



Mobile Energy Efficiency

An Energy Efficiency Benchmarking Service for Mobile Network Operators

Methodology

June 2011



www.gsmworld.com/mee

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Executive summary

Energy efficiency is becoming a strategic priority for mobile network operators (MNOs). Managing energy usage can both lower costs and reduce MNOs' carbon footprint. The GSMA is uniquely placed to assist MNOs to identify areas where energy efficiency can be improved by aggregating operator data and producing a set of key performance indicator (KPI) benchmarks, so that MNOs can assess their performance relative to each other.

This document is designed to inform MNOs and other stakeholders about:

- The GSMA's Mobile Energy Efficiency benchmarking service for MNOs;
- How the service works;
- The methodology employed;
- The types of outputs generated;
- The benefits to MNOs; and
- How to participate.

Introduction to the GSMA

The GSMA represents the interests of mobile operators worldwide. Spanning 219 countries, the GSMA unites nearly 800 of the world's mobile operators, as well as more than 200 companies in the broader mobile ecosystem, including handset makers, software companies, equipment providers, Internet companies, and media and entertainment organisations. The GSMA is focused on innovating, incubating and creating new opportunities for its members, all with the end goal of driving the growth of the mobile communications industry.

The GSMA produces industry-leading events such as the Mobile World Congress and Mobile Asia Congress.

For more information, please visit Mobile World Live, the online portal for the mobile communications industry, at www.mobileworldlive.com or the GSMA corporate website at www.gsmworld.com.

Objectives of the service

The objectives of the GSMA's Mobile Energy Efficiency (MEE) benchmarking service are to:

- Identify and quantify cost and greenhouse gas (GHG) savings for MNOs;
- Promote a consistent methodology for benchmarking energy efficiency with common KPIs;
- Collate industry data and benchmark outputs to enable MNOs to measure themselves externally and internally, highlighting areas for potential energy efficiency gains;
- Coordinate across the industry and with regulatory stakeholders so that the benchmarking methodology is adopted as a global standard.

MEE now includes 25 MNO participants, accounting for over 170 networks. A successful pilot was completed with Telenor, Telefonica and China Mobile.

Context

Why industry-level action is required

Industry level action is needed for two reasons. First, there are at present different methodologies used by MNOs for calculating energy and GHG emissions, leading to sets of energy and emissions data and KPIs that are not comparable. There is no mechanism to provide MNOs with standardised benchmarks for assisting them with energy and emissions reduction, for internal benchmarking and for benchmarking against other operators. Second, there is pressure from the European Union (EU) and national governments for the industry to measure its energy efficiency with the objective of reducing GHG emissions.

Such action fits well into existing industry initiatives. The GSMA's MEE service is, in addition to facilitating cost and GHG reduction opportunities for MNOs, contributing to the Global eSustainability Initiative Energy Efficiency Inter-Operator Collaboration Group (GeSI EE-IOCG)¹ which is working to develop common ICT industry standards for energy efficiency. In addition, the GSMA is collaborating with the European Commission and the International Telecommunication Union Study Group 5 (ITU SG5) to ensure that the methodology is adopted as a global standard.

Why the GSMA?

As the industry association which represents the interests of the worldwide mobile communications industry, the GSMA has the expertise, the relationships, the brand and the neutral positioning to lead this benchmarking service. The GSMA is continually trying to develop and enable new opportunities for its members, with the aim of driving the growth of the mobile communications industry. The financial, performance and environmental benefits of the MEE service are a very good fit with the GSMA's goals.

Benefits to MNO participants

MEE enables operators to lower their network energy costs and emissions. Participation in the service enables operators to:

- View detailed analysis of the relative performance of their networks benchmarked against one another and against peers (anonymised to ensure confidentiality);
- Quantify potential cost and GHG savings, and identify where and how such savings can be realised;
- Benefit from being part of a large dataset which delivers more insightful analysis, higher statistical significance and action orientated results;
- Use a proven methodology which employs a unique "normalisation" analysis, enabling like-for-like comparison of networks;
- Map improvements year by year and quantify the impact of cost reduction initiatives;
- Promote the industry's visible commitment to energy and emissions reduction, which will have a positive impact on regulators, investors, customers and other stakeholders.

¹ <http://www.gesi.org/Initiatives/EnergyEfficiency/tabid/72/Default.aspx>

Approach

Overview

Around 80% of MNOs' energy consumption is in the network, hence the focus of the service. However, comparing energy efficiency across networks has been difficult as KPIs and KPI methodologies have differed by technology, market and geography, if employed at all.

The GSMA's approach is to use a standard methodology that incorporates a "normalisation" process, using multi-variable regression, which accounts for factors outside an MNO's control and provides a more like-for-like comparison (apples to apples).

Methodology

The methodology benchmarks mobile networks by country by comparing four energy KPIs, which are:

1. Mobile network energy consumption per mobile connection;
2. Mobile network energy consumption per unit mobile traffic;
3. Mobile network energy consumption per cell site;
4. Mobile network energy consumption per unit mobile revenue.

It is not straightforward to make meaningful comparisons of mobile networks that, for instance, have different technologies, use diesel rather than electricity or are located in countries with different population densities, geographies and climates. The MEE methodology enables the consistent evaluation and comparison of network energy efficiency across a range of variables. It "normalises", or adjust energy KPIs for variables outside the energy managers' control, in order to make different networks comparable, for example country, market and technology factors and thus enables like-for-like comparison. After normalisation it is possible to see which networks are over- or under-performing in terms of energy consumption and management, and where there might be significant potential to reduce energy costs and emissions. See Figure 1.

Energy consumption can be converted into GHG emissions using country grid electricity and diesel conversion factors to help the mobile industry to lower its GHG emissions per connection in accordance with Mobile's Green Manifesto.

