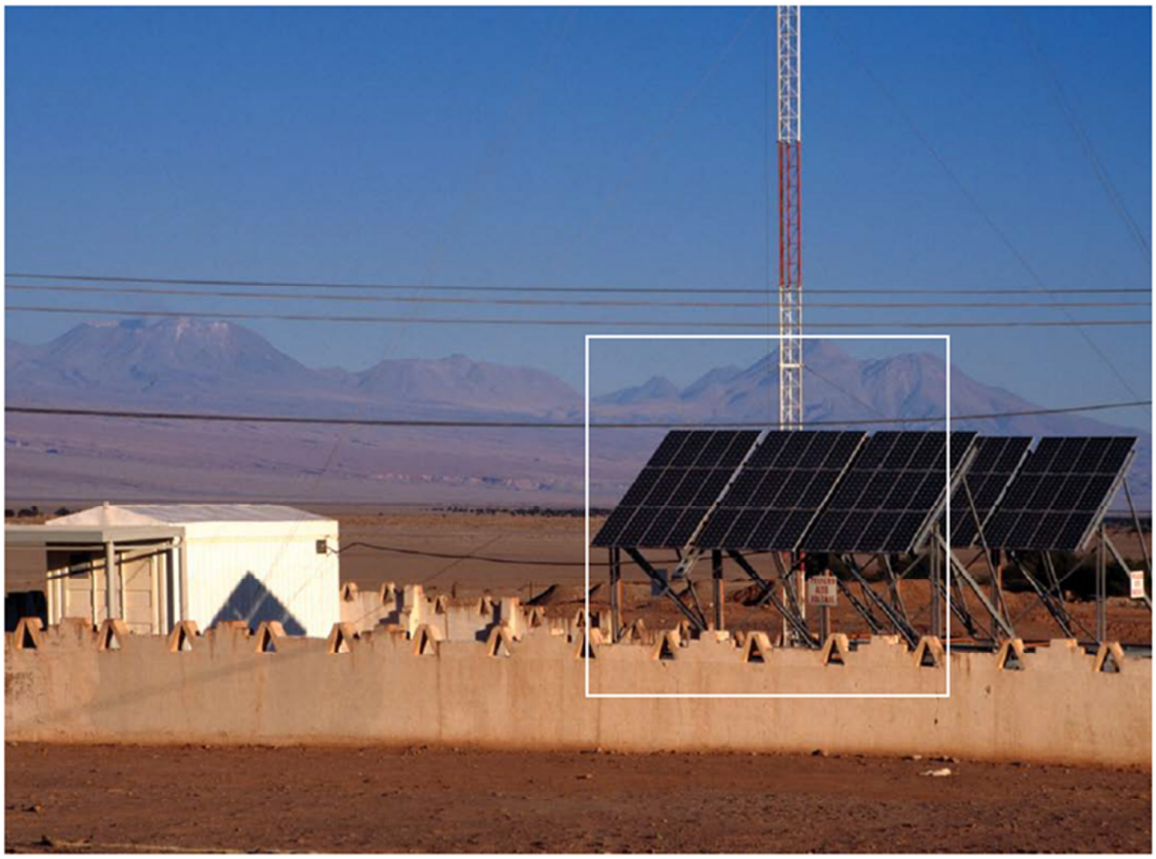
Arthur D. Little S.p.A.
Corso Sempione 66a
20124 Milan
Italy
Tel.: +39 02 673 761
Fax: +39 02 673 76251
www.adlittle.it

"Fixed Network Operators Energy Efficiency Benchmark"

A Report by the Global e-Sustainability Initiative



1. INTRODUCTION

About GeSI

The Global e-Sustainability Initiative (GeSI) is a strategic partnership of the Information and Communication Technology (ICT) sector and organisations committed to creating and promoting technologies and practices that foster economic, environmental and social sustainability. Formed in 2001, GeSI's vision is a sustainable world through responsible, ICT-enabled transformation. 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. GeSI has 31 members representing leading companies and associations from the ICT sector. GeSI also partners with two UN organizations - the United Nations Environment Program (UNEP) and the International Telecommunications Union (ITU) - as well as a range of international stakeholders committed to ICT sustainability objectives. These partnerships help shape GeSI's global vision regarding the evolution of the ICT sector, and how it can best meet the challenges of sustainable development. *(For more information, see www.gesi.org)*

Figure 1: Global eSustainability Initiative

Energy Efficiency (EE) is a top priority on the agenda of different stakeholders. The EU Commission Recommendation of October 2009 encourages ICT operators to develop a common framework and methodology to measure energy efficiency and set ambitious targets. Energy Efficiency and Carbon Management is becoming increasingly important for Telecom operators as well.

Current Telecom Operators' reporting methodologies are perceived not yet satisfactorily due to lack of standard and consistent Key Performance Indicators (KPIs). In fact, Fixed and Mobile operators use different methodologies for calculating energy consumptions and GHG emissions KPIs that are therefore not comparable. No mechanism is at today available to provide Fixed and Mobile Operators with standardized benchmarks with whom assist their energy and emissions reduction activities.

The GeSI EEWG and the GSMA decided to support fixed (GeSI) and mobile (GSMA) Telco operators to develop a framework of standard energy efficiency KPIs. In particular, main objectives of GeSI study can be summarized as follow:

- Identify standard energy efficiency KPIs for Telco operators
- Conduct a pilot benchmarking exercise to test, fine-tune and validate the proposed standard
- Provide a tool-kit to be used by FNOs to monitor EE performances in time
- Create the basis for an EE Best Practices platform
- Demonstrate FNOs commitment to Sustainability and Energy Efficiency

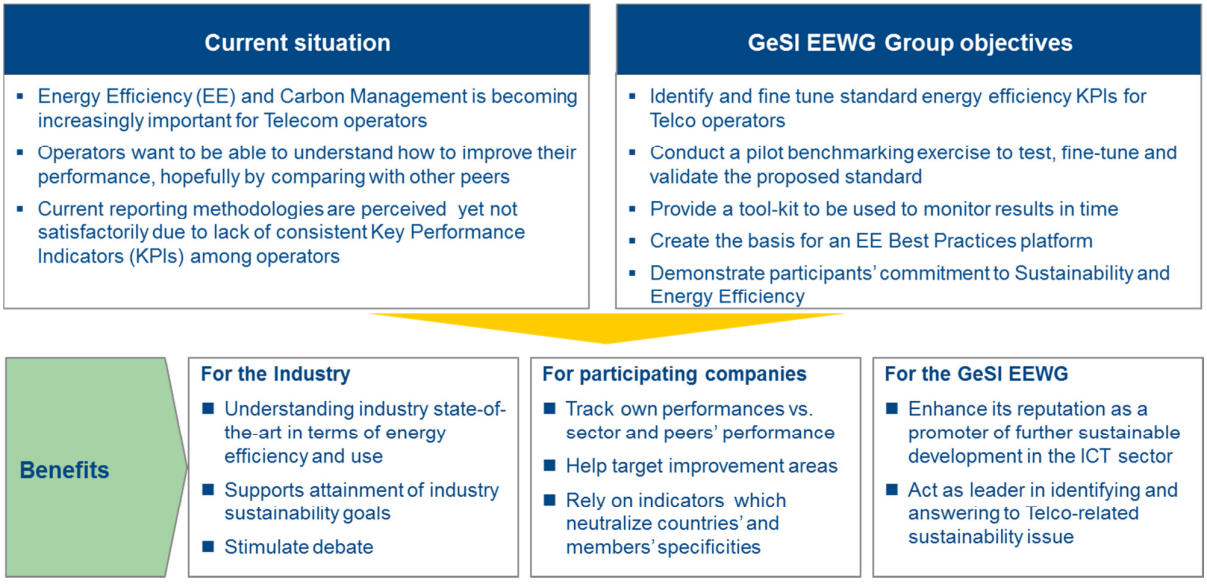


Figure 2: GeSI EEWG Objectives

Overall approach for FNOs EE Benchmarking

The benchmark exercise's overall approach foresees a three step analysis, aiming at progressively deepening the study and fine-tuning the methodology.

