabit products and 4k TV further strengthens the case for fiber

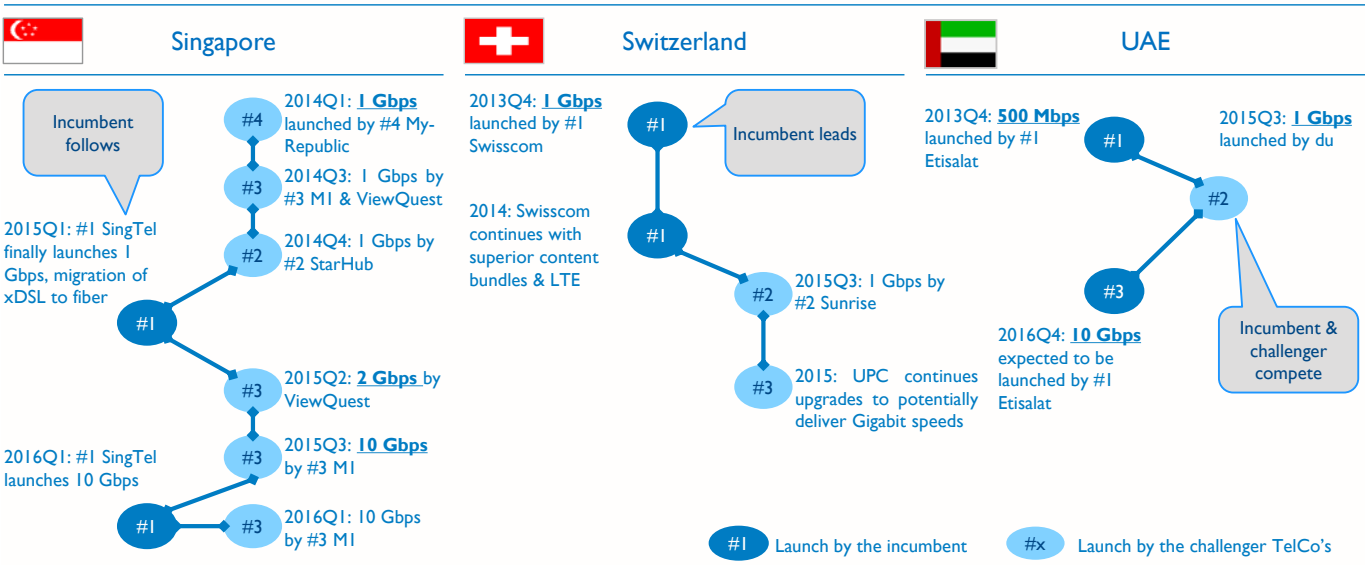
Launch of Gigabit offers



Source: Arthur D. Little Analysis, Euromonitor, IDATE World FTTx market June 2016, Publicly available information on respective countries
HHs – Households in the country, HHp – Households passed by FTTH/B HHc – Households connected by FTTH/B
Note: Zon (now called Nos) in Portugal and Com Hem offers 1 Gbps based on FTTH in Portugal, Both these operators own both FTTH and Cable D3.0/1 networks

Gigabit products and 4k TV further strengthens the case for fiber. We observe that fiber is still a supplier driven market. Suppliers launch an innovative product, which in turn creates demand for the new product. When there is fiber, there is demand for fiber. If there is no fiber, there seems to not yet be a strong demand from consumers for high speed fiber.