FIGURE 1: NORMALISATION FACTORS

<u>Example Factors</u>	<u>Implications</u>
■ Country factors - Population density - Urban / rural population split - Number of cooling degree days - Topology ■ Market factors - Market share - Traffic, both voice and data - Geographic coverage - Population coverage - GDP per capita (adjusted) ■ Technology factors: - 2G / 3G connections split - Diesel vs. electricity consumption ■ Other - Data accuracy	■ A larger data set enables normalisation of multiple factors whilst retaining statistical significance ■ Availability and accuracy of data is important, whether from operator or public domain ■ Data that are difficult to gather, e.g. age of legacy kit, cooling methods and number of transceivers, can be progressively included as they become available ■ Multi-linear regression techniques test intuitive assumptions about factors ■ Factors must be grouped in a way that makes sense when looking for a linear relationship

Source: GSMA

The methodology follows a six-step process:

Step 1: Collect data

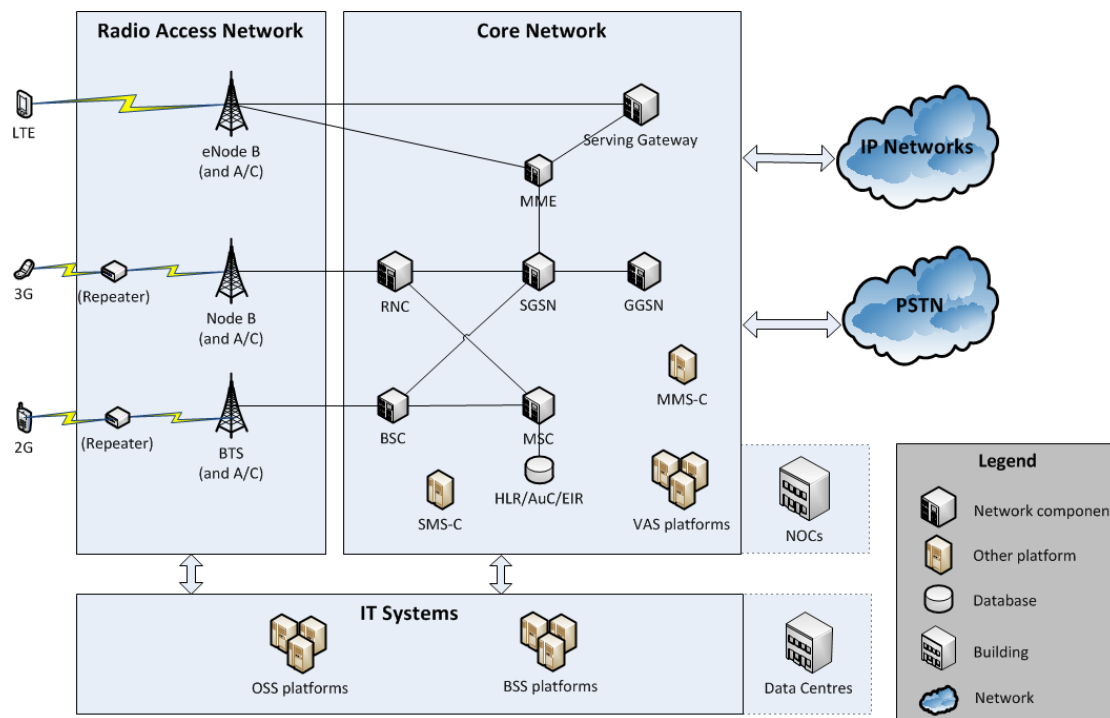
Much of the country and market information has been gathered independently by the GSMA. The data required from participating operators are the following by country or region, annually:

- Mobile network electrical energy usage and diesel energy usage;
- Number of physical cell sites and total number of technologies;
- Number of mobile connections;
- Minutes of mobile voice traffic and bytes of mobile data traffic;
- % mobile coverage (geographic, population);
- Mobile revenues.

In addition, we ask participating MNOs to estimate the average voice bandwidth across their networks, for all countries.

Mobile network energy usage data are gathered from three different segments of network operations: the Radio Access Network (RAN), the Core Network and IT Systems, see Figure 2. Detailed definitions of each segment and the data required are contained in the Appendix to this document.

FIGURE 2: ENERGY USAGE DATA SEGMENTS



Source: GSMA

MNOs supply energy usage data for their RAN and Core Network, and can optionally supply data for Data Centres and other IT platforms.

Some of the data require estimation by operators, especially the allocation of energy to the mobile network where there is overlap with fixed networks. Mobile operators are invited to explain the assumptions they are making and to give a confidence rating to the data submitted.

It may be the case that certain other data might enable even more useful energy efficiency benchmarking, although we have found from our work to date that the above are sufficient for producing useful analyses and considerable insights. Moreover, it is our intention to use information that should be readily available or easy to gather for most operators in the first two years of the benchmarking. In subsequent years the data request could be gradually expanded if MNOs so desire.

The GSMA has gathered country and market data, which can assist with normalisation, from various sources, e.g.:

- GSMA Wireless Intelligence: 2G versus 3G connections, contract versus pay-as-you-go connections, market share, population coverage, geographical coverage;
- United Nations (UN): population, split by rural and urban; GDP per capita;
- World Resources Institute (WRI CAIT): cooling degree days per capita;
- International Energy Agency (IEA): electrification rates;
- Centre for International Earth Science Information Network (CIESEN): dispersion of population by altitude.

Step 2: Review data for possible inaccuracies, inconsistencies or definitional issues

The data submitted by operators are reviewed for inaccuracies, inconsistencies or definitional issues. The benchmarking process highlights outliers, which can sometimes be explained by exceptionally good (or bad) energy performance, but also by issues with the data.