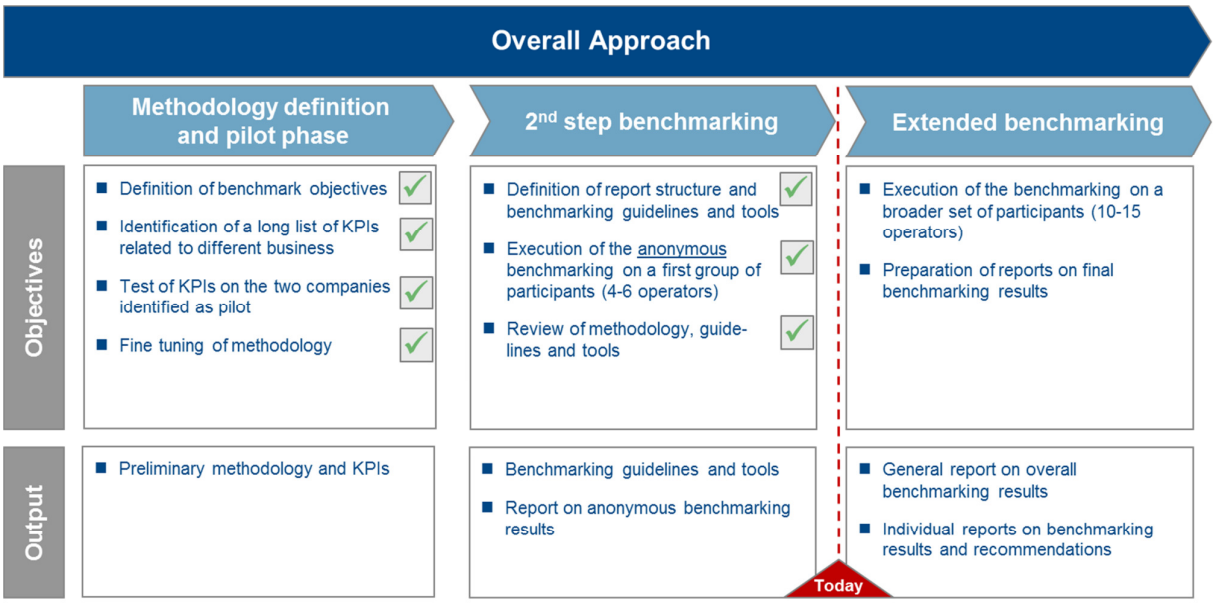


Figure 3: Overall benchmarking approach

The present document's scope is to describe main outcomes from the second step benchmarking phase, ended in March 2012. It is divided in 3 sections:

- Benchmark methodology and results
- Open debates from second step benchmarking phase
- Lesson learned and future developments

2. BENCHMARK METHODOLOGY AND RESULTS

The second phase of the FNOs benchmark study involved five European incumbent operators and analyzed three energy efficiency KPIs.

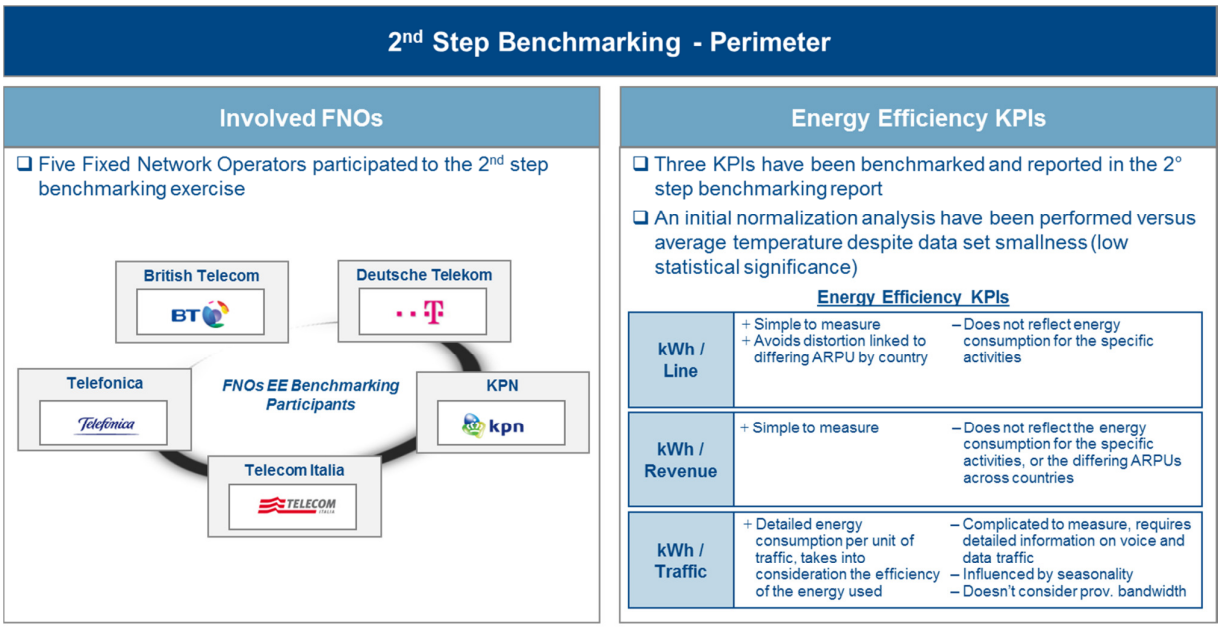


Figure 4: Second step benchmarking participants and KPIs

2.1 Energy Efficiency KPIs methodology

Three energy efficiency KPIs analyzed during the second step benchmarking are:

- KWh per access line
- kWh per revenue (€)
- Kwh per traffic (Pbit)