Launch of Gigabit offers driving competition



Source: Arthur D. Little Analysis, Euromonitor, IDATE World FTTx market June 2016, Publicly available information
HHs – Households in the country, HHp – Households passed by FTTH/B HHc – Households connected by FTTH/B
Note: 1) No reference was made by Etisalat on when the new faster broadband speeds will become available for UAE consumers
2) #1, #2, #3, #4 denotes the market position of that particular operator in terms of market share in the FBB market in that country 3) D3.1 = Docsis 3.1

4K availability

Devices

- Multiple 4k devices available today at a reasonable price
- 4k device is no longer a constraint
- 2015 saw the launch of 20+ 4k devices
- In MENA – 4k TV sales from 0.2m (2014) to 1m (2015) to 3.2m (2017e)
- Examples:
  - Samsung, Panasonic, Phillips 4k TVs
  - Chromecast, Roku, Xbox, PS4, DirecTV

Connectivity

- 4k broadcast is still in launch phase with only a few IPTV/ DTH broadcasters
- In 2014, DirecTV launched 4k DTH
- In 2014, China Telecom (Sichuan) also launched 4k IPTV
- In 2016, Ooredoo launched 4k TV in Qatar, followed by Etisalat in UAE
- Ooredoo is the fastest in the world to achieve 60% 4k penetration in its existing IPTV customer base

Content

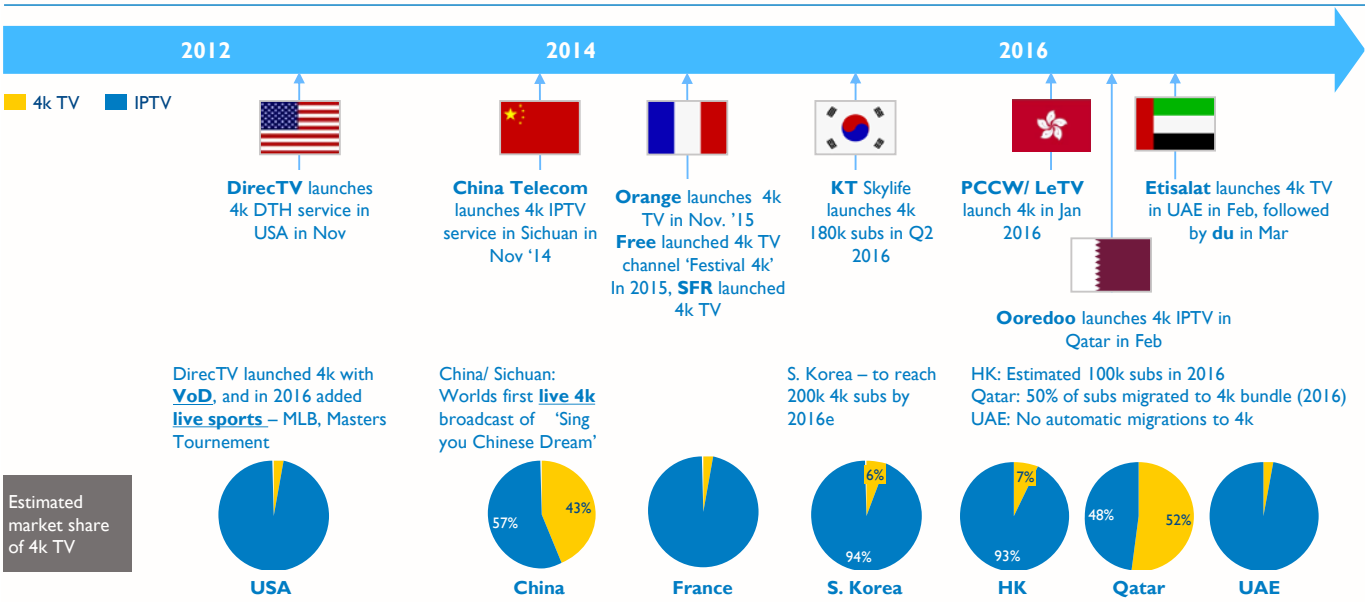
- 4k content is becoming common with selected live sports & series
- Live sports is most valuable 4k content
  - BeIN Sports - Euro 2016
  - BT Sports – Champions League, EPL
- Netflix, Amazon, Hulu, YouTube already have 4k content libraries
  - Netflix – House of Cards, Breaking Bad
- Most video games are in 4K
  - Tomb Raider, Call of Duty, Metal Gear