Step 3: Calculate energy KPIs and compare graphically

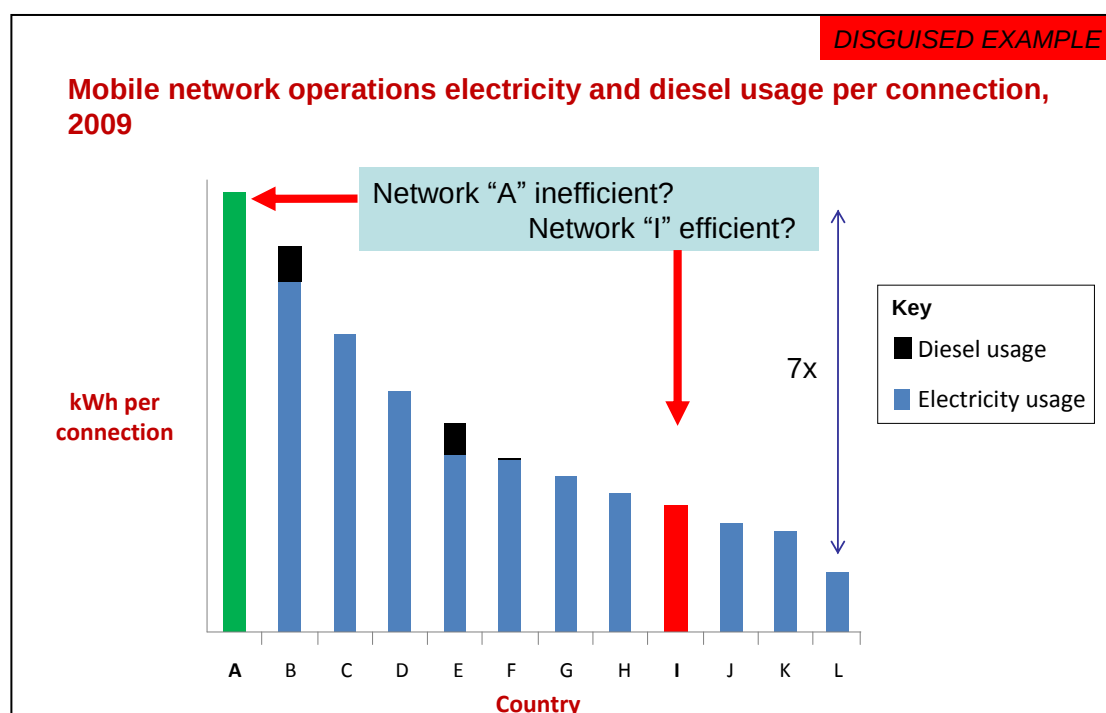
The four energy KPIs are calculated directly from data supplied by the operators prior to normalisation.

More detailed definitions are available in the Appendix, but in summary:

- Energy is calculated by summing the electricity consumption and the diesel consumption from the RAN plus the Core Network. Diesel consumption in litres is converted into MWh of electrical energy by estimating the energy content in diesel using standard published figures and by assuming an average generator efficiency;
- Total number of SIMs or, where SIMs do not exist, a unique mobile telephone number that has access to the network for any purpose (including data only usage), except telemetric applications;
- Mobile traffic is calculated in bytes. This requires converting voice traffic from voice minutes into bytes using a voice bandwidth figure, and adding this to data traffic in bytes;
- The cell site is defined as a physical cell site (which includes a Base Transceiver Station and/or a Node B and/or eNode B);
- Revenue is defined as all revenues from mobile operations including recurring service revenues, non-recurring revenues, as well as MVNO, wholesale and roaming revenues.

MNO networks are compared across countries against these energy KPIs. This can be insightful but before normalisation the spread is large given the differences in country, market and technology factors. See Figure 3, which shows a seven times spread between least and most efficient.

FIGURE 3: EXAMPLE OUTPUT - COMPARISON OF COUNTRIES BY ENERGY PER CONNECTION

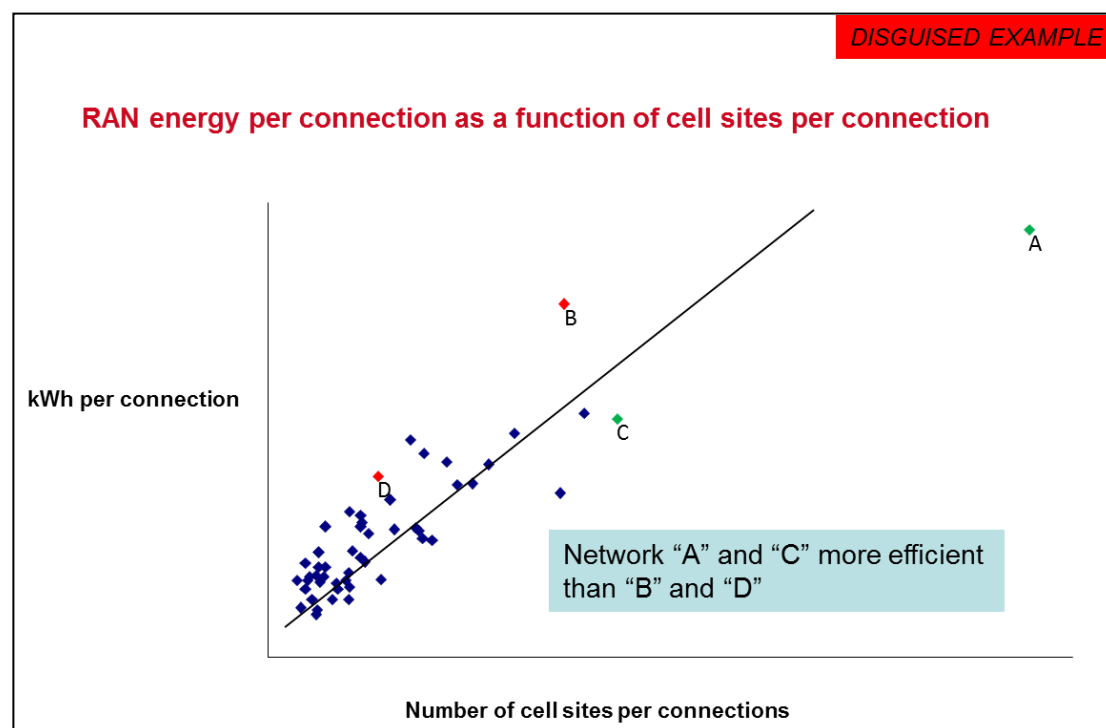


Source: MNOs, GSMA data and analysis

Step 4: Analyse data using multi-variable regression techniques based on energy usage hypotheses

It is relatively easy to normalise energy KPIs for single variables using a linear regression. For instance, by plotting energy per connection against cell sites per connections, it is possible to see the effect of number of cell sites per connection on this energy KPI, and therefore to adjust for its impact. Figure 4 shows Networks B and D under-performing (i.e. higher energy than expected) on energy per connection, and Networks A and C over-performing, where a network can be across a whole country or part of a country.

FIGURE 4: EXAMPLE LINEAR REGRESSION AGAINST NUMBER OF CELL SITES PER CONNECTION



Source: MNOs, GSMA data and analysis

However, normalising for just one variable only would represent an unfair comparison as in this case it fails to take into account factors such as population density, urban versus rural population split, market share and country temperature. Therefore, more factors need to be included in the regression. Using multi-variable regression analysis, it is possible to normalise for a number of variables. We have used a standard feature of Excel to perform this multi-variable regression analysis so that it can be easily reviewed by MNOs themselves.

