

## Capacity utilization and fixed-to-mobile broadband substitution potential with existing macro site grids – 2017

A study of 80 European, US, Japanese, Korean, Australian and New Zealand mobile operators  
 Topical for operators contemplating fixed-to-mobile broadband substitution ahead of upcoming 700, 1400 (SDL), 2300, 3400-3800 MHz spectrum auctions

Rewheel research PRO-study, 10<sup>th</sup> September 2018

### Capacity utilization in 2017 and capacity potential of existing macro cell site grids

$$\text{Capacity} \approx \text{Macro sites} \times \text{Spectrum}$$

- Elisa in Finland is the operator (and Finland is the country) with the highest mobile data capacity potential in the world
- Verizon was the operator with the highest yearly average capacity utilization of 57% in 2017. Most mobile operators utilized in 2017, similarly to 2016, a fraction (below 20%) of their readily available network capacity
- The United States was the country with the highest capacity utilization of 33% in 2017 even though the US mobile networks carried in average only 4 GB per person per month (US ranked fourteenth in mobile data usage per capita).
- In Europe Play Poland was the operator with the highest mobile data capacity utilization of 55% in 2017 (48% in 2016)
- Operators in the Nordics, Austria and Korea have 5 to 10 times denser macro site grids than operators in the United States or Canada and hence much higher capacity potential (i.e. 3.6 GHz massive MIMO deployed on macro sites)

Mobile network operator name - country code	Country population 2017	Annual data volume Terabytes 2017	Monthly mobile data usage per capita Gigabytes 2017	Aggregate Downlink Busy Hour throughput Gbit/s 2017 year average	Radio network capacity utilization		Fixed-to-mobile broadband substitution potential					
					5% most loaded sectors	50% least loaded sectors	Incremental 200 GB/month MBB connections expressed as a % of country population that can be carried by operator existing macro site grid capacity (up to 80% utilisation in 5% most loaded macro site sectors)					
					2017 year average, existing FDD & SDL & 2.5/2.6 GHz TDD spectrum holdings, existing macro site grid, 4x4 MIMO, 256 QAM, downlink		with existing FDD & SDL & 2.5/2.6 GHz TDD spectrum holdings	AND add existing 2.3 GHz TDD spectrum holdings	AND add massive MIMO on existing 2.3/2.5/2.6 GHz TDD	AND add massive MIMO on existing 2.3/2.5/2.6 GHz TDD	OR add massive MIMO on existing 2.3/2.5/2.6 and on 40 MHz of 3.4-3.8 GHz TDD	OR add massive MIMO on existing 2.3/2.5/2.6 and on 100 MHz of 3.4-3.8 GHz TDD
Verizon-US	325,719,200	5,562,215	1.4		57%	4%						
Play-PL	37,972,964	612,758	1.3		55%	4%						
FreeMobile-FR	66,989,083	570,570	0.7		39%	3%						
Vodafone-IE	4,784,383	105,297	1.8		35%	3%						
ATT-US	325,719,200	5,143,349	1.3		32%	2%						
Vodafone-AU	24,450,561	258,000	0.9		31%	2%						
3-UK	65,808,573	785,359	1.0		30%	2%						
DNA-FI	5,503,297	529,441	8.0		29%	2%						
T-Mobile-AT	8,772,865	313,503	3.0		29%	2%						
3-AT	8,772,865	500,000	4.7		28%	2%						
T-Mobile-US	325,719,200	2,724,879	0.7		28%	2%						
Meteor-IE	4,784,383	56,386	1.0		26%	2%						
Orange-PL	37,972,964	438,000	1.0		25%	2%						
KDDI-JP	127,484,450	2,251,467	1.5		25%	2%						
Optus-AU	24,450,561	279,199	1.0		22%	2%						
NTTdocomo-JP	127,484,450	3,395,550	2.2		22%	2%						
Elisa-FI	5,503,297	637,200	9.6		22%	2%						
TDC-DK	5,748,769	178,573	2.6		22%	2%						
O2-UK	65,808,573	401,489	0.5		21%	2%						
KT-KR	50,982,212	1,260,352	2.1		21%	2%						
Telia-FI	5,503,297	407,746	6.2		20%	2%						
Poikomtel-PL	37,972,964	700,000	1.5		20%	2%						
Telstra-AU	24,450,561	494,013	1.7		19%	1%						
3-DK	5,748,769	123,089	1.8		19%	1%						
T-Mobile-PL	37,972,964	359,242	0.8		17%	1%						
BouyguesTelecom-FR	66,989,083	598,794	0.7		16%	1%						
Tele2-SE	9,995,153	233,067	1.9		16%	1%						
Sprint-US	325,719,200	2,289,557	0.6		15%	1%						
SKTelecom-KR	50,982,212	1,611,711	2.6		15%	1%						
A1-AT	8,772,865	229,577	2.2		15%	1%						
LGUplus-KR	50,982,212	830,139	1.4		14%	1%						
Telenor-SE	9,995,153	221,073	1.8		13%	1%						
Windtre-IT	60,589,445	810,600	1.1		13%	1%						
Tele2-NL	17,081,507	39,194	0.2		13%	1%						
Sunrise-CH	8,419,550	105,662	1.0		13%	1%						
Softbank-JP	127,484,450	1,467,062	1.0		12%	1%						
Swisscom-CH	8,419,550	269,916	2.7		12%	1%						
3-SE	9,995,153	149,978	1.3		12%	1%						
Orange-FR	66,989,083	603,338	0.8		11%	1%						
SFR-FR	66,989,083	534,718	0.7		11%	1%						
Telia-DK	5,748,769	102,673	1.5		11%	1%						
Salt-CH	8,419,550	85,713	0.8		11%	1%						
Telenor-DK	5,748,769	93,919	1.4		11%	1%						
Yoigo-ES	46,528,024	72,569	0.1		11%	1%						
KPN-NL	17,081,507	107,783	0.5		10%	1%						
3-IE	4,784,383	109,729	1.9		10%	1%						
Telia-SE	9,995,153	202,125	1.7		10%	1%						
Vodafone-TR	79,814,871	630,388	0.7		10%	1%						
TIM-IT	60,589,445	459,360	0.6		9%	1%						
Telia-NO	5,258,317	94,877	1.5		9%	1%						
Vodafone-IT	60,589,445	452,430	0.6		9%	1%						
Movistar-ES	46,528,024	397,882	0.7		8%	1%						
2degrees-NZ	4,705,818	18,545	0.3		8%	1%						
T-Mobile-NL	17,081,507	91,452	0.4		8%	1%						
Vodafone-ES	46,528,024	352,887	0.6		8%	1%						
Vodafone-NL	17,081,507	87,269	0.4		7%	1%						
Spark-NZ	4,705,818	31,868	0.6		7%	1%						
T-Mobile-HU	9,797,561	65,568	0.6		6%	0%						
Vodafone-UK	65,808,573	295,428	0.4		6%	0%						
T-Mobile-DE	82,521,653	555,740	0.6		6%	0%						
ice-NO	5,258,317	20,230	0.3		6%	0%						
Turkcell-TR	79,814,871	890,955	0.9		6%	0%						
TurkTelekom-TR	79,814,871	475,824	0.5		5%	0%						
Vodafone-DE	82,521,653	414,174	0.4		5%	0%						
Vodafone-NZ	4,705,818	33,107	0.6		5%	0%						
Vodafone-CZ	10,578,820	46,350	0.4		5%	0%						
Orange-ES	46,528,024	230,668	0.4		5%	0%						
Orange-BE	11,351,727	37,461	0.3		5%	0%						
Proximus-BE	11,351,727	55,871	0.4		5%	0%						
EE-UK	65,808,573	388,524	0.5		5%	0%						