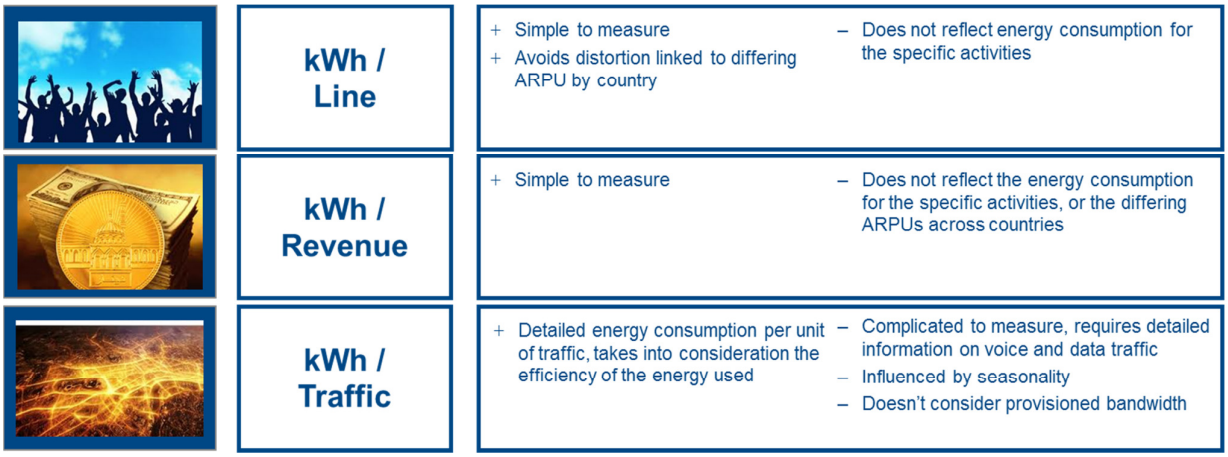


Figure 5: FNOs Energy Efficiency KPIs

Main assumption on data used to calculate EE KPIs can be summarized as follow:

kWh: FNOs energy consumption related to:

- Equipment dedicated to fixed voice services and Fixed BB services plus shared equipment
- IT data centers allocated to Fixed Network (it includes housing and hosting and cloud computing services)

Access lines: Access lines taken into account refer to the same period of observation of energy consumption. They refer to:

- Retail and Wholesale Fixed Voice services (as released in FNOs' investor relation website)
- Retail and Wholesale Fixed BB services (as released in FNOs' investor relation website)

Revenues: Revenues taken into account refer to the same period of observation of energy consumption. They refer to:

- Retail and Wholesale Fixed Voice and Fixed BB services (as released in FNOs' investor relation website)
- IT services (housing, hosting and cloud computing)

Traffic: Traffic volumes taken into account refer to the same period of observation of energy consumption. They refer to:

- Data traffic volumes in Pbit
- Voice traffic volumes in Pbit (estimated assuming an average energy use of 77 kb per second[1])

[1] Souce: Intelec 2007; Eco-Efficiency Indicator: an Operator's energy performance Indicator

2.2 Benchmark main results

As illustrated below the identified Energy Efficiency KPIs allowed tracking sector performances with no disclosure of Participants data.

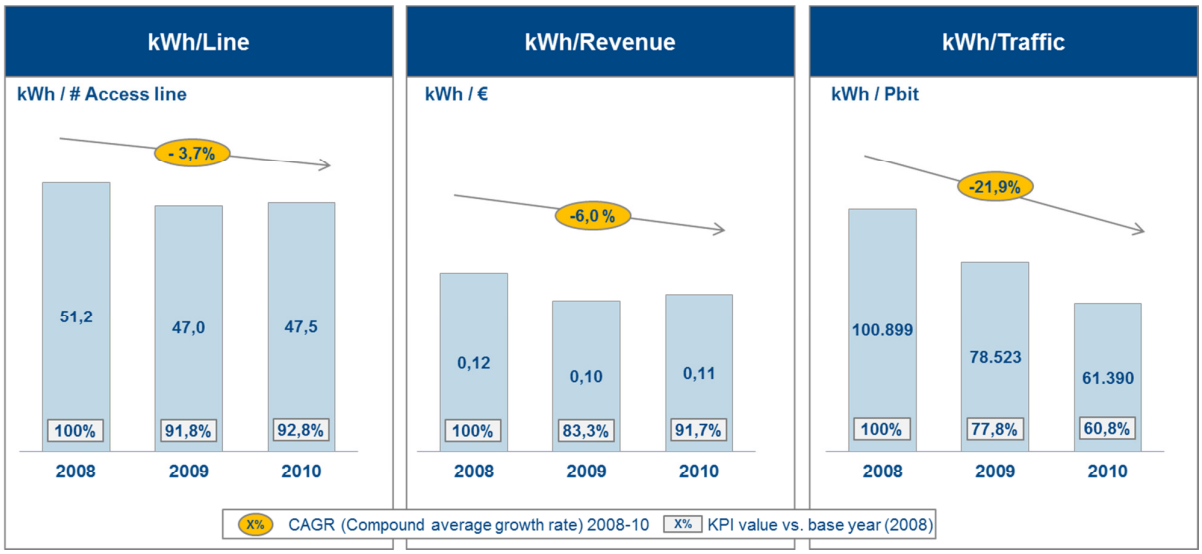


Figure 6: FNOs Energy Efficiency performances 2008-2010

1. kWh per access Lines:

Despite the slight decrease of the overall fixed access lines (Voice and Broadband) between 2008 and 2010, which is mainly due to Fixed-Mobile substitution, the kWh per access line KPI show a trend of reduction in the same period.

Future trends are still unpredictable given the uncertain outcome of the combination of many factors that will affect Fixed Networks development such as further equipment efficiency, denser networks and migration o NGAN.

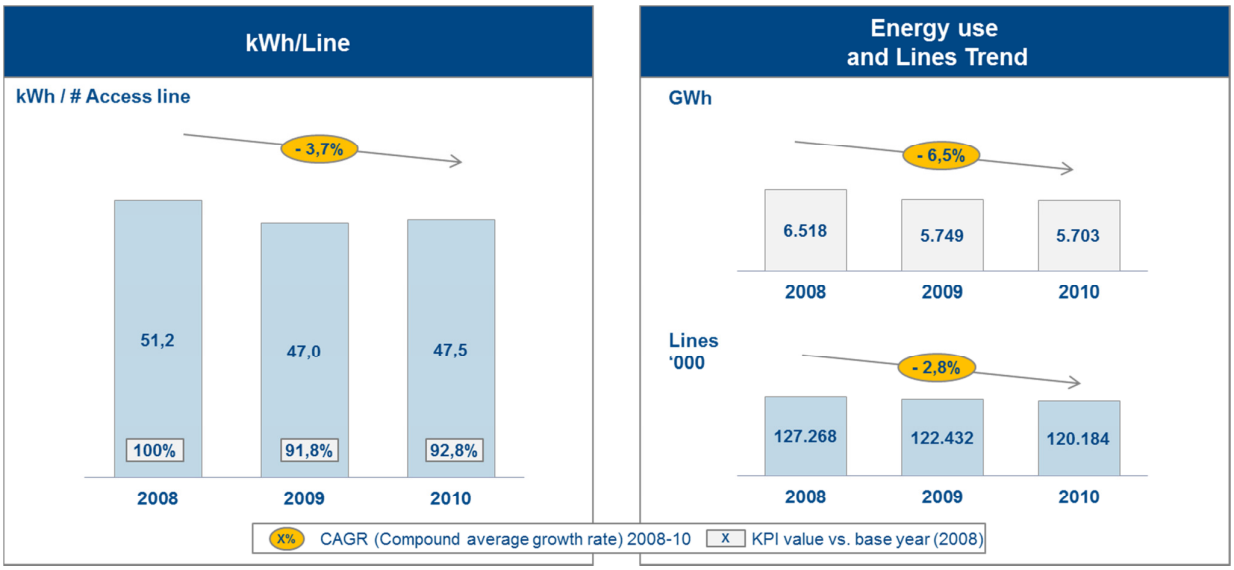


Figure 7: FNOs kWh per access line KPI 2008-2010

2. kWh per revenue

kWh per € of revenue KPI show a decreasing trend as well between 2008 and 2010, but appear to be mainly driven by FNs revenues trend.