Regression analysis is purely a mathematical exercise, and models the relationship between a dependent variable and one or more independent variables. It is important to ensure that the variables used in the regressions make practical sense and are not just chosen because they provide a mathematical fit. If we assume that all networks are designed in the same way from an energy management perspective, that they use equipment with similar energy efficiency, and that they use similar cooling technologies, then there should be a formula that describes the energy consumption of a network, which we can use to define the variables used in the normalisation analysis. In the Appendix, we show how we derive such a formula to normalise for energy per connection.

The dependent variables are energy per connection, energy per cell site and energy per unit traffic. The independent variables differ for each dependent variable. For example:

- For energy per connection the independent variables are % 2G connections, % urban population / % population covered by MNO, adjusted GDP per capita, number of cell sites per connection and number of cooling degree days per capita;
- For energy per cell site they are % 2G connections, number of connections per cell site, geographical area covered by MNO per cell site and number of cooling degree days per capita;
- For energy per unit traffic they are number of cell sites per unit traffic, % voice traffic, number of cooling degree days per capita and adjusted GDP per capita.

The regression analysis produces a set of results which enables a mathematical equation to be written to explain the relationship. For example, the equation for energy per cell site could be:

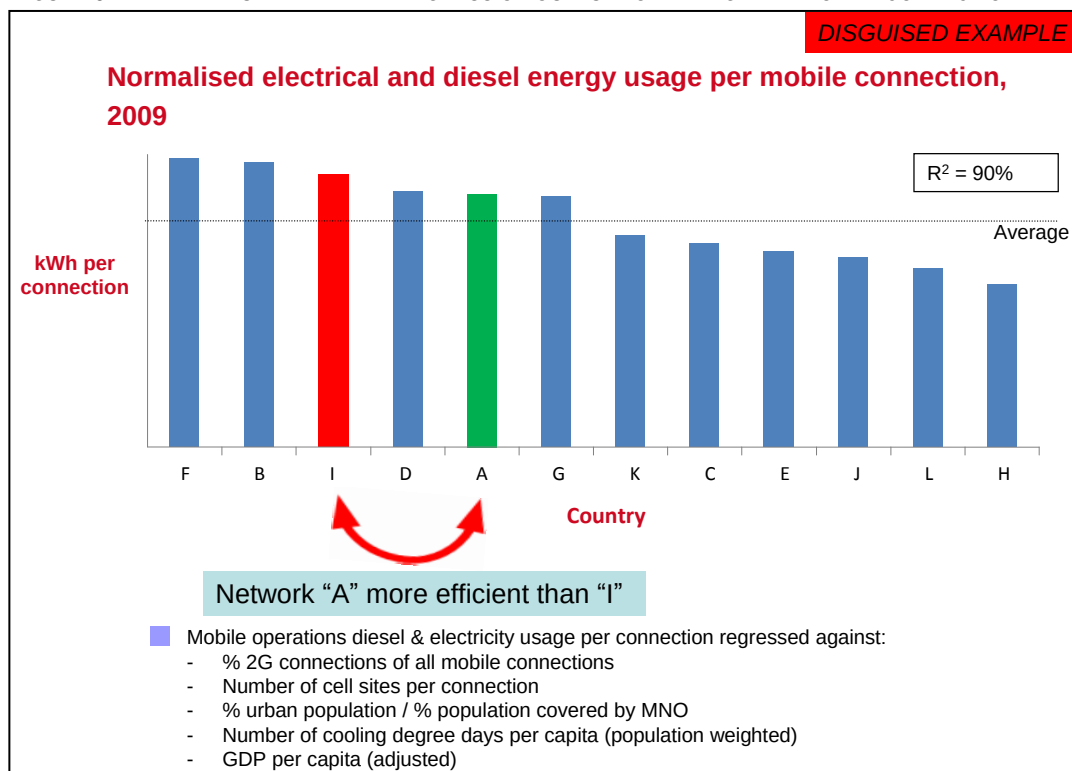
$$\text{Energy per cell site} = 16 - 7X_1 + 3X_2 + 0.03X_3 + 0.002X_4$$

where X_1 is % 2G connections, X_2 is number of connections per cell site, X_3 is area covered by MNO per cell site and X_4 is number of cooling degree days per capita.

With the equation, the theoretical energy per cell site for a network can be calculated using the network's values for each of the independent variables. Subtracting the network's actual value from the theoretical value gives a measure in MWh per cell site of whether the network is over- or under-performing versus the theoretical value. This approach can be extended to multiple networks. Therefore the effect of differing values of independent variables for multiple networks can be removed, and so networks can be compared like-for-like.

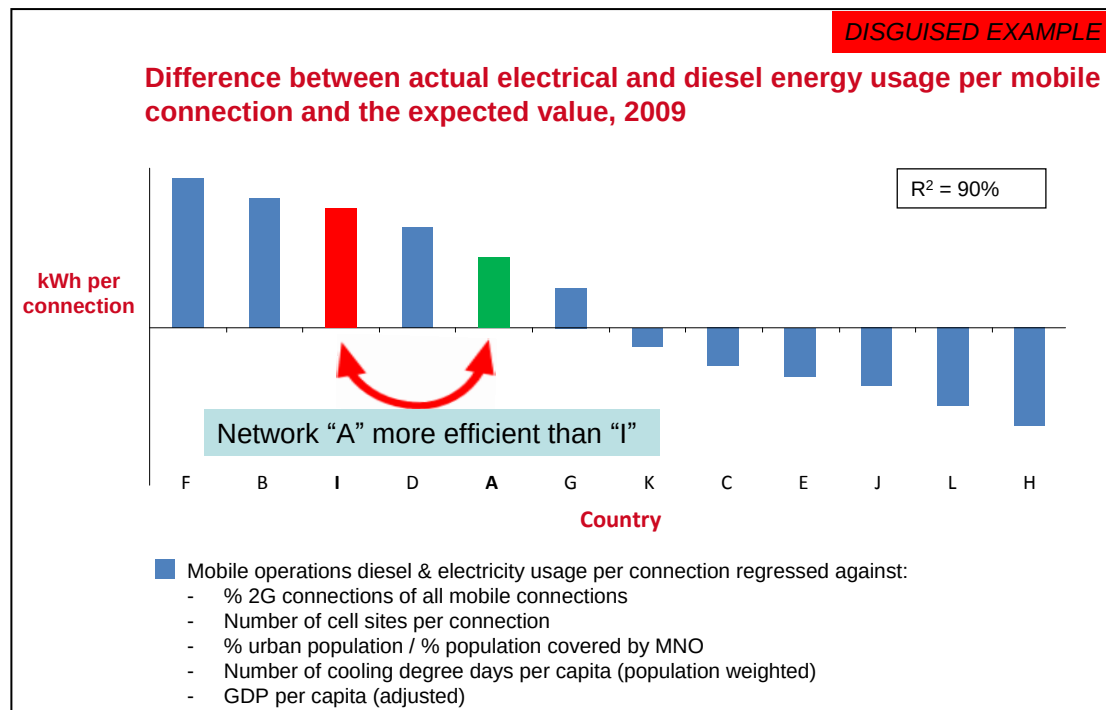
The types of output from the regression analysis are shown in Figure 5 and Figure 6. The regression has resulted in Country A moving from least efficient in Figure 3 to being near the middle of the pack once the normalisation has been undertaken, as shown in Figure 5 and Figure 6. Country I has moved from being fourth most efficient in Figure 3 to one of the least efficient post normalisation, see Figure 5 and Figure 6.