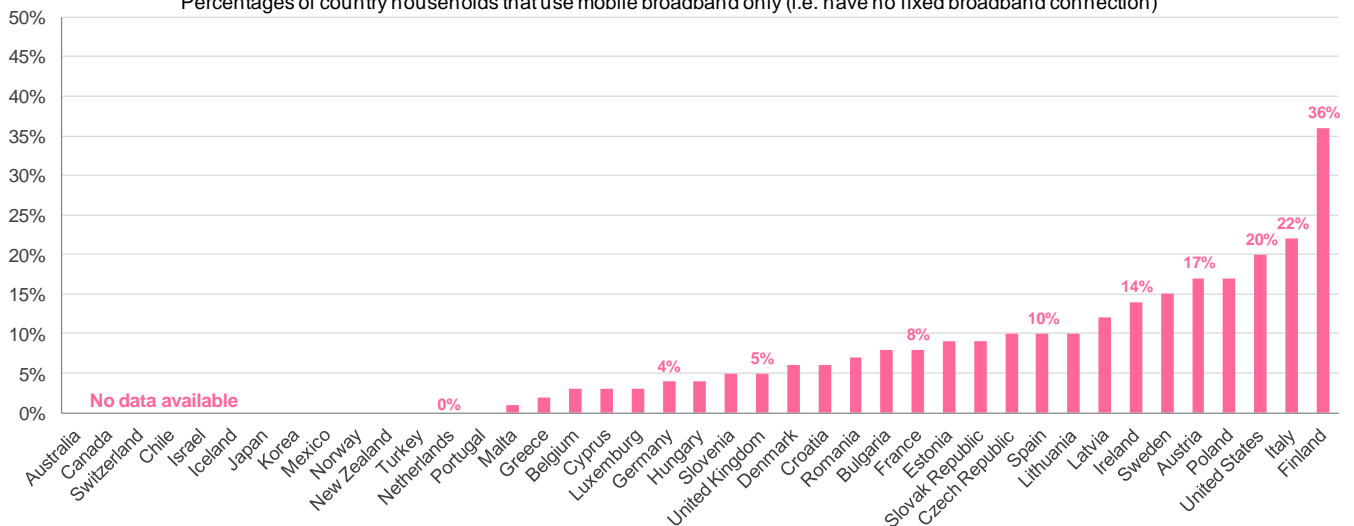
### Fixed-to-mobile broadband substitution potential with existing macro cell site grids

- Elisa in Finland was the operator with the highest mobile data and spectrum usage per capita in the world and as well the operator with the highest fixed-to-mobile broadband substitution potential
- Finland is the country with the highest fixed-to-mobile broadband substitution potential of 185% followed by Sweden, Norway, Denmark, Korea and Austria. The United States ranks second from the bottom in this metric with 37%.
- Mobile operators that will gain access to sizable TDD spectrum holdings in the 3400-3800 MHz bands and deploy it with massive MIMO can unleash the full potential of fixed-to-mobile broadband substitution i.e. 200 GB per person per month or ≈500 GB per household
- In Finland where 36% of all households were mobile broadband only households (no fixed broadband connection) the average mobile data consumption per capita reached 30 gigabytes per month in 1H2018 (≈60 gigabytes per household)