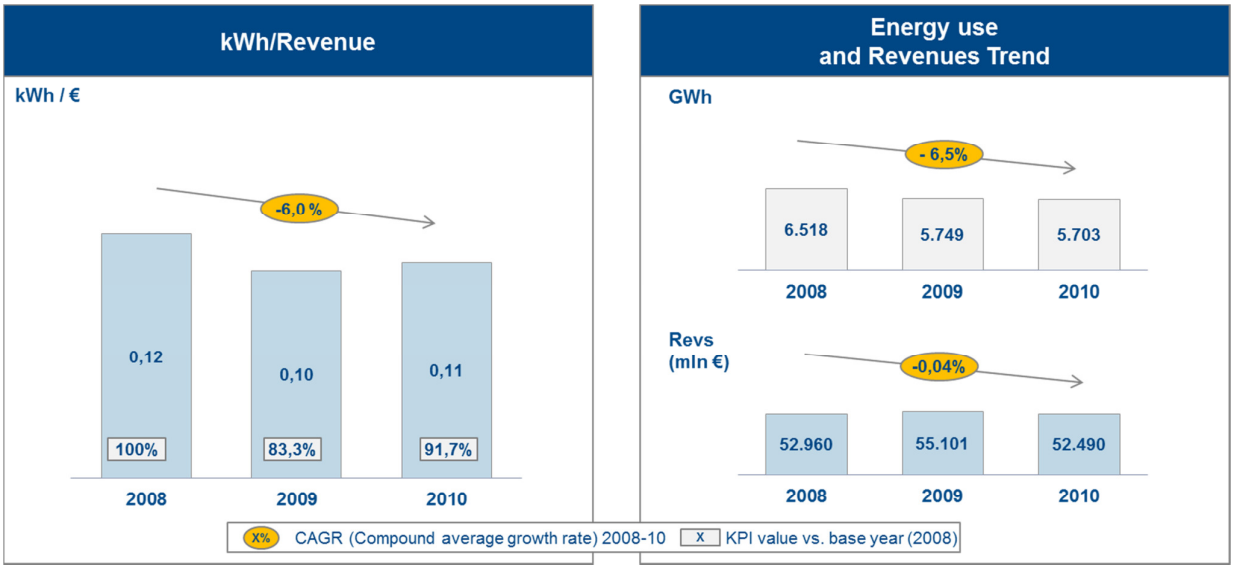


Figure 8: FNOs kWh per revenue KPI 2008-2010

3. kWh per traffic data

The kWh/Traffic KPI trend shows a significant decrease. In the analyzed period, we see a strong increase of traffic volumes without an equally important increase in energy consumption.

Traffic analysis from other sources suggests that increase in traffic mainly depends from increase of internet usage for browsing, mails, social networks, internet videos sharing (YouTube, Skype, etc.) while IPTV is still at an initial stage.

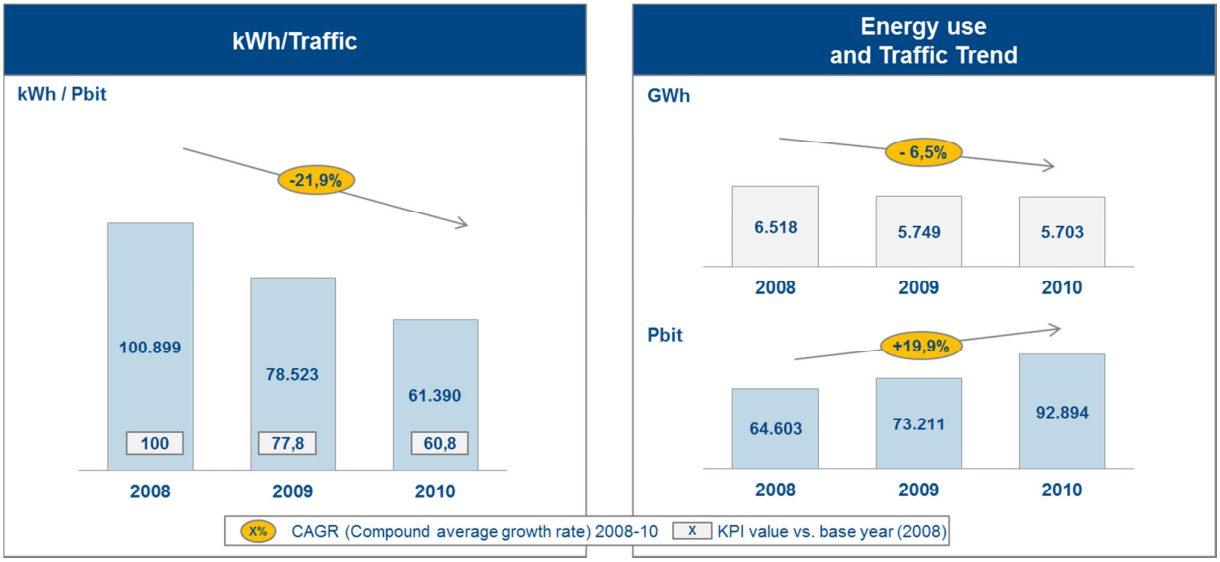


Figure 9: FNOs kWh traffic KPI 2008-2010

IT Consumption

IT share of total fixed network energy use show a slightly growing trend between 2008 and 2010.

Part of this increase is driven by the increase IT services offerings (Housing and Hosting) by FNOs to 3rd parties.

As the Cloud Services annual growth between 2010 and 2013 is expected to be of about 26%, IT related energy consumption is expected to have an increasing weight on the energy consumption of FNOs.

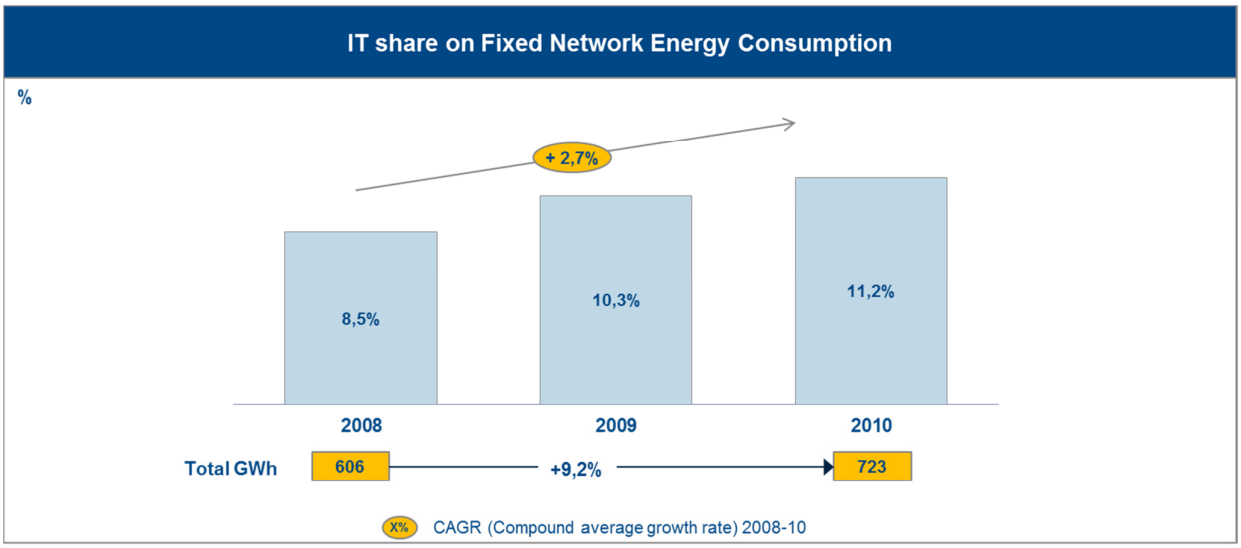


Figure 10: IT Consumption

Overall, the analyzed data highlighted relevant gaps between low and high performers' KPIs. Nevertheless Low and High performers' KPIs' trends appear similar between 2008 and 2010.