FIGURE 5: EXAMPLE MULTI-VARIABLE REGRESSION OUTPUT FOR ENERGY PER MOBILE CONNECTION



Source: MNOs, UN, GSMA data and analysis

FIGURE 6: EXAMPLE MULTI-VARIABLE REGRESSION OUTPUT FOR ENERGY PER MOBILE CONNECTION, SHOWING DEVIATION FROM THE AVERAGE



Source: MNOs, UN, GSMA data and analysis

The regression analysis also produces statistics, which show amongst other things:

- How well the equation fits the data points: this is denoted by the coefficient of determination R^2 which measures how much of the variation in the dependent variable can be explained by the independent variables.
 - E.g. an R^2 of 90% means that approximately 90% of the variation in the dependent variable can be explained by the independent variable.
 - The remaining 10% can be explained by unknown variables or inherent variability other factors outside of energy manager's control, such as cooling method used, the energy efficiency of the equipment, as well as network design and data accuracy.
- The probability that the coefficient of the independent variable is zero, i.e. that the independent variable is useful in explaining the variation in the dependent variable. These probabilities are given by the P-values. A P-value of 10% for the coefficient of the independent variable '% 2G connections' means that this coefficient (value -7 in the equation above) has a 10% chance of being zero, i.e. a 10% chance that this independent variable is not useful in explaining the variation in the dependent variable.

Note that regression analysis does not prove causality but instead demonstrates correlation (i.e. that a relationship exists between the dependent and independent variables), and also that we are assuming a linear relationship over the ranges of variables covered in this analysis.

More variables can be used in a normalisation with a larger data set so that much greater insights will emerge from comparing 100 operators rather than 50, for example. Larger data sets also help with the statistical significance of the results. In future we plan to feed back results to MNOs using more independent variables in the regressions, and showing separate regressions for developed and emerging market countries and possibly other data sub-sets, such as 2G versus 3G networks.

Step 5: Feed back results to MNOs

The results of the energy efficiency benchmarking are fed back bilaterally to each MNO. This is carried out on an energy consumed basis and can also be done on a GHG basis. Energy is converted to GHG emissions using standard emission factors for diesel and the electrical grid in each country.

The results can be used in two ways. First, they can be used to quantify the potential for energy cost savings. This is best demonstrated by calculating the impact of improving the underperforming countries to the average of the group. Second, they can be used to focus energy reduction efforts within MNOs. Since several factors that might explain variation in energy performance have been explained away, it is likely that the remaining differences can be explained by issues such as approach to cooling, type and age of equipment, and network design.

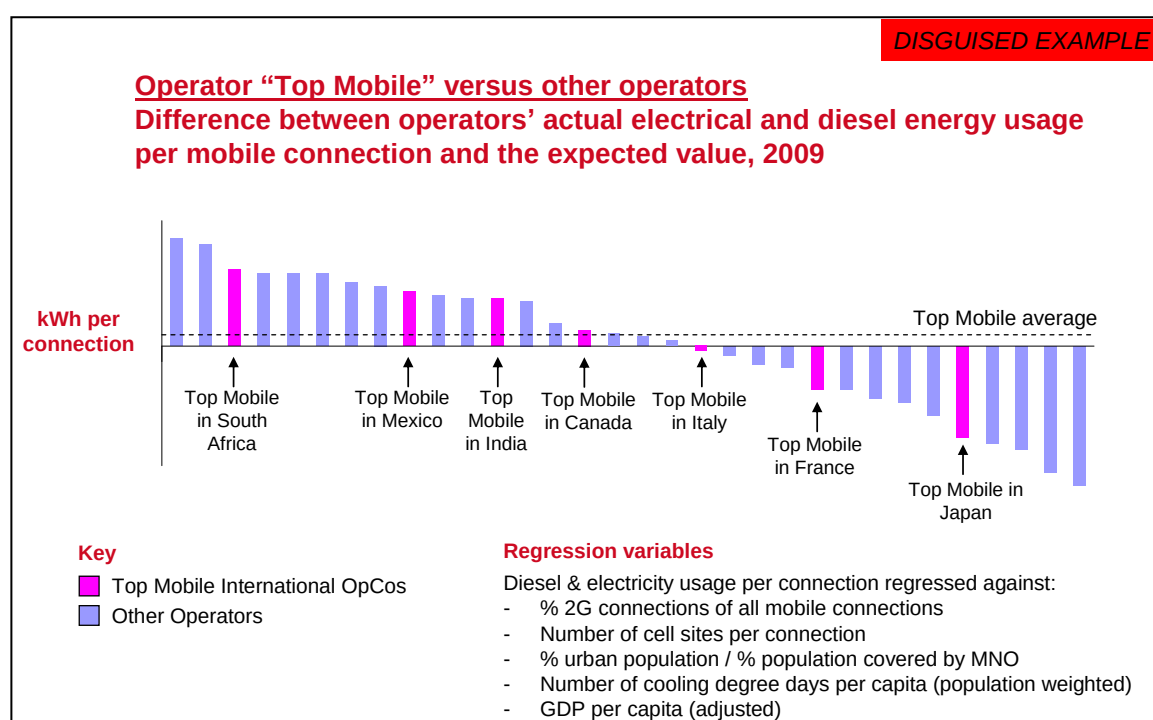
Step 6: Share anonymised benchmarking results with participant MNOs

A greater benefit comes from benchmarking against other operators, done on an anonymous basis to protect confidentiality. A larger data set allows for better analysis because the statistical significance increases and more variables can be used in the regression analyses. A larger data set also provides greater insight.