Country name	Country population 2017	Annual data volume Terabytes 2017	Monthly mobile data usage per capita Gigabytes 2017	Aggregate Downlink Busy Hour throughput Gbit/s 2017 year average	Radio network capacity utilization		Fixed-to-mobile broadband substitution potential							
					2017 year average, existing FDD & SDL & 2.5/2.6 GHz TDD spectrum holdings, existing macro site grid, 4x4 MIMO, 256 QAM, downlink	5% most loaded sectors	5% least loaded sectors	Incremental 200 GB/month MBB connections expressed as a % of country population that can be carried by country existing macro site grid capacity (up to 80% utilisation in 5% most loaded macro site sectors)						
							with existing FDD & SDL & 2.5/2.6 GHz TDD spectrum holdings	AND add existing 2.3 GHz TDD spectrum holdings	AND add massive MIMO on existing 2.3/2.5/2.6 GHz TDD	AND add massive MIMO on existing 2.3/2.5/2.6/3.4-3.8 GHz TDD	OR add massive MIMO on existing 2.3/2.5/2.6 and on 40 MHz of 3.4-3.8 GHz TDD	OR add massive MIMO on existing 2.3/2.5/2.6 and on 100 MHz of 3.4-3.8 GHz TDD		
Finland	5,503,297	1,574,387	23.8		24%	2%								185%
Sweden	9,995,163	831,071	6.9		13%	1%								131%
Norway	5,258,317	235,836	3.7		6%	0%								122%
Denmark	5,748,769	515,295	7.5		16%	1%								116%
Korea	50,982,212	3,702,202	6.1		17%	1%								97%
Austria	8,772,865	1,043,080	9.9		24%	2%								81%
Czech Republic	10,578,820	182,736	1.4		4%	0%								75%
Switzerland	8,419,550	461,291	4.6		12%	1%								74%
Turkey	79,814,871	1,997,767	2.1		7%	1%								67%
Japan	127,484,450	7,114,079	4.7		20%	2%								63%
Ireland	4,784,383	271,412	4.7		24%	2%								62%
Spain	46,528,024	1,054,006	1.9		8%	1%								61%
United Kingdom	65,808,573	1,870,800	2.4		16%	1%								53%
Germany	82,521,653	1,388,000	1.4		5%	0%								49%
New Zealand	4,705,818	83,520	1.5		7%	1%								49%
Hungary	9,797,561	139,200	1.2		5%	0%								48%
Italy	60,589,445	1,661,000	2.3		10%	1%								47%
Netherlands	17,081,507	326,616	1.6		9%	1%								45%
Greece	10,768,193	60,937	0.5		2%	0%								44%
Poland	37,972,964	2,110,000	4.6		29%	2%								44%
France	66,989,083	2,307,419	2.9		19%	1%								42%
Belgium	11,351,727	120,580	0.9		5%	0%								39%
United States	325,719,200	15,700,000	4.0		33%	3%								37%
Australia	24,450,561	1,031,212	3.5		24%	2%								33%

### Mobile broadband only household penetration - 2017

Percentages of country households that use mobile broadband only (i.e. have no fixed broadband connection)



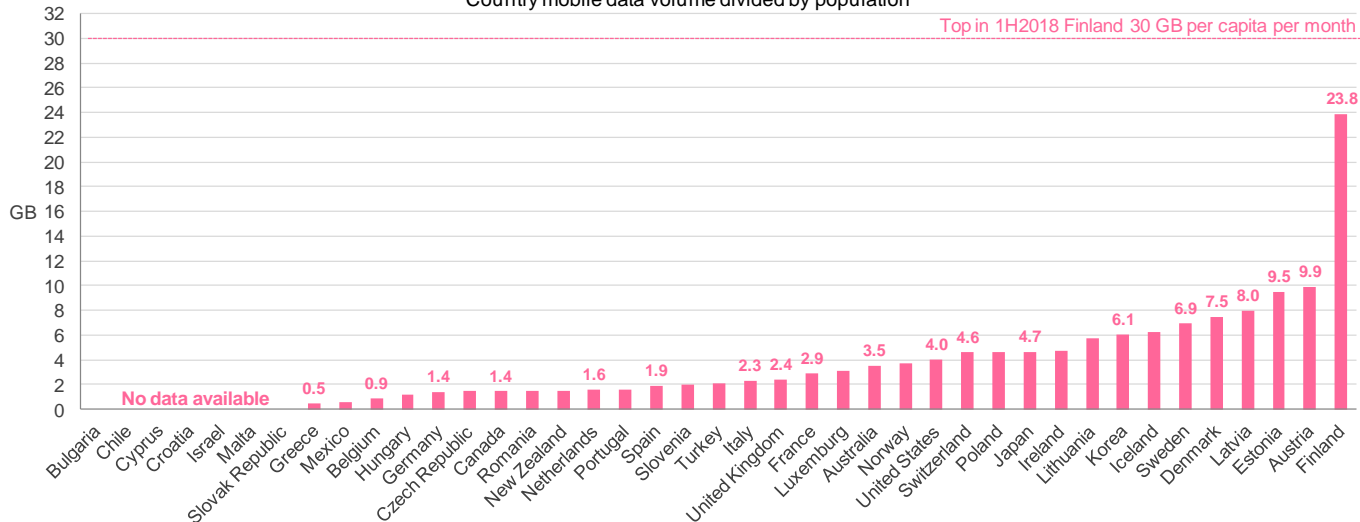
Source: Eurostat ICT survey data 2017 and Rewheel analysis  
 US data source NTIA 2016 survey: 20% of US households using internet at home with mobile only connection