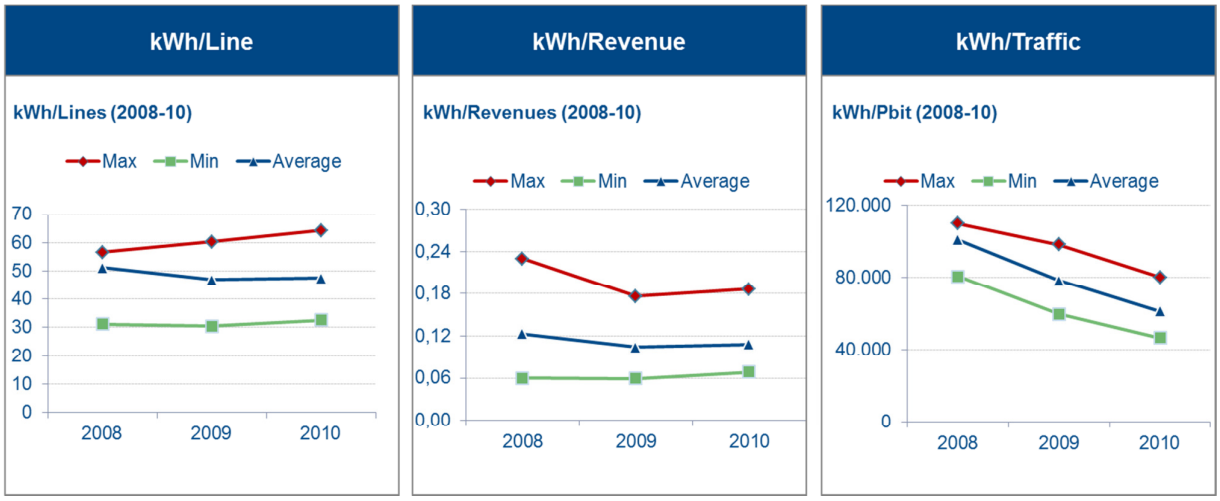


Figure 11: Energy Efficiency High vs. Low performers

2.3 Normalization analysis

Large spread between different FNOs KPIs (highlighted in the report) can be explained by differences in country, market and technology factors which are not under the control of the energy managers. If the overall objective is to compare FNOs networks across countries, benchmarking against energy KPIs can be insightful but a "normalization" process is needed in order to

- allow the analysis to account for factors outside an FNO‟s control
- provide a more like-for-like comparison

A first exercise of normalization (linear regression) has been done taking into consideration average temperature as independent variable.

Nevertheless, data set smallness didn't allow to perform a normalization statistically significant (low regression R2).

More variables should be used for a normalization with a larger data set, in order to ensure statistical significance of the results and get greater insights from the analysis. In particular, normalization analysis have to be deepen considering:

- a larger panel of FNOs
- more normalization factors as independent variables of the regressions (multi-variable regression)

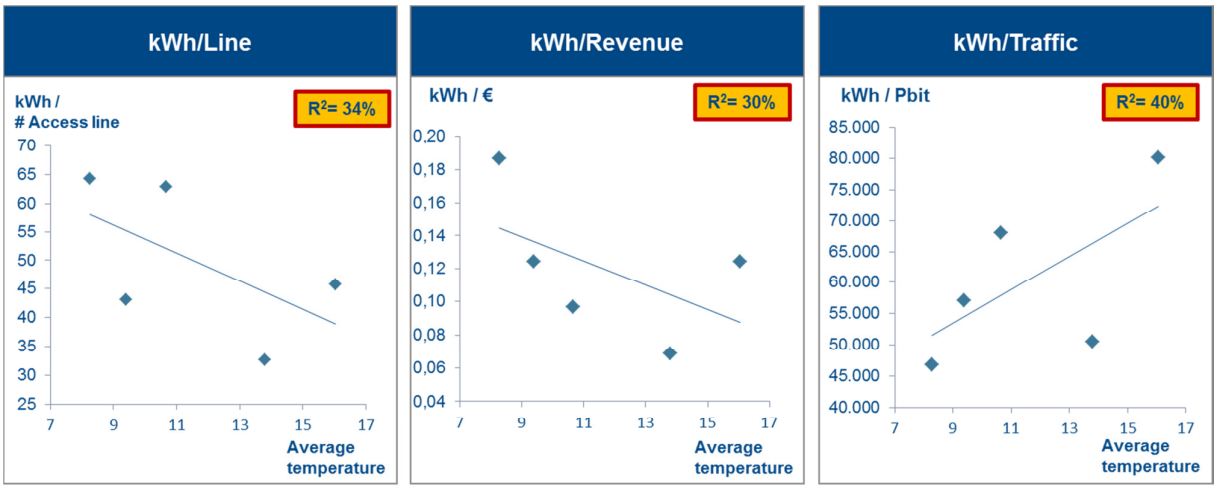


Figure 12: Normalization's results

Despite low statistical significance, normalization analysis allowed to explain part of the large spreads between low and high performance FNOs.

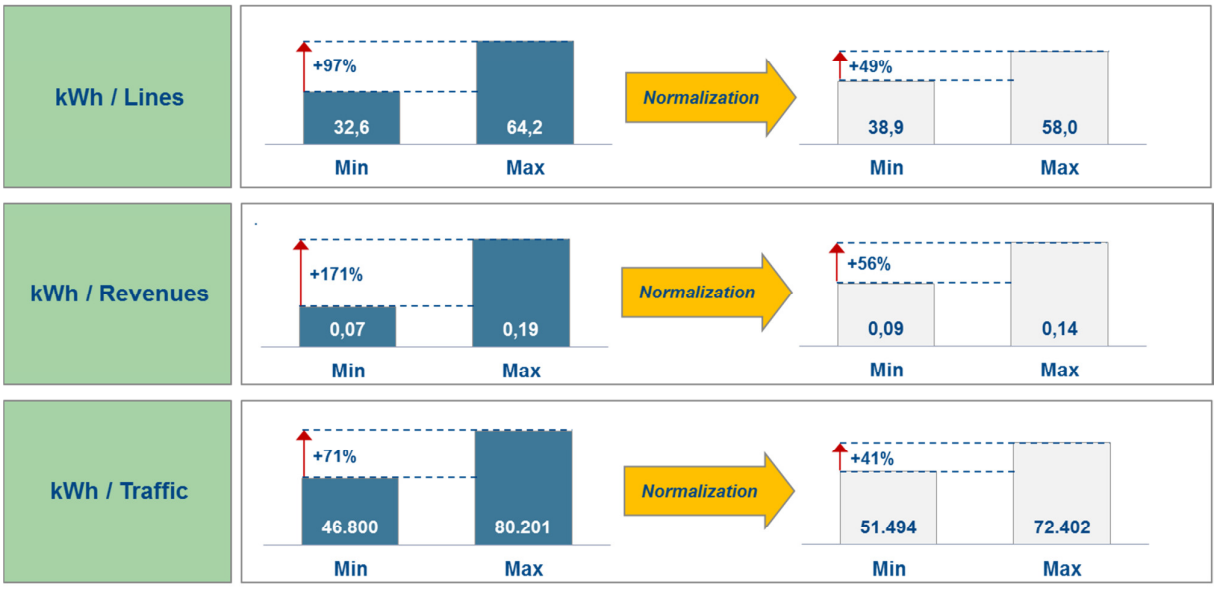


Figure 13: Normalization's results – Low and High performers

Normalized overall EE KPIs as well as their trends did not show substantial differences compared to the original data, except for a slight slowdown in the decline of the kWh / Line KPI.