Participant MNOs agree to share data with other operators on an anonymised basis. The MNO participants will receive, for each benchmark, how their markets rank on energy efficiency against other MNO participants, including the benchmark values for each network. The anonymised data is fed back on a confidential basis using charts such as in Figure 7 below, showing the graphical feedback to an MNO with operations in seven countries.

The MNO will be able to use the results of the benchmarking against other MNOs to re-focus energy efficiency improvement initiatives and refine the potential for energy cost savings.

FIGURE 7: EXAMPLE ANONYMISED OUTPUT FOR FEEDBACK TO AN MNO



Source: MNOs, UN, GSMA data and analysis

The MNO participants agree in advance which results of the benchmarking can be made public. Participation is likely to lead to improved harmonisation in data gathering and sharing of good practice. This will increase the accuracy of the input data and therefore the benchmarking analysis.

Aggregated reports will be produced on an annual basis to demonstrate the industry's progress towards energy and GHG related commitments.

Contact details

Any MNOs wishing to participate in the service, or anyone with questions regarding this document, should contact Gabriel Solomon at gsolomon@gsm.org.

Information on the service is also provided at www.gsmworld.com/mee.

Appendix

Analysis of energy per connection

Energy usage will be a function of the number of cell sites; however, deploying cell sites in rural areas has different energy implications than deploying in urban areas, so it makes sense to treat the number of urban cell sites and rural cell sites as two independent variables. Energy consumption will also be a function of the number of 2G connections and of the number of 3G connections, since 2G and 3G customers will place different demands on the network (particularly data traffic), which in turn will have an impact on energy consumption. Other variables to consider are the number of cooling degree days, which affects the cooling load, the amount of network voice and data traffic, and GDP per capita, which influences network quality. By converting litres diesel into electrical energy generated by the diesel genset using a common generator efficiency value of 20%, we have taken into account the extent of diesel energy generation.

The initial analysis focused on a dataset with fewer than 60 MNO networks, so we restricted the normalisation to the five most significant variables in order to avoid mathematically spurious correlations. After trying numerous combinations, Equation 1 in Box 1 below shows how we have defined the five most significant variables which both impact energy per connection and also show a high degree of independence. However, we need to ensure that the variables we use in the normalisation are represented by datasets which are relatively easy for MNOs and the GSMA to collect; Equation 1 is developed further in Box 1, resulting in Equation 2, which we use to normalise energy per connection data.

Operator countries that have energy per connection greater than that calculated by Equation 2 in Box 1 above have a higher than expected energy consumption per connection. Those with a lower figure are performing better than would be expected, as a result of superior network design, more energy efficient equipment, a superior cooling technology, or a combination.

We look for results from the regression analyses that:

- Exhibit high correlations, or R^2 close to 100%;
- Have high degrees of statistical significance, i.e. p-value, for each variable;
- Make logical sense;
- Use input data which have high to medium levels of data confidence;
- Employ variables which are defined in such a way that a linear relationship is plausible.

Box 1: Hypothesis for Factors Influencing Energy per Mobile Connection

Equation 1: we could approximate energy per connection as:

$$\text{Energy per connection} \approx \frac{\left\{ \begin{aligned} &A \times (\# \text{ urban cell sites}) + B \times (\# \text{ rural cell sites}) + C \times (\# \text{ 2G connections}) \\ &+ D \times (\# \text{ cooling degree days}) \times (\# \text{ connections}) \\ &+ E \times (\text{adjusted GDP per capita}) \times (\# \text{ connections}) \end{aligned} \right\}}{\text{total connections}}$$

where energy is electrical and diesel energy consumption; connection is defined as MNO mobile connection; A, B, C, D and E are constants for a particular market; and # is number.

In a city, it is likely that the number of urban cell sites is constrained by capacity and therefore is simply a function of the number of connections (ignoring 2G/3G issues), so:

$$\# \text{ urban cell sites} \approx F \times (\# \text{ urban connections})$$

where F is a constant for a particular market.

And:

$$\frac{\# \text{ urban cell sites}}{\text{connection}} \approx F \times \frac{(\# \text{ urban connections})}{\text{total connections}}$$

But the number of urban connections may not be easy data for MNOs to collect. As an approximation, using readily available inputs:

$$\frac{\# \text{ urban cell sites}}{\text{connection}} \approx F \times \frac{\% \text{ country urban population}}{\% \text{ country population coverage}}$$

Similarly in a rural area, it is likely that the number of rural cell sites is a function of the area covered (and to a lesser degree the topography), so:

$$\# \text{ rural cell sites} \approx G \times (\# \text{ square kilometres covered})$$

where G is a constant for a particular market.

Equation 2: we can rewrite Equation 1 as:

$$\begin{aligned} \frac{\text{Energy}}{\text{connection}} \approx & H \times \frac{\% \text{ country urban population}}{\% \text{ country population coverage}} + I \times \frac{\# \text{ square kilometres covered}}{\text{total connections}} + C \times \frac{\# \text{ 2G connections}}{\text{total connections}} \\ & + D \times (\# \text{ cooling degree days}) + E \times (\text{adjusted GDP per capita}) \end{aligned}$$

where C, D, E, H and I are constants for a particular market.

Data capture sheet

	Mandatory fields
	Optional fields. Some data will be used to track issues of future importance, other fields will enable bespoke reports to MNOs who request more detailed feedback
	Calculated fields