# Highlights

## Mobile data usage per capita per month in 2017 – Countries and operators

### Mobile data usage per capita per month - 2017

Country mobile data volume divided by population

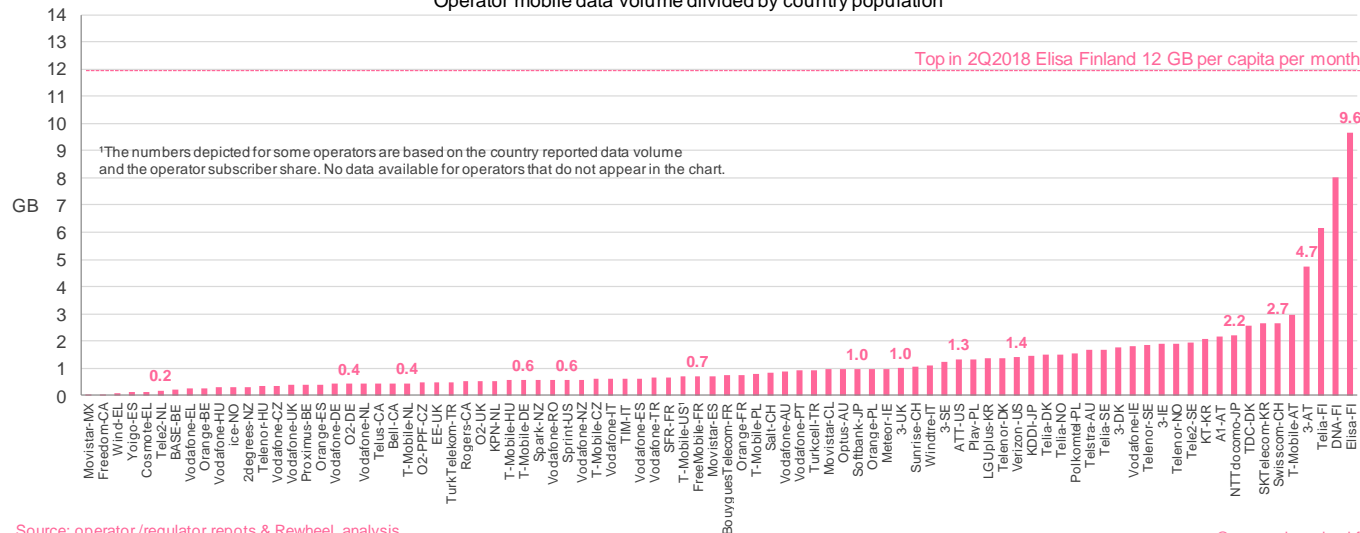


Source: regulator reports & Rewheel analysis

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### Mobile data usage per capita per month - 2017

Operator mobile data volume divided by country population



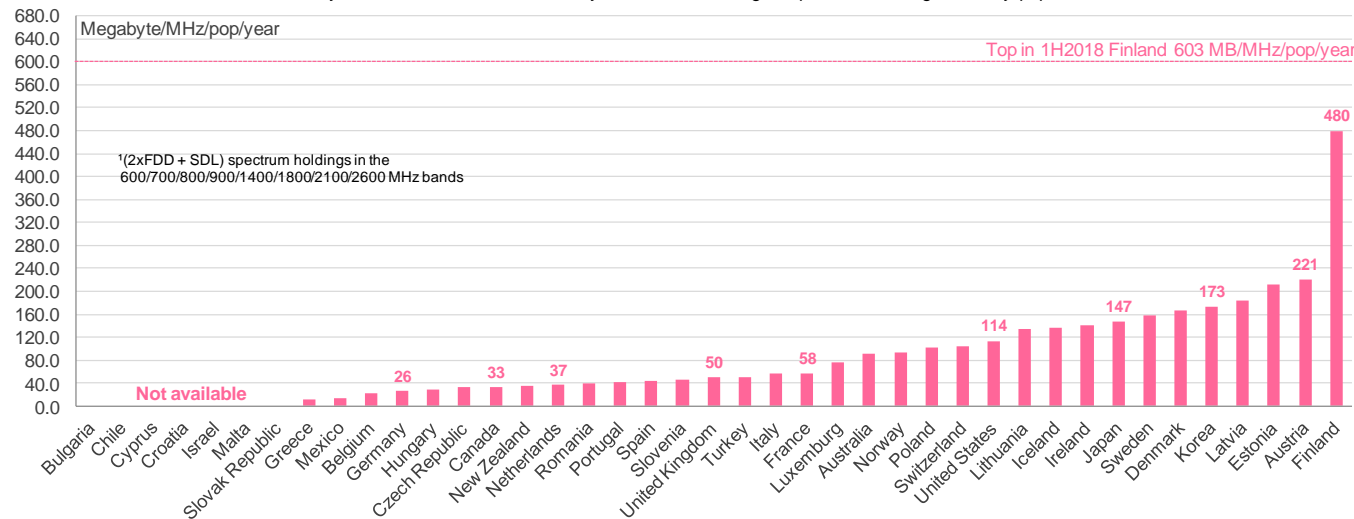
Source: operator/regulator reports & Rewheel analysis

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## Spectrum usage (Megabyte/MHz/pop/year) in 2017 – Countries and operators

### Spectrum usage per capita per year - 2017

Country mobile data volume divided by FDD & SDL assigned spectrum holdings<sup>1</sup> and by population