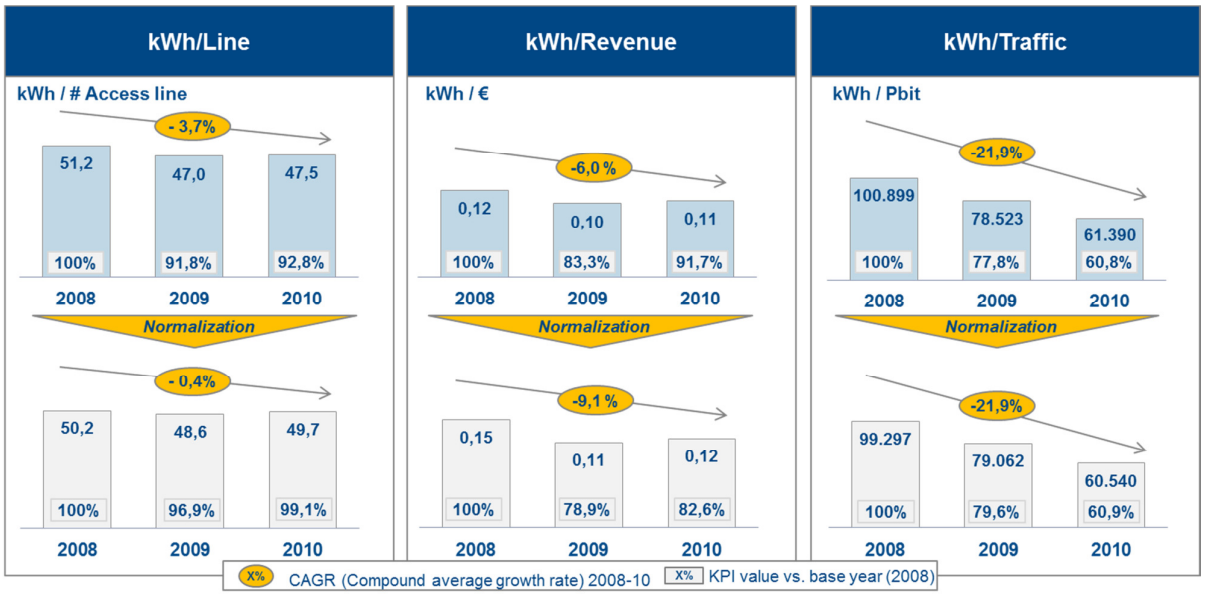


Figure 14: Normalization's results – Normalized vs. Original data trend

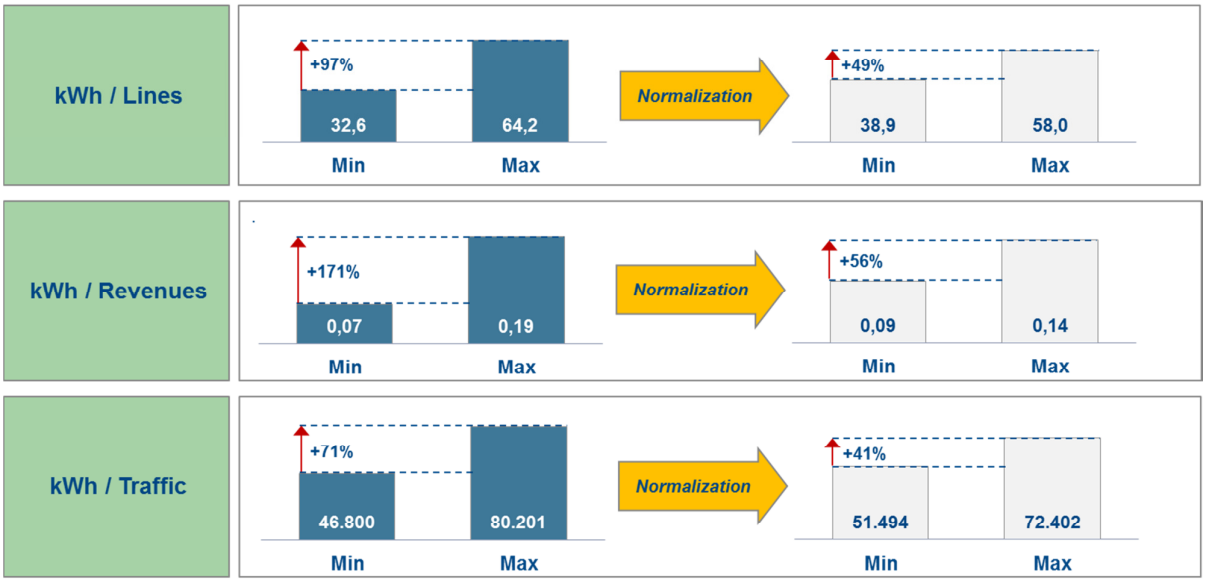
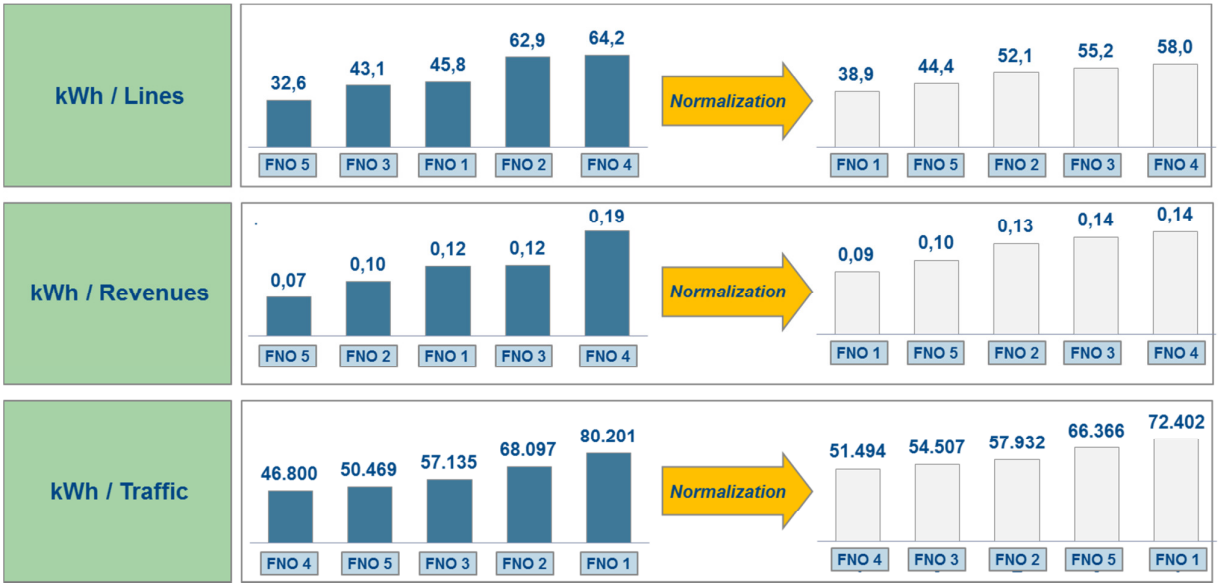


Figure 15: Normalization's results – Normalized vs. Original data – Low and High performers

On the other end, Participants normalized ranking showed differences compared to original data in all the analyzed KPIs.