Ref.	Parameter	Unit	Formula	Year ²³	By Country/Region/Province	
					Network 1	Network 2
1	Electrical energy consumption - mobile network operations					
1.1	Total electrical energy consumption ²	MWh	=1.2+1.3	2009		
1.2	Electrical energy consumption from Radio Access Network (RAN) ³	MWh		2009		
1.3	Electrical energy consumption from Core Network ⁴	MWh		2009		
2	Diesel energy consumption - mobile network operations					
2.1	Total diesel energy consumption ⁵	Litres		2009		
2.2	Total diesel energy consumption	MWh	=2.3+2.4	2009		
2.3	Diesel energy consumption from Radio Access Network (RAN) ³	MWh		2009		
2.4	Diesel energy consumption from Core Network ⁴	MWh		2009		
3	Mobile connections during calendar year⁶					
3.1	Average number of mobile connections ⁷	#		2009		
3.2	Average number of MVNO connections	#		2009		
3.3	Average number of machine to machine connections	#		2009		
4	Cell Sites					
4.1	Average number of Cell Sites ⁸	#		2009		
4.2	Total number of Technologies on Cell Sites ⁹	#		2009		
4.3	Number of on-site renewable energy powered Cell Sites	#		2009		
4.4	Approximate average age of kit	years		2009		
4.5	Approximate % of Cell Sites with air-conditioning	%		2009		
5	Mobile voice and data traffic¹⁰					
5.1	Net minutes of voice use ¹¹	Minutes		2009		
5.2	Inbound roaming voice minutes	Minutes		2009		
5.3	MVNO voice minutes	Minutes		2009		
5.4	Other voice minutes (e.g. non-completed calls)	Minutes		2009		
5.5	Gross minutes of voice use ¹²	Minutes	=5.1+5.2+5.3+5.4	2009		
5.6	Voice bandwidth ¹³	Kbps		2009		
5.7	Data traffic including SMS and MMS ¹⁴	Gbytes		2009		
5.8	SMS and MMS data traffic ¹⁵	Gbytes		2009		
6	Coverage					
6.1	Coverage of GSM/GPRS by % population	%		2009		
6.2	Coverage of GSM/GPRS by % geographical area	%		2009		
6.3	Coverage of 3G by % population	%		2009		
6.4	Coverage of 3G by % geographical area	%		2009		
7	Revenue					
7.1	Revenue of mobile operations ¹⁶	€m		2009		
7.2	MVNO Revenue	€m		2009		
8	Energy prices					
8.1	Average electricity price	Currency/kWh		2009		
8.2	Average diesel price	Currency/litre		2009		
9	Other energy consumption					
9.1	Electrical energy consumption from Data Centres ¹⁷	MWh		2009		
9.2	Electricity consumption from offices and call centres	MWh		2009		
9.3	Diesel energy consumption from Data Centres ¹⁷	MWh		2009		
9.4	Diesel consumption from offices and call centres	MWh		2009		
9.5	Gas consumption from offices and call centres	MWh		2009		
9.6	CO ₂ e emissions from staff travel	tonnes		2009		
10	Other indicators					
10.1	Electrical energy consumption from on-site renewables ¹⁸ (which should be included in totals in 1 above)	MWh		2009		
10.2	Electrical and diesel energy consumption from shared Cell Sites ¹⁹ (which should be included in totals in 1 and 2 above)	MWh		2009		
10.3	Average number of Femtocells ²⁰	#		2009		
11	Energy data accuracy					
	Level of confidence in the electrical and diesel energy data			2009		
11.1	(High / Medium / Low) ²¹			2009		
11.2	Please explain how the electrical and diesel energy data is collected by country ²²			2009		

Note #	Term	Definition
1		Minority and majority owned networks should be submitted only once to the GSMA. All parameters for minority and majority owned networks should be provided on a like-for-like basis for 100% of the business. If parts of the network are outsourced or leased (e.g. outsourced network functional elements, lease lines for transport) then this energy consumption should be also accounted for.
2	Total energy consumption	Electrical Energy consumption from Radio Access Network (RAN) plus Core Network.
3	RAN energy consumption	Energy consumed by Radio Access Network (RAN). This includes BTS, Node B and eNode B energy usage and all associated infrastructure energy usage such as air-conditioning, inverters and rectifiers. It includes energy usage from repeaters and all energy consumption associated with backhaul transport. It excludes picocells, femtocells and Core Network energy usage, as well as mobile radio services such as TETRA. Mobile Network Operators (MNOs) should include an estimation of the proportion of energy consumption from shared Cell Sites, including the shared proportion of infrastructure (DC, air-conditioning, etc.) if it cannot be measured.
4	Core Network energy consumption	Energy consumed by Core Network. This includes the RNC, BSCs, MSC (or MSC-S and MGW), SGSN, GGSN, HLR (including AuC), SMS-C, MMS-C, MME, Serving Gateway and all associated infrastructure energy usage such as air-conditioning, inverters and rectifiers. It includes energy usage from NOCs and Value Added Services platforms and all energy consumption associated with backhaul transport. It excludes energy usage from BSS and OSS systems, call centres and offices. Where core network infrastructure is shared between different country networks, (eg an SMSC located in one country serves several countries' operators), MNOs should allocate the energy used to each network proportional to the number of connections.
5	Diesel energy consumption	Energy consumed by diesel generators used to power RAN and Core Network. This includes prime and standby diesel energy usage from RAN and Core Network, but does not include diesel consumption from travel, delivery trucks or buildings which are unrelated to the network. Where diesel usage is negligible then this section should be left blank.
6	Mobile connections	Total number of SIMs or, where SIMs do not exist, a unique mobile telephone number that has access to the network for any purpose (including data only usage), except telemetric applications. SIMs that have never been activated and SIMs that have not been used for 90 days should be excluded. Total number of SIMs includes wholesale SIMs but excludes mobile Machine to Machine (M2M) connections.
7	Average number of mobile connections	Number of mobile connections averaged over the calendar year, equal to [connections on 1st January + connections on 31st December]/2.
8	Average number of Cell Sites	Number of physical Cell Sites averaged over the calendar year, equal to [Number of Cell Sites on 1st January + Number of Cell Sites on 31st December]/2. A Cell Site includes a BTS and/or a Node B and/or eNode B. Femtocells, repeaters and picocells are excluded. A co-located site (e.g. 2G or 3G) equals one Cell Site.
9	Total number of Technologies on Cell Sites	Averaged over the calendar year and equal to [Number of Technologies on 1st January + Number of Technologies on 31st December]/2. For example a co-located site with two 2G layers (900 MHz and 1800 MHz), 3G and LTE counts as four Technologies. Where Cell Sites have active sharing, the number of technologies is divided by the number of MNOs actively sharing those technologies.
10	Mobile voice and data traffic	Traffic should be measured using SI units, i.e. 1 kilobit is 1000 bits, not 1024 bits.
11	Net mobile voice minutes	Minutes used by the MNO's customers, both outbound and inbound. On-network minutes, i.e. calls within an MNO's network, are only included once (outbound) and promotional minutes are also included. Minutes not associated with the MNO's mobile customers (inbound roaming, MVNOs, interconnection of third parties, wholesale minutes and other business lines) are excluded.
12	Gross mobile voice minutes	Total minutes used on the Network, equal to [Net mobile voice minutes + Inbound roaming voice minutes + MVNO voice minutes + Other voice minutes (e.g. non-completed calls)].