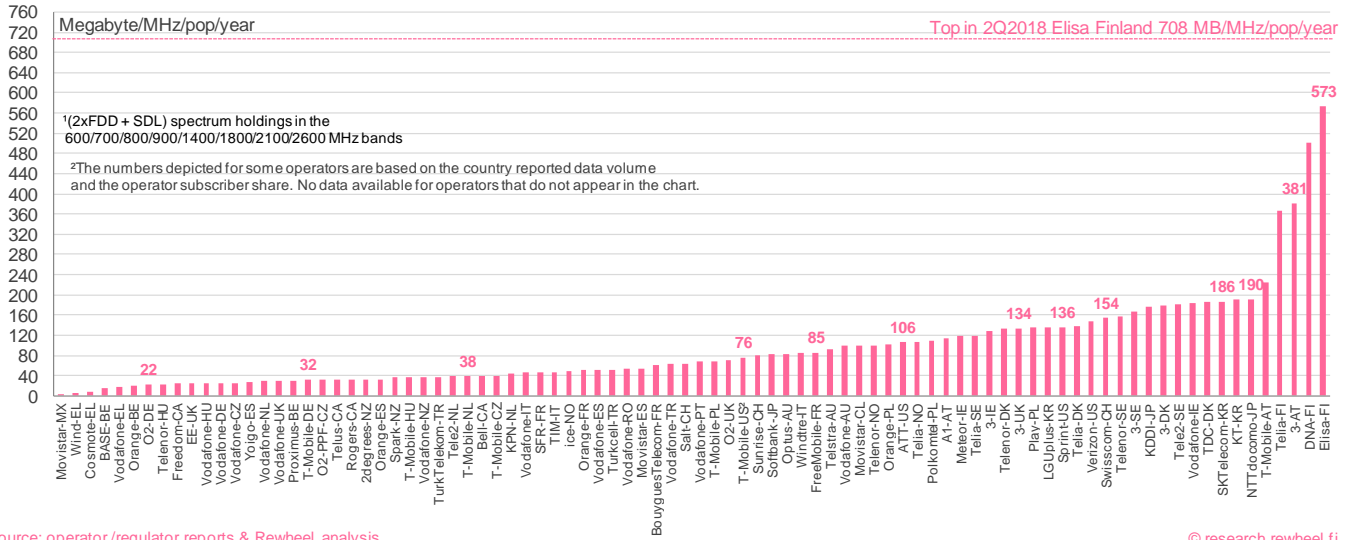


Source: operator/regulator reports & Rewheel analysis

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### Spectrum usage per capita per year - 2017

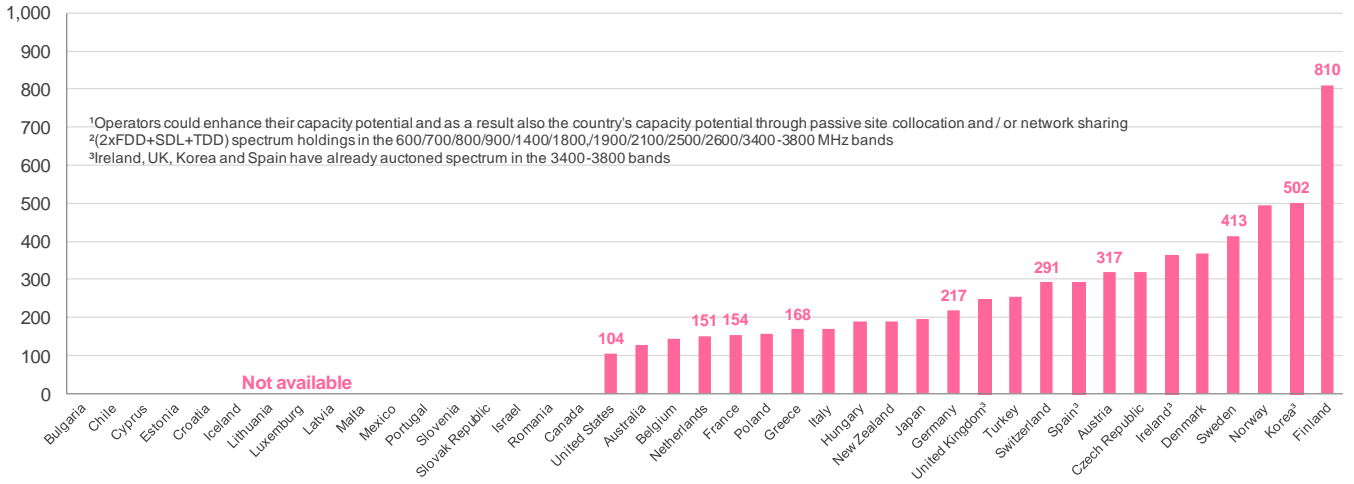
Operator mobile data volume divided by FDD & SDL assigned spectrum holdings<sup>1</sup> and by population