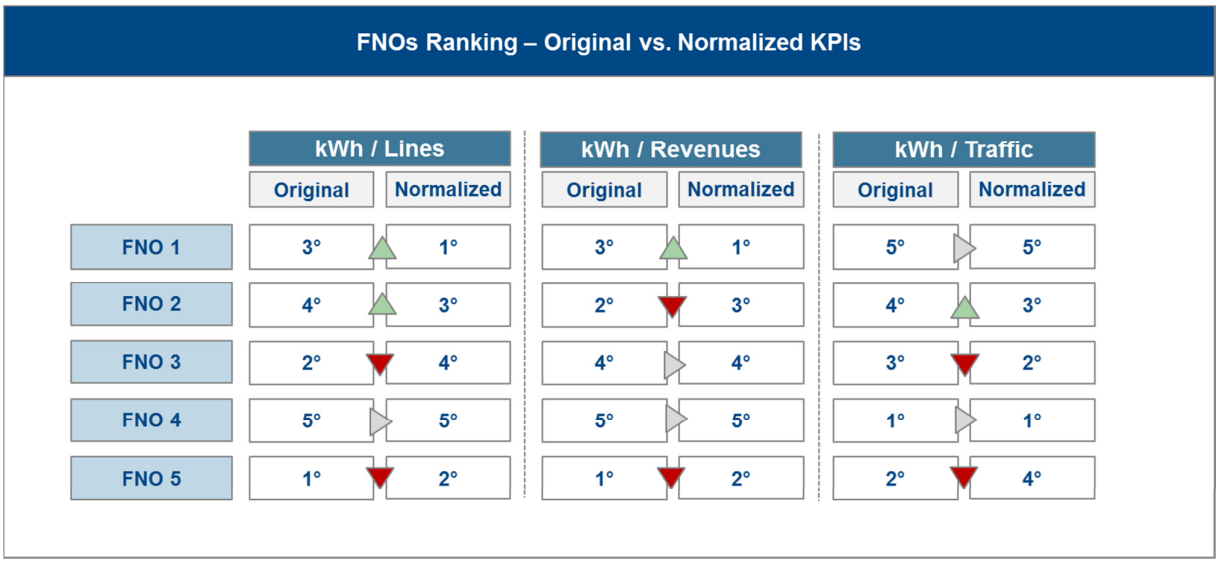


Figure 16 and 17: Normalization's results – FNOs ranking

3. OPEN DEBATES FROM SECOND STEP BENCHMARKING PHASE

Pilot benchmark exercise allowed highlighting and discussing several open debates, particularly regarding:

Objectives of the analysis:

- Which objective: measuring or identifying reduction best practices?

As highlighted during the benchmark exercise, the act of measuring is always linked to participants' specificities: replicating others' performance maybe wishful thinking. Furthermore, there is risk for "apple – orange comparison". For this reasons it was believed by some of the FNOs participants that sharing energy efficiency saving best practice would be more effective than measuring and comparing EE KPIs.

- Which scope: energy efficiency? energy use? CO_2 emissions? abatement potential?

Being energy efficient is not the same as saving energy / consumption (Energy efficiency KPIs can easily hide growth in energy use) and doesn't result in carbon footprint reduction. As the ultimate goal is Energy consumption and CO2 abatement, the exercise should have measured overall Energy Consumptions and CO2 emission rather than Operator's efficiency.

- Discontinuity track & monitor

Significant energy efficiency improvements can be achieved by dismantling legacy platforms and implementing NGAN. For this reason it's considered pointless to measure energy efficiency without

taking into consideration the radical changes affecting FNOs' business and operations, while what is important is to provide figures on the efforts to migrate from Legacy to NGAN, for example separating legacy network consumption form NGAN and future Cloud platforms.

Outcome use

- **Own vs. Sector performances**

"Will participants participate to a competition?"

"Should best practice (best KPI) win a price?"

"Should we otherwise derive sector goal from this exercise?"

Energy consumption data are sensitive as energy reputation may influence financial reputation. If the ultimate goal is to compare Operators' efficiency, any operator will be willing to win the price and this may jeopardize the real exercise objective.

- **Intra-sector vs. other sectors' performances**

Efficiency benchmark is not addressing Telecom sector's commitment to reduce its own consumption as well as other sectors' one by benefiting from ICT development. Efficiency benchmark appears more focused on intra-sector trends.

Methodology:

- **Unavailability of required data**

Most of Benchmark Participant does not measure energy and traffic data with the required breakdown details. Getting / estimating current unavailable / unpublished information requires the implementation of complex internal processes of data gathering as well as Top Management endorsement (especially when dealing with sensitive data).

- **Data inconsistency**

Data unavailability required estimation efforts and assumptions. Integrations' assumptions made during Pilot benchmark exercise in order to ensure results' comparability may lead to data inconsistencies.

- **Incomplete / uncertain perimeter**

It is difficult (impossible) to differentiate between RAN data and fixed wireline networks one and therefor calculate / estimate ICT consumption within Fixed Network. As highlighted by Benchmark participants, it may be possible to estimate the total bytes of data and energy use originating in the RAN, but it still does not account for the energy used by core equipment to handle wireless data.

Next steps debate

- **New KPIs**

The goal is to reduce energy use, increase efficiency, mitigate climate change and monitor improvement actions results. New KPIs should be evaluated in order to achieve main goals (e.g. Formula-based metrics are better able to identify areas for investigation)

- **Review of existing KPIs**

Existing KPIs need to be fine-tuned in order to:

- Increase data verifiability
- Optimize the perimeter
- Monitor discontinuities and exploit improvement potential

- **Normalization analysis**

Deepen the normalization analysis is crucial if we want to make different networks comparable as KPIs can be adjusted for variables outside the energy managers' control.

- **Benchmark process improvement**

It's worthwhile to create a permanent group of work focusing on Energy Efficiency analysis: periodic data collection, KPIs measurements, methodology fine tuning, new KPIs development. Secondly, network equipment vendors may be included in the analysis process and participate to the discussion.

4. LESSONS LEARNED AND FUTURE DEVELOPMENTS

Overall the GeSI table provided insightful contribution and allowed to identify guide-lines and suggestions for the benchmark process next phases.