Source: techradar.com; cleeng.com, sportsvideo.org, http://4k.com/news/according-to-the-latest-findings-from-ihs-4k-tv-penetration-will-hit-35-as-of-2019-11434/
Note: 1) Google's Chromecast Ultra streaming device, launched in October 2016, enables 4K quality on any TV; 2) Netflix requires new subscribers to be on the highest tier four-stream Family Plan in order to access 4K content. Existing subscribers will be grandfathered into 4K for two years on their existing lower-tier plans;

As seen in the chart on page 8, there has been a dozen gigabit product launches in the past few years – all of them facilitated by fiber.

It is interesting to see how the launch of gigabit speeds triggers fiber competition. In Singapore, even though fiber was available from 2012, for a period of time there was not much commercial push nor demand from customers for fiber. In 2014, one of the smaller operators, MyRepublic, followed by another smaller player, M1, launched Gigabit broadband. This in turn caused the two bigger operators StarHub and SinTel to respond with equivalent Gigabit products. Now competition in Singapore is moving to multi-gigabit products creating a new market for Gigabit broadband. While in countries like Switzerland and UAE, the incumbent took the lead to launch gigabit products which was soon followed by the challenger TelCos also launching Gigabit products.

Success of 4k launches



Source: Arthur D. Little Analysis, Euromonitor, IDATE World FTTx market June 2016
HHs – Households in the country, HHp – Households passed by FTTH/B HHc – Households connected by FTTH/B
Note: Data from China Telecom, KT Skylife, PCCW, and Ooredoo are publishes sources, 4k market share for the rest are estimated

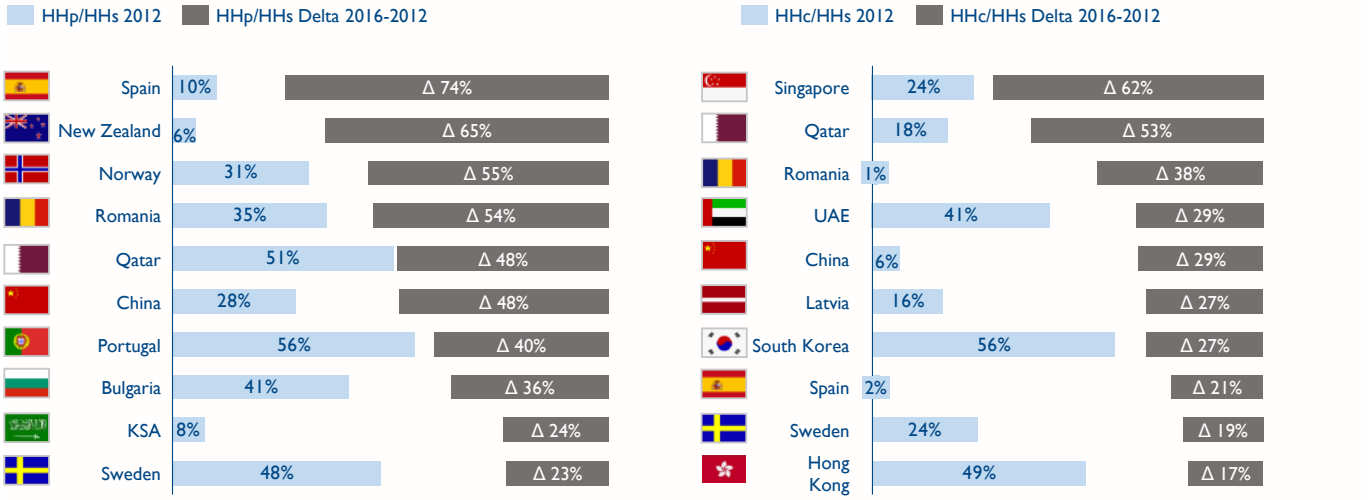
4k TV is another product making the case for fiber. Technically, 4k TV can also be delivered over legacy technologies, but for the best customer experience, low latency, and multiple simultaneous viewing, 4k TV is best delivered over fiber. As of 2016, there are more than a dozen easily available devices supporting 4k TV and a small but growing library of 4k content such as that offered by Netflix and some live premium sports broadcasters. But 4k TV connectivity offered by TelCos is still in launch phase.