### Capacity potential [macro sites x MHz] per 1,000 pop – Countries and operators

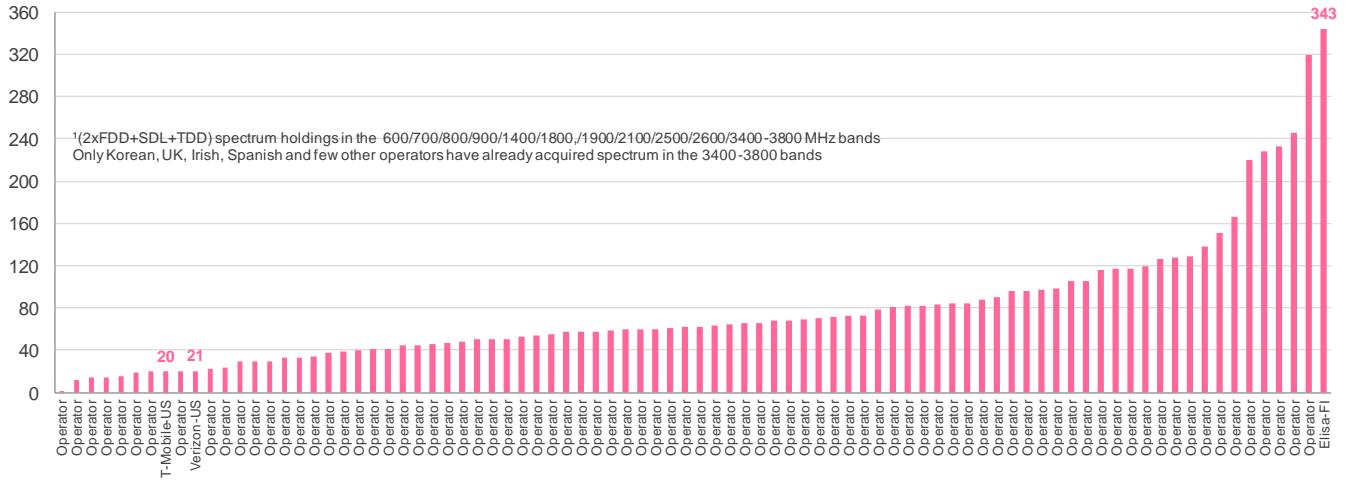
#### Capacity potential - [macro sites x MHz] per 1,000 pop

Country macro cell sites<sup>1</sup> times [FDD & SDL & TDD] spectrum holdings<sup>2</sup> per 1,000 pop

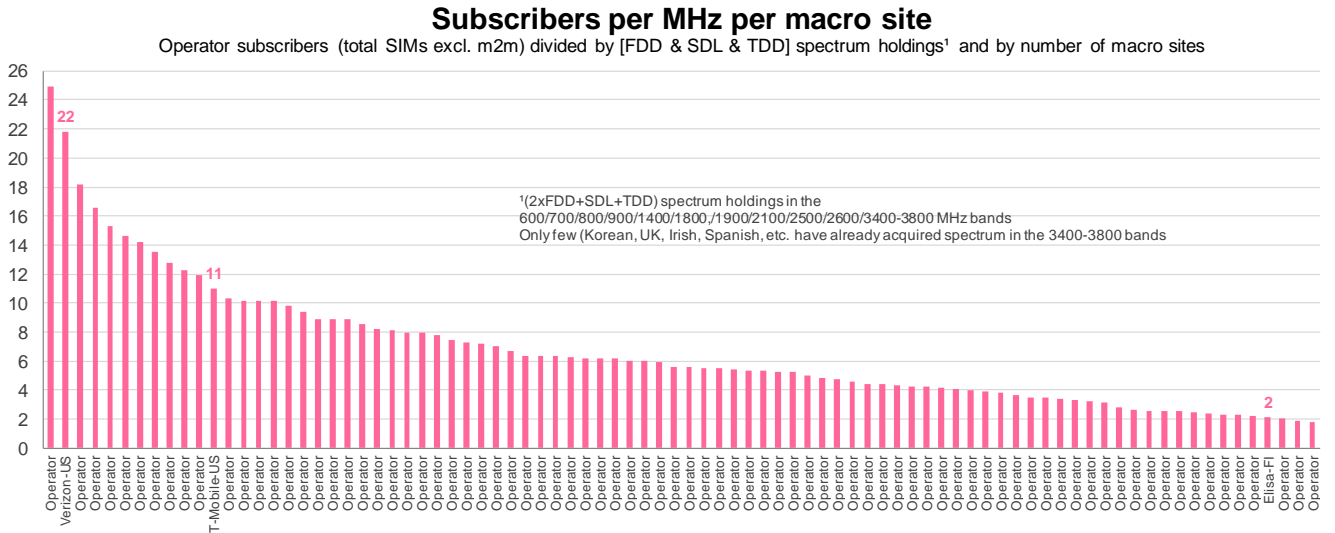


#### Operator capacity potential - [macro sites x MHz] per 1,000 pop

Operator macro cell sites times [FDD & SDL & TDD] spectrum holdings<sup>1</sup> per 1,000 pop



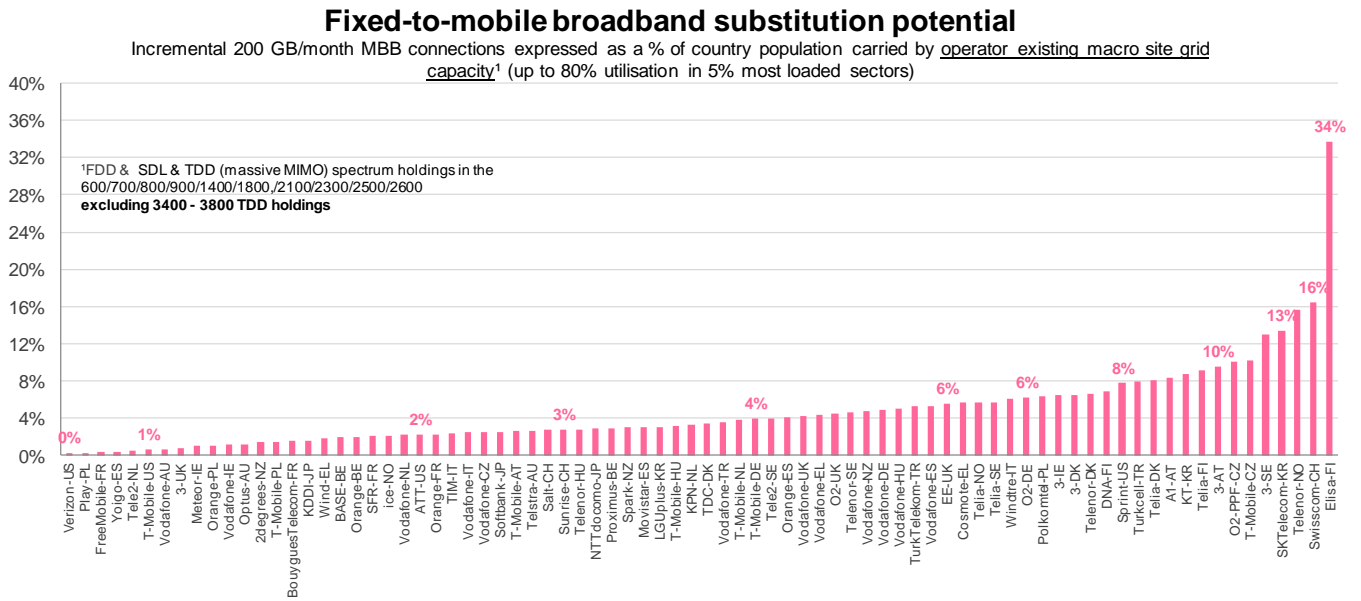
Subscribers per MHz per macro site – Operators



