Energy Savings: a key challenge and opportunity in Mobile Networks

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Abstract

Telecom operators are some of the biggest energy users in the world, responsible for up to 3 percent of energy demand around the globe. Unsurprisingly, telecom energy usage—and the carbon footprint it leaves behind—is predicted to grow along with the rise in 5G technology and the increased traffic it is expected to bring.

Power Savings in mobile networks is becoming an area that most operators have or will have on their priority list for the foreseeable future. This is for several obvious reasons: energy prices are soaring, good corporate citizenship requires green initiatives, and based on the findings in this white paper, there is significant room for improvement in optimizing the power savings usage.

The technological building blocks are there: extensive power savings features provided by OEMs (original equipment manufacturers), AI-based agile decision-making machinery, and a way to measure and mitigate **customer impact**. However, putting all these technologies together and easily applying operator-specific strategies 24/7 in a multi-vendor and multi-technology environment is not trivial.

This paper discusses the problematics and concludes with practical recommendations and real-life examples of achieving the mentioned power savings. Bottom line: It is hard to argue against using the already developed features to their full extent – and this paper describes how to do it safely without a negative impact on customer experience.

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Situation today

The good news

Last couple of years have seen increased amount of news from operators on green initiatives, including more power-efficient products being sourced from the **OEMs** - in fact, earlier years between **2015** and **2021** have been heavy on modernization of base stations, which are known to be the main culprit of high-power consumption (source GSMA[1]).

Other worthy actions to mention include **Deutsche Telecom's** announcement to be sourcing 100% of their energy from renewables. A good list of other ICT green credentials can be found here[2].

The bad news

The perfect storm is happening to drive the energy bills up for operators: significant increases in per kWh prices together with rapidly increasing data consumption.

The data consumption is estimated by virtually all sources to have another step function with the adoption of 5G.

In addition, and according to Omdia research[3] only 16% of operators take advantage of embedded software functionality to reduce power consumption (that is to say, they do not use power saving features.)

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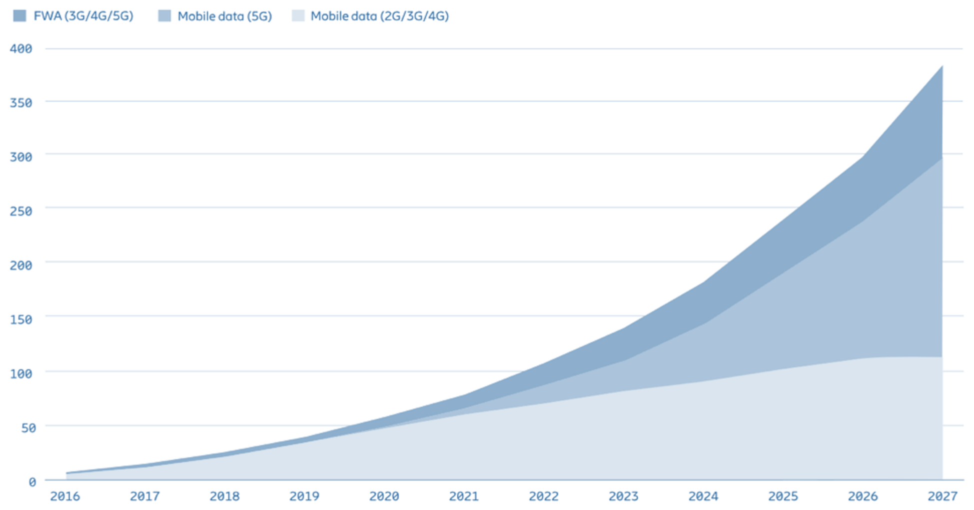
The facts

Energy costs constitute between 20% to 40% of all network OPEX (source: GSMA[1]) accounting for estimated 3 billion USD per year in the US and 7 billion in Europe (estimation based on Tupl's experience and report by Cable.co.uk[4])

One can make the case that the share is likely to increase further in the coming years, when considering the traffic projections (source: Ericsson[5]) of a 4x increase from 2021 to 2027 *(figure 1)*.