China Telecom (in Sichuan province) was the first in the world to launch a large scale 4k TV proposition also with relevant 4k content. Since then, there were many more 4k TV launches in most of the leading fiber countries. Ooredoo Qatar is another example of a successful 4k TV proposition – they have migrated more than half their customers to 4k TV through an active on-the-ground marketing campaign and attractive bundling of 4k TV with their existing triple play bundles.

6. Lessons learnt from the leaders and the laggards

Benchmarks of fiber coverage: Top 10 in terms of fiber (FTTH/B) growth

HHp/HHs in country ratio – 2016 vs. 2012



Government incentives, ambitious incumbents, mobile competition moving into fixed, cable competition, high quality content – multiple drivers have resulted in successful fiber rollout and take-up

Source: Arthur D. Little Analysis, Euromonitor, IDATE World FTTx market June 2016
HHs – Households in the country, HHp – Households passed by FTTH/B HHc – Households connected by FTTH/B

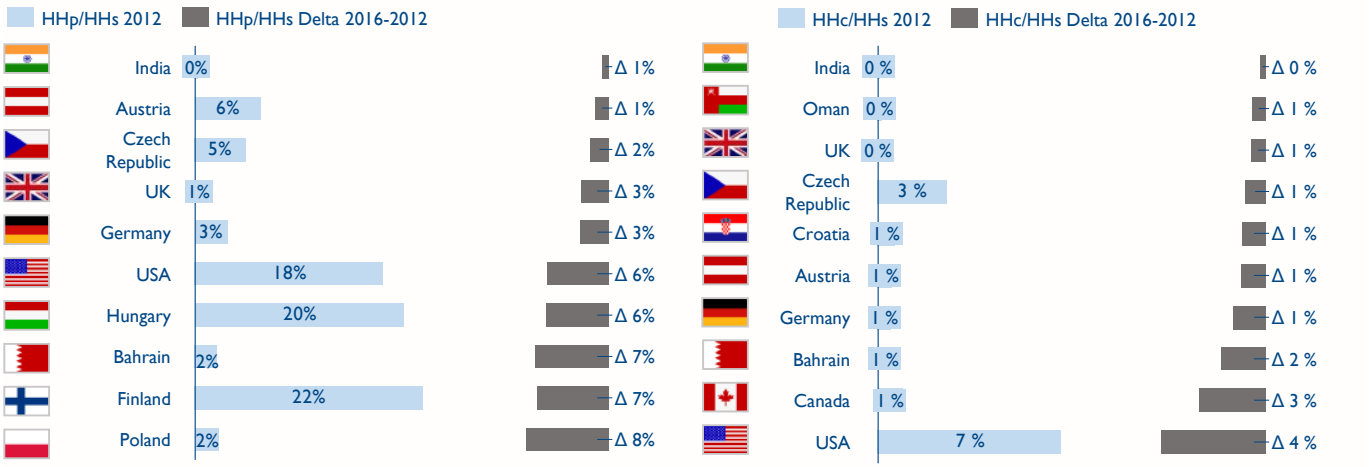
Incumbents played a major role in all countries that have seen successful fiber roll out and take-up. In most countries, the government was also involved, by incentivizing rural fiber rollout with subsidies. In some countries like Switzerland and Sweden, local utilities also co-financed and jointly rolled out parts of the fiber network. In countries like Spain, Portugal the challenger TelCos (and even the CableCos) also rolled out fiber[5], resulting in overall quicker and more competitive rollout for the whole country.