Source: Rewheel analysis. No site data available for operators that do not appear in the chart

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Fixed-to-mobile broadband substitution potential – Operators

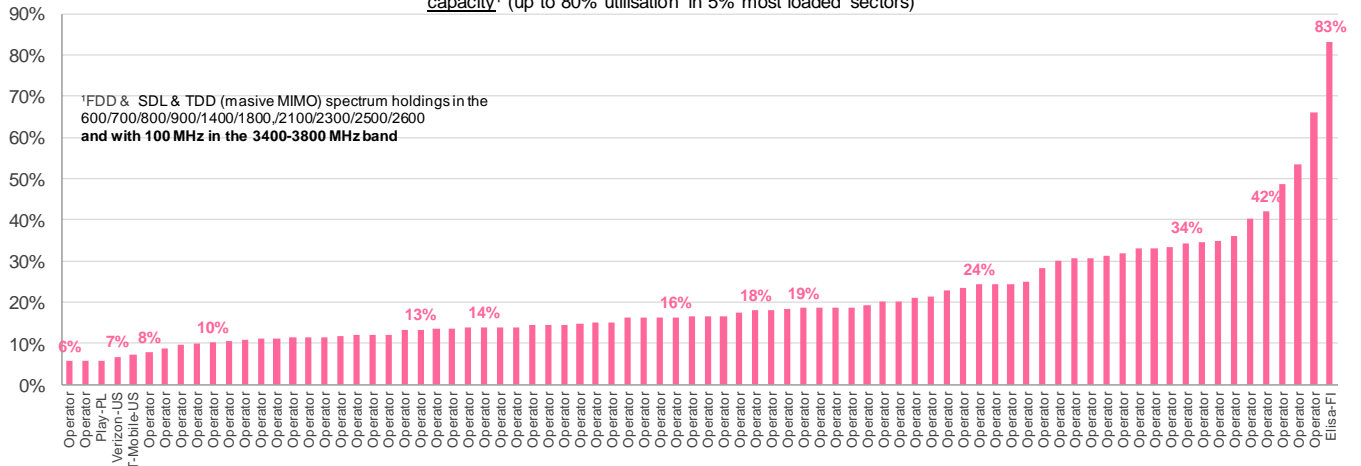


Source: Rewheel analysis. No site data available for operators that do not appear in the chart

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### Fixed-to-mobile broadband substitution potential with 100 MHz of 3.6GHz

Incremental 200 GB/month MBB connections expressed as a % of country population carried by operator existing macro site grid capacity<sup>1</sup> (up to 80% utilisation in 5% most loaded sectors)



Source: Rewheel analysis. No site data available for operators that do not appear in the chart

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## Context

In March 2017 we released a study<sup>1</sup> titled “*Capacity utilization and fixed-to-mobile broadband substitution potential – A study of 64 European operators*”. This was our first comprehensive study that examined the state of capacity utilization and estimated the fixed-to-mobile broadband substitution potential of European mobile networks.

The motivation of our March 2017 study, which reported the yearly average capacity utilization of 64 European mobile operators in 2016, was to disprove the unsubstantiated claims of an imminent mobile capacity crunch that are frequently made by a handful of incumbent fixed-line operators and their investors.

As we wrote in 2017 many in the industry have held and are still holding the mistaken conviction that mobile operators are running out or soon will run out of spectrum and network capacity. A spectrum crunch has been prophesized the last 10 years by some in the industry due to the explosive growth in smartphone use, the proliferation of data-only connected mobile devices and the significant fixed-to-mobile broadband substitution in some markets (e.g. Finland, Austria).

Well, the doomsayers are wrong. As we showed in our 2017 study most European mobile operators utilized in 2016 a tiny fraction of their available network capacity. So the big crunch was deferred yet one more year, to 2017.

In this September 2018 study we present the yearly average 2017 radio network capacity utilization estimates for 80 mobile operators: the 64 European operators we included in our first study and 16 more mobile operators from the United States, Japan, Korea, Australia and New Zealand. Similarly to our first study we calculate the network capacity utilization and fixed-to-mobile broadband substitution potential with the existing macro site grids. Our calculations do not include capacity from already built micro and/or small cells or from the future deployment of TDD 2500/2600/3400-3800 spectrum in small cells.