Figure 1: Global mobile network data traffic (EB per month)



Also, the mentioned GSMA study, based on data from seven operators, says RAN (Radio Access Network) consumes 73% of energy, while 13% is consumed for core, 9% for data centers, and 5% for the rest. While there is a significant effort in optimizing data centers and core network power usage, the RAN matters the most.

Costs are not the only concern, however. Telecom operators already account for 2 to 3 percent of total global energy demand, often making them some of the most energy-intensive companies in their geographic markets. As operators' energy consumption expands, so will their carbon footprint, hurting not just the environment but also their reputation and standing, particularly among the expanding class of socially responsible investors (source: McKinsey[6]).

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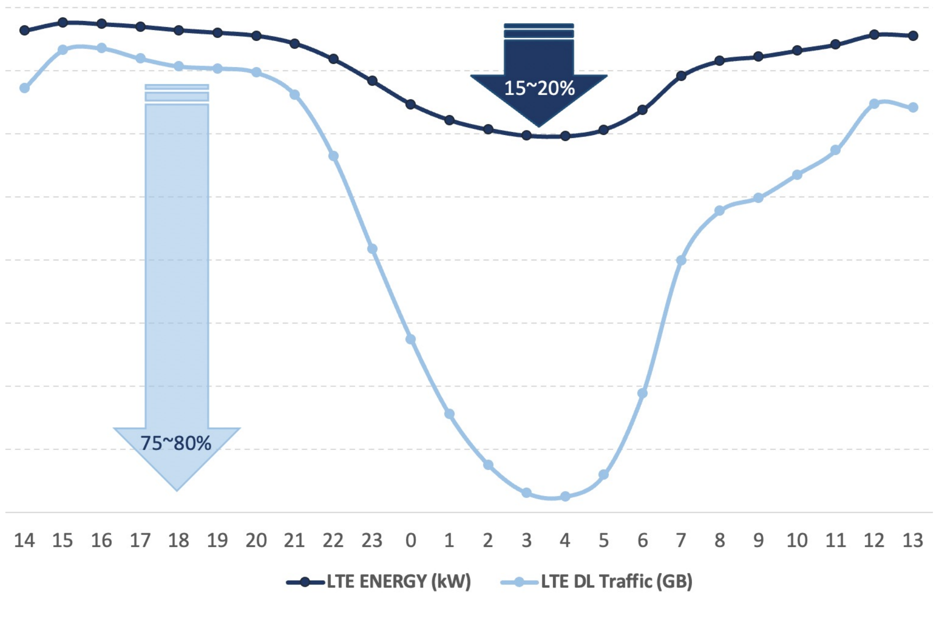
But this does not have to be the case. All mobile operators have considerable scope to cut energy costs and consumption. In current mobile networks, for example, transferring data only consumes around 15 percent of energy. Some 85 percent is wasted because of heat loss in power amplifiers, equipment kept idling when there is no data transmission, and inefficiency in systems such as rectifiers, cooling systems, and battery units (source: McKinsey[6]).

Based on a study done by Tupl (2021, 2022) from real networks, the image below (*figure 2)* shows how a RAN network typically behaves on energy consumption vs the traffic payload curve. **The opportunity for savings is clear - while the traffic volume reduces by 75%-80% (peak vs lowest hours), the energy consumption observed by accurate RAN counters only reduces by 15%-20%**. The writers of this white paper believe this is the single most powerful finding to show why the industry is driving to do more on power savings - opportunity is huge.

Figure 2: RAN Network Energy Consumption (kW) vs. Payload (GB)



As mentioned before, it is essential to note that at the time of writing this white paper (1Q2022), it is estimated that only around 16% of networks have any activation of OEM's Power Savings Features.

Let's first describe what these features are in more detail.

What are Power Saving Features

A Power Saving Feature (PSF) is a piece of software in one or more types of Radio Access Network (RAN) elements that provides specific functionality to reduce the energy consumption compared to the default performance of the equipment.

For a given OEM and radio technology (e.g., 5G) there are different types of PSFs depending on the radio procedure they aim to optimize.

Every large RAN OEM has an extensive set of PSFs. An example based on Ericsson's report [7] is shown below *(figure 3)*.