In all countries that are lagging in fiber rollout – the incumbent has not taken the lead or not played an active role. Relatively prosperous countries like Austria , Germany, UK and many others, do not yet have a nationwide fiber program in place, and the incumbents rely on upgrades to their existing legacy network. In countries like USA, Verizon, AT&T and now Google Fiber have tried to roll out fiber in parts of the country; however this is an expensive proposition for such a large country without direct government support. Countries like Hungary and Finland already have active nationwide fiber rollout programs in place and are expected to have high fiber coverage by 2020. In many of these countries, lack of regulatory clarity on open access, rural funding, subsidies, etc is discouraging bold fiber investment moves by the TelCos.

5 In case of CableCos, fiber rollout is mostly using FTTP/C/N instead of FTTH/B

Benchmarks of fiber coverage: 10 examples of low fiber (FTTH/B) growth

HHp/HHs in country ratio – 2016 vs. 2012



Lack of government support, lack of fixed competition, unclear regulation are reasons for low or no fiber (FTTH/B) rollout in these countries

Source: Arthur D. Little Analysis, Euromonitor, IDATE World FTTx market June 2016, HHs – Households in the country, HHp – Households passed by FTTH/B HHc – Households connected by FTTH/B

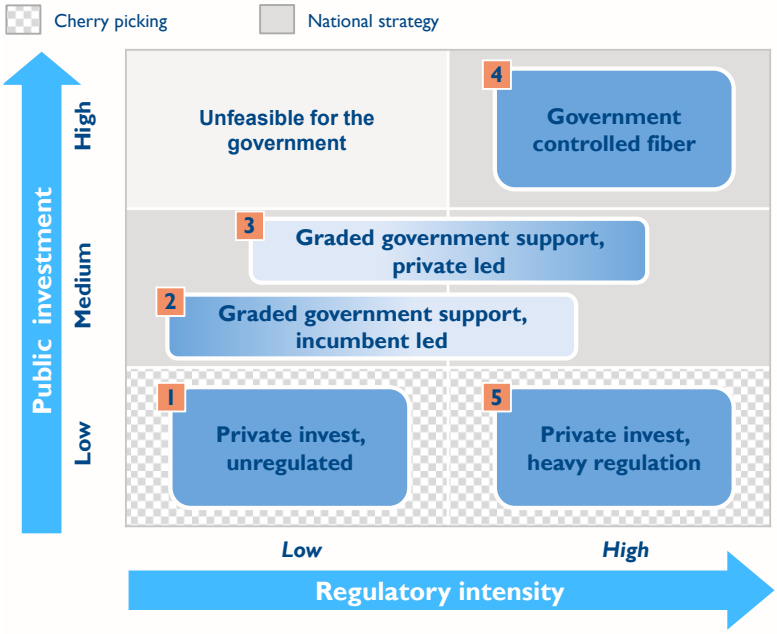
Note: Hungary and Finland are currently rolling out fiber, USA started and stopped rolling out fiber, We look at countries in Europe, N. America, Middle East and Asia-Pacific for this analysis. In some markets like Belgium, high cable competition caused the incumbent Proximus to rollout of FTTC with VDSL which is faster and cheaper than full fledged FTTH/B

In Australia, mis-alignment between the government and the incumbent, and in some cases direct competition between the govertment sponsored fiber and the incumbents copper network, resulted in a slow down, and eventually a pause in fiber rollout. As of 2016, the government is planning to restart the fiber program, this time with greater cooperation with the incumbent, using FTTC solutions instead of FTTH/B.

7. Successful fiber rollout models have been driven by incumbents

In the 2013 edition of this report 'National fiber strategies' we had proposed 5 models for nationwide fiber investment. In that report we also recommended that 'Model #2: Graded government support incumbent led' and 'Model #3: Graded government support private led' would be the most successful. We observe that the recommendation is still valid and most successful nationwide fiber rollout programs – Switzerland, New Zealand, Singapore, and many more - have followed model #2 or #3. Model #4 – Government driven fiber rollout should also be watched – countries like Oman, Kuwait and Ireland currently have government driven fiber rollout programs in place.