### **Hard mobile data network capacity drivers: number of macro sites and spectrum bandwidth**

$$\text{Capacity} \approx \text{Macro sites} \times \text{Spectrum}$$

In this study we estimate the radio network capacity utilization of mobile operators in the 5% of their most loaded sectors and across the entire network by taking into account all of their existing FDD (600/700/800/900/1800/2100/2600), SDL (1400) and TDD (2500/2600) spectrum holdings, the reported (or in some cases estimated) number of macro cell sites, the reported (or in some cases estimated) 2017 traffic volume and by applying typical data traffic geo-distribution, busy hour and spectrum efficiency profiles (corresponding to typical 4x4 MIMO and 256QAM macro sector capacity). In the 2016 capacity calculations we took into account only the existing FDD operator holdings.

### **Soft capacity drivers: base station equipment hardware, software licences, backhaul, core: out of scope of this study**

It is important to note that the capacity utilization figures we calculate assume that operators have deployed – where needed – all of their available FDD, SDL and TDD (2500/2600) spectrum holdings. So, it is the capacity utilization of the readily available macro site grid capacity resources rather than the capacity utilization of the spectrum and equipment actually deployed by operators in their sites in 2017. For example, the capacity utilization of an operator in its top 5% most loaded sectors could be substantially higher than the figures we present herein simply because that given operator has not deployed its 2600 FDD or TDD spectrum (even though they have it) and/or because they still use most of their 900 and 1800 spectrum for GSM service.

Having estimated the 2017 radio network capacity utilization for each of the 80 mobile operators, considering their existing FDD, SDL and 2500/2600 TDD spectrum holdings, we estimate the incremental number of 200 gigabyte per month (average usage) mobile broadband connections expressed as a percentage of country population that can be accommodated by the operators' currently available macro site network capacity. It is important to note that our capacity estimations do not include capacity enhancements from future new macro or small cell site rollouts. In the 2016 fixed-to-mobile broadband substitution calculations we used an average monthly usage of 100 gigabytes per connection (i.e. user) compared to the 200 gigabytes we used herein.

<sup>1</sup>[http://research.rewheel.fi/insights/2017\\_mar\\_pro\\_network\\_utilisation\\_mimo/](http://research.rewheel.fi/insights/2017_mar_pro_network_utilisation_mimo/)

We repeat the capacity dimensioning we described above for FDD, SDL and 2500/2600 TDD spectrum holdings by also taking into account the operators' 2300 MHz TDD spectrum holdings, if any, first without assuming massive MIMO and in the next step by assuming that all operators will significantly boost their capacity by using massive MIMO technology on their 2300/2500/2600 TDD spectrum. In the next iteration we add the operators' 3400-3800 TDD spectrum holdings, if any, into the mix by assuming that those as well will be deployed with massive MIMO. In the last two iterations we assume that each of the 80 operators will acquire 40 or 100 MHz in the 3400-3800 bands and deploy it with massive MIMO (i.e. we substitute the actual holdings of the few operators that already hold spectrum in the 3400-3800 bands first with 40 MHz and then with 100 MHz).

Our latest findings re-confirm our field experience gained through our recent 700/1400/3400-3800 spectrum valuation and fixed-to-mobile broadband substitution business case consulting engagements: most mobile operators are currently utilizing only a fraction of their readily available macro network capacity. The fact that most mobile networks are essentially heavily under-utilized today raises the following question: how should mobile operators put into use all the readily available mobile network capacity and improve the return on already realized investments?

Should mobile operators continue the agonizing search for '*5G black swans*' or should they '*keep it real*' and execute proven fixed-to-mobile broadband substitution strategies similar to those successfully executed by Finnish or Austrian operators?

Our bets are with non fixed-line incumbent operators that will actively pursue fixed-to-mobile broadband substitution (encourage consumers to switch from outdated DSL-based broadband/TV or expensive fibre connections) by using the abundant capacity of their 4G/5G networks to offer affordably priced unlimited volume mobile broadband/TV plans.

In this study we have also incorporated the 2017 mobile data and spectrum usage analysis (per country and operator). Going forward, we intend to release an annual update of the capacity utilization, capacity potential, fixed-to-mobile broadband substitution potential, mobile data and spectrum usage figures. The next annual update with the 2018 figures will be released in autumn 2019.

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Founded in 2009, Rewheel is a Finland based boutique telecoms management consultancy. Our clients are mainly European mobile network operators, telco groups, MVNO groups, sector regulators, governments, global internet firms, mobile data-centric startups, PE and VC investors.

Our core belief is that new radio spectrum bands, 4.5G and 5G technology, massive MIMO, near zero marginal cost, unlimited mobile data plans and the Internet of Things radically change mobile network operators' cost, revenue and profitability dynamics. Rewheel's mission is to help prepare for the paradigm shift in network and spectrum strategy, spectrum valuation, network sharing, M&A, MVNO economics and mobile data pricing.

We delivered management consultancy work for clients in the United Kingdom, United States, Ireland, Switzerland, Finland, Sweden, Belgium, Greece, Poland, Slovenia, Hungary, Russia, Romania. Buyers of our research reports and related strategic workshops include many companies and authorities across Europe and worldwide.

Since 2010 we have been supporting a number of European challenger mobile operators in multiband (700, 700 SDL, 800, 900, 1400 SDL, 1800, 2600, 3400 – 3800 MHz) auctions with spectrum valuation fixed-to-mobile broadband substitution business case and strategic advisory services.

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#### **The state of 4G pricing – 2H2017 – Digital Fuel Monitor 8<sup>th</sup> release**

⇒ [http://research.rewheel.fi/insights/2017\\_nov\\_pro\\_2h2017\\_release/](http://research.rewheel.fi/insights/2017_nov_pro_2h2017_release/)

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#### **The approval of the 4 to 3 Telefonica E-Plus merger with Mickey Mouse MVNO remedies made Germany the least competitive market in EU28**

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