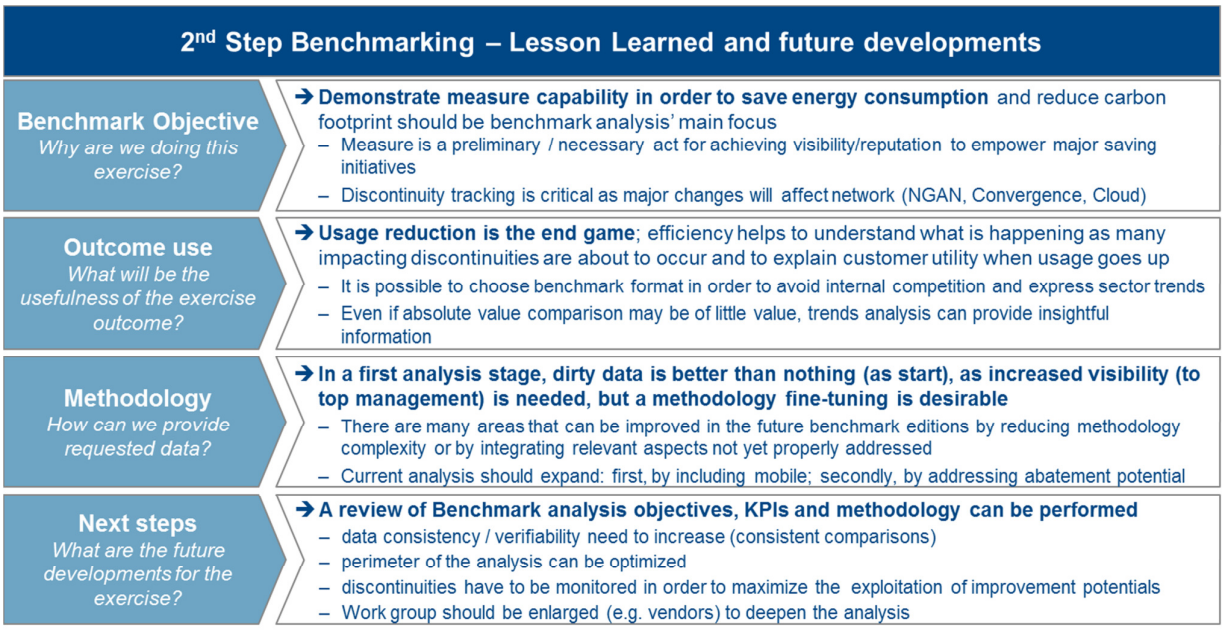


Figure 18: Lesson learned and future developments

Arthur D. Little believes that GeSI should insist in pushing the benchmark exercise as major structural changes (both on mobile and fixed sides) are about to modify the energy use horizon, such as:

- The adoption of efficiency equipment (from TDM to IP)
- The migration to NGAN (from copper to fiber)
- The development of cloud services (peripheral IT, network centered IT)
- The introduction of micro/pico/femto cellular networks (convergence, hyper mobility, hyper speed)

Drivers	Impact on energy use	Rationales
Adoption of efficient equipment *(from TDM to IP)*	↓	■ COC sets goals and roadmap for equipment efficiency
Migration to NGAN *(from copper to fiber, from TDM to IP)*	↑↓	■ Replacement of copper-to-fiber and TDM equipment –to-IP ■ Energy usages decreases due to: reduction of space requirements, reduced network elements, Zero-touch networks with remote maintenance, efficient IP over fiber equipment ■ NGAN overlay to copper impedes improvements in the first 3/5 years
Introduction of Cloud *(Peripheral IT, network centered IT)*	↑	■ Processing power and storage capabilities expected to migrate (or duplicate) into networks in the next 15 years ■ Energy usage attributed to Telcos will certainly increases
Introduction of micro/pico/femto cellular networks *(convergence, hyper mobility, hyper speed)*	↑	■ Mobile traffic is expected to growth at least 30% YoY in Western countries ■ Energy usage increases due to: additional mobile sites (likely +50% in the next 10 year), additional antenna layers (likely +300% in the next 10 years), others capacity increase techniques (more spectrum efficiency & MIMO, passive offload)

Figure 19: Telco industry trends impact on energy use

Main objective to be pursued during the next steps of Benchmark analysis is to fine-tune, consolidate and expand consensus on the standard methodology developed for Fixed Network Operators Energy Efficiency monitoring and to release a final extended benchmarking report.

ADL is keen to continue assisting GeSI in the final phase of the Fixed Telecom EE benchmarking process, leading to the consolidation of the methodology and the release of the extended report. In order to do that Arthur D. Little has identified three main tasks to be performed by the work group:

- Involve a large number of FNOs in order to expand the analysis
- Fine-tune the methodology and the perimeter though dedicated workshop with extended benchmark participants
- Review, finalize and release a new version of the EE Benchmark report

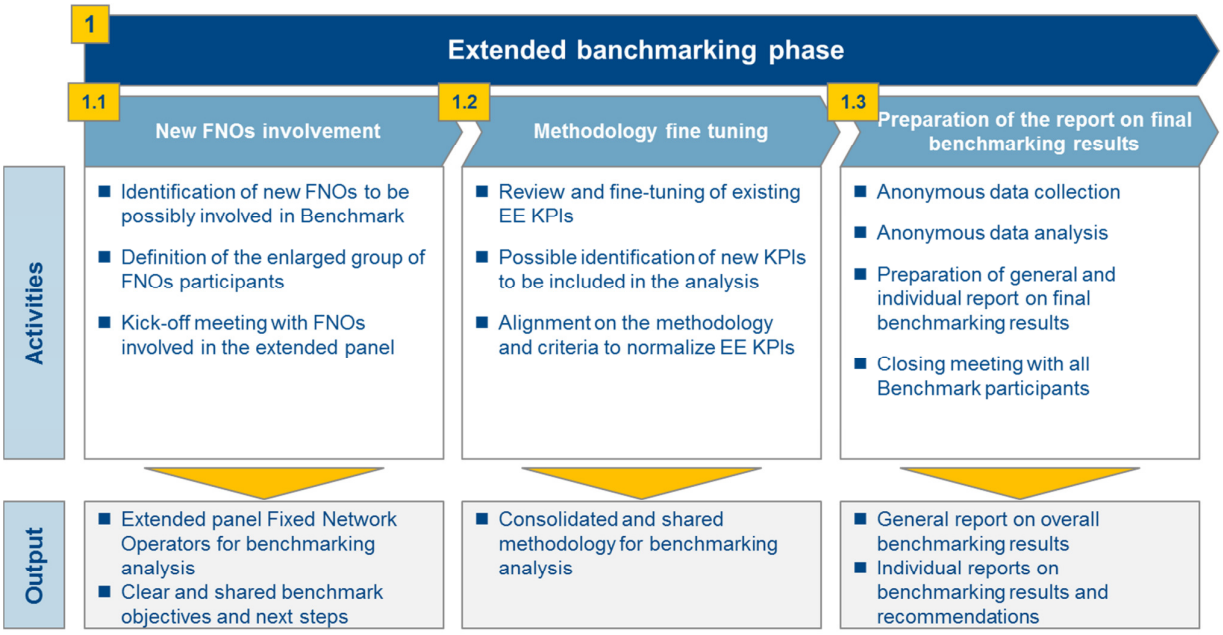


Figure 20: Extended benchmarking phase

The proposed approach described above aims at settling open debates highlighted during the 2nd phase and issuing a final extended version of the report, basing on a consolidated and shared methodology.