13	Voice bandwidth	Average bandwidth per voice bearer across the network. The voice bandwidth figure is used to convert mobile voice minutes into bytes of mobile voice traffic. If operators do not know this figure, the GSMA will estimate it.
14	Data traffic including MMS and SMS	The gross data traffic from the radio interface, both uplink and downlink, including traffic generated by MMS and SMS. This also includes MVNO, wholesale and roaming customers' data consumption.
15	SMS and MMS data traffic	Data traffic from all types of MMS and SMS. This also includes MVNO, wholesale and roaming customers' data consumption.
16	Revenue of mobile operations	All revenues from mobile operations including recurring service revenues (e.g. voice, messaging and data) and non-recurring revenue (e.g. handset sales) as well as MVNO, wholesale and roaming revenues. It excludes fixed line and fixed broadband revenues.
17	Data Centres' energy consumption	Energy consumed by Data Centres, which is the physical site that hosts the MNO's IT, including OSS and BSS and intranet infrastructure
18	On-site renewables	On-site self-generated renewables are zero carbon in use energy sources located at the Cell Site, and include solar and wind. On-site renewably generated energy used to power operations outside the network should not be included (e.g. export to third parties).
19	Energy consumption from shared Cell Sites	Shared Cell Sites are sites where more than one MNO shares the site. MNOs should estimate the proportion of energy consumption from shared cell sites, including the shared proportion of infrastructure (DC, air-conditioning, etc.) if it cannot be measured.
20	Number of Femtocells in use	Equal to [Number of Femtocells in use on 1st January + Number of Femtocells in use on 31st December]/2 where a Femtocell is a small cellular base station, typically designed for use in a home or small business.
21	Confidence levels	High confidence: e.g. smart meters installed on over 50% of Cell Sites. Medium confidence: e.g. data based on invoices received for 50% or more of Cell Site consumption with the average energy consumption of those 'invoiced' Cell Sites used to estimate the remaining consumption. Low confidence: e.g. data based on invoices received for less than 50% of Cell Site consumption with the average energy consumption of those 'invoiced' Cell Sites used to estimate the remaining consumption.
22	Data collection methodologies	For example, this could be: RAN - electrical energy data based on invoices received for 60% of Cell Site consumption with the average energy consumption of those 'invoiced' Cell Sites used to estimate the remaining consumption; RAN diesel energy data based on an estimated 75% of total litres of diesel purchased.
23	Calendar year	1st January to 31st December.

Glossary

A/C: Air Conditioning.

AuC: Authentication Centre.

BSC: Base Station Controller.

BSS: Business Support Systems.

BTS: Base Transceiver Station.

Cell site: The physical location where BTS equipment is sited.

CIESEN: Centre for International Earth Science Information Network.

EIR: Equipment Identity Register.

Emerging markets: Business and market activity in industrialising or emerging regions of the world.

Emission factor: A factor allowing greenhouse gas emissions to be estimated from a unit of fuel or electricity consumed (e.g. litres of fuel consumed).

eNode B: 4G equivalent of a BTS.

GGSN: Gateway GPRS Support Node.

Global e-Sustainability Initiative (GeSI): An international strategic partnership of ICT companies and industry associations committed to creating and promoting technologies and practices that foster economic, environmental and social sustainability and drive economic growth and productivity. Formed in 2001, GeSI fosters global and open cooperation, informs the public of its members' voluntary actions to improve their sustainability performance and promotes technologies that foster sustainable development. It partners with the United Nations Environment Programme (UNEP) and the International Telecommunication Union (ITU).

Greenhouse gases (GHGs): These are the gases covered by the Kyoto Protocol: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF₆). The unit of GHG is carbon dioxide equivalent (CO₂e) which describes how much global warming a given type and amount of a GHG may cause, using the functionally equivalent amount of carbon dioxide (CO₂) as the reference.

GSM: Global System for Mobile communications, an open, digital cellular technology used for transmitting mobile voice and data services.

HLR: Home Location Register.

IEA: International Energy Agency.

IP: Internet Protocol.

Kilowatt hour (kWh): Measure of energy.

KPI: Key Performance Indicator.

Linear regression: Analysis which mathematically models the relationship between an independent variable and a dependent variable by fitting a linear equation to observed data.

LTE: Long-Term Evolution (4G).

MGW: Media Gateway.

MME: Mobility Management Entity.

MMS-C: Multimedia Message Service Centre.

MNO: Mobile network operator.

Mobile connection: A SIM, or where SIMs do not exist, a unique mobile telephone number, which has access to the network for any purpose (including data only usage) except telemetric applications.

MSC: Mobile Switching Centre.

MSC-S: Mobile Switching Centre Server.

Multi-variable regression: Analysis which mathematically models the relationship between two or more independent variables and a dependent variable by fitting an equation to observed data.

NOC: Network Operations Centre.

Node B: 3G equivalent of a BTS.

Normalisation: The adjustment of a set of metrics or measurement to make them comparable by taking into account variations in certain external variables. For this energy efficiency benchmarking service, the adjustment is made using multi-variable regression.

OSS: Operations Support Systems.

PSTN: Public Switched Telephone Network.

p-value: The P-value gives the probability that the coefficient of the independent variable is zero, i.e. that the independent variable is useful in explaining the variation in the dependent variable. As an example the independent variable could be “% 2G connections of all mobile connections” and the dependent variable “Energy per connection”.

R²: The coefficient of determination. An R² of 90% means that approximately 90% of the variation in the dependent variable can be explained by the independent variable. The remaining 10% can be explained by unknown variables or inherent variability.

RAN: Radio Access Network.

RNC: Radio Network Controller.

SGSN: Serving GPRS Support Node.

SMS-C: Short Message Service Centre.

Subscriber Identity Module (SIM): Typically on a removable SIM card, it securely stores the service-subscriber key used to identify a subscriber on mobile telephony devices (such as computers and mobile phones).

TETRA: Terrestrial Trunked Radio.

VAS: Value Added Service.

Watt (W): Measure of power.

WRI: World Resources Institute.

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The GSMA represents the interests of mobile operators worldwide. Spanning 219 countries, the GSMA unites nearly 800 of the world's mobile operators, as well as more than 200 companies in the broader mobile ecosystem, including handset makers, software companies, equipment providers, Internet companies, and media and entertainment organisations. The GSMA also produces industry-leading events such as the Mobile World Congress and Mobile Asia Congress.

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