Partnership models for fiber investment



Comments

- Model 1: Netherlands, Qatar – KPN and Ooredoo rollout out nationwide fiber without co-investment by the government
- Model 2: Multiple countries – Switzerland, New Zealand – Swisscom and Chorus respectively rolled out nationwide fiber with government co-investment in non-economic areas
- Model 3: Singapore – SingTel, StarHub and the government rolled out nationwide fiber splitting the rollout into passive and active parts between the two TelCos
- Model 4: Australia – Government created a new entity to rollout fiber, without direct incumbent involvement
- Model 5: Not yet a clear example

Source: Arthur D. Little Analysis, Euromonitor, IDATE World FTTx market June 2016
HHs – Households in the country, HHp – Households passed by FTTH/B HHc – Households connected by FTTH/B

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Conclusion

Multiple entities play a role in successful nationwide fiber rollout – most importantly the incumbent TelCo and the government. The most successful fiber rollout models were based on a collaborative approach.

The **incumbent** usually is the entity that leads fiber deployment and proactively engages with the government and other investors. The incumbent is best placed to kick-start fiber roll out in economic areas, and encourage the government to identify and fund non-economic areas

The **government** should develop a long term broadband vision for the country to encourage investments from TelCos and investors. It also plays the role of a co-investor by subsidizing and facilitating fiber investment in rural and non-economic areas.

Stability of **regulation** is the most important factor for long term investment. Governments should be clear about the criteria for co-funded rollout and the selection criteria for co-funded areas. This in turn can stimulate the incumbent to roll out fiber in as many areas as possible, pre-empting the government from declaring a certain area as a co-funded region, thus opening it to competition. Regulators should be clear about open access obligations. There has been successful fiber rollout - both in countries without open access such as Qatar and Spain, as well as in countries with open access regulation such as Singapore and Switzerland.

Challenger Telcos also play an important role – stimulating competition both for rollout as in France, Spain as well as in facilitating take-up as in Singapore, Sweden.

Local governments, utilities, private investors and even **construction companies,** can play their part – such as in Switzerland and Sweden where they were partners both for funding as well as to rollout. Attractive joint venture and off-balance sheet models have been used to manage capex contribution, equity ownership and risk sharing. For example in Switzerland, Swisscom and its local partners have a pre-determined capex funding mechanism, even though both entities can have access to the entire fiber of its partner. In the Netherlands, KPN and its partner ReggeBorough had multiple call options built in to manage risk and transfer ownership back to the TelCo on achieving pre-determined targets.

Fiber is a long term investment that will last for the next two decades - hence Telcos, the government and other financial/ utility partners should think, plan and execute sufficiently long term programs to ensure successful fiber investment for their respective countries.

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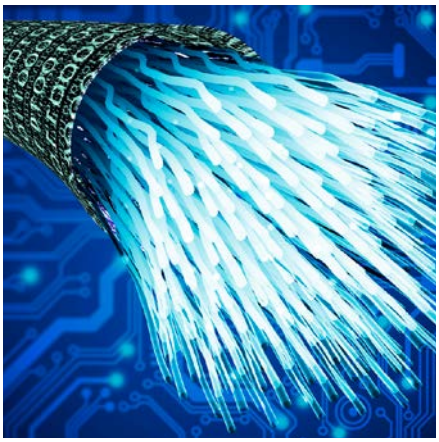

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Our consultants have strong practical industry experience combined with excellent knowledge of key trends and dynamics. Arthur D. Little is present in the most important business centers around the world. We are proud to serve most of the Fortune 1000 companies, in addition to other leading firms and public sector organizations.

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