Figure 3: Examples of Ericsson's 4G and 5G Power Saving Features

Energy-saving feature	Capabilities: energy-saving mechanism
Micro Sleep tx (MSTx)	Automatically switches off the radio power amplifiers on a symbol-time basis, when no signaling or user data needs to be transmitted on downlink
Low Energy Scheduler Solution (LESS)	Reschedules downlink transmissions for non-critical data. Time-sensitive transfers, such as voice, are excluded, making sure the quality of service is never compromised.
MIMO Sleep Mode (MSM)	Deactivates power for a subset of the antenna branches. The feature automatically reconfigures from MIMO to SIMO mode and back, based on traffic load.
Cell Sleep Mode (CSM)	Turns off the power amplifier for a capacity cell when the total traffic is below a set threshold.
Massive MIMO Sleep Mode	Deactivates one or several M-MIMO antenna elements, depending on traffic needs.

Most of the PSFs provide a set of parameters to control the intensity of their actions, allowing to tune their behavior per cell or node level.

So why are MNOs not using PSFs to their full extent? Let's deep dive into this question in our next chapter.

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Why are MNOs not using Power Savings Features?

We have identified three main reasons why mobile operators might not be using PSFs:

Traditional focus on RAN performance

Mobile Network Operators (MNOs) have traditionally put all their effort on RAN performance, competing to be the top performers in their respective markets' benchmarks. This focus pushed the already developed OEM's Radio PSFs into the background. Most MNOs have been reluctant to activate radio PSFs at all, as almost all engineering departments are measured only by network KPIs. In case of PSFs, there is always a lingering doubt about whether there is an impact on the performance.

Transition from legacy technologies

Another issue is the transition between technologies, which discourages the investment of energy saving efforts in, on the one hand, technologies that will soon be disconnected (3G before 2G), and on the other hand, in the new technology (5G) whose current focus is on deployment and market adoption.

Lack of optimization of PSF capabilities

Finally, there is a more advanced matter, which is PSF optimization. It is possible to have PSFs active at every RAN site but, like any other radio feature, most of them can be optimized. PSFs can get activated with default settings. This one-size-fits-all approach may be conservative enough to create confidence that no single site or cluster is degraded across the entire network, but it falls short in most sites in the energy savings target.

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To conclude this section on a positive note, an estimated 16% of MNOs are indeed using some type of PSFs, which constitutes an improvement compared to the approach in which no power saving measures were considered.

Among the mobile operators, there is a growing awareness of the need to reduce energy consumption and timid attempts to do so. Of course, we are still far from a full acceptance scenario in which power saving features are fully implemented and continuously optimized.

However, every drop counts, and there is **a huge potential for energy savings** by ensuring that all possible actions are implemented and optimized. There are currently up to four technology generations consuming energy; even if some of them are going to be switched off soon, it is possible to cut down the consumption starting today.

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An ideal solution for controlling the energy consumption

The authors and contributors to this white paper have significant practical experience on this subject and are knowledgeable of the earlier optimal architecture references in the telecom sector, for instance, the role of decentralized SON, aka D-SON, vs Centralized SON, aka C-SON. One can consider OEM's PSFs to be closed-loop decentralized functions, while Power Saving "Orchestrator" continuously implements, with the help of AI, the right strategies and configurations to these features, all the way to the cell level. Analogously in Open RAN networks, PSFs correspond to x-Apps running at near-Real Time RIC (RAN Intelligent Controller), whereas Power Savings "Orchestrator" corresponds to r-App running at non-Real Time RIC.

Based on this experience, some recommendations are worth discussing to maximize the use of PSFs. These recommendations are based on three essential concepts:

AI is the way

As a mission statement, one can refer to the direct quote from a NGNM report: "*Here, Artificial Intelligence (AI) could play an important role. By predicting and learning the traffic behavior, AI algorithms define the activation/deactivation of sleep mode functionality and site energy management without impacting the overall performance, including Quality of Experience (QoE). AI is still in an early phase, and more development and research are needed to reach its full potential. AI-based energy saving solutions can greatly increase the energy performance of cellular networks.*"

Furthermore, NGNM Alliance's CEO is calling for "*path to zero watt at zero load for future network generations*", using artificial intelligence (AI) *"to intelligently coordinate and optimize more precise decisions for activation and deactivation of the sleep-mode and shut-down features, as well as on-demand network dimensioning*" (source: NGNM Network Energy Efficient report[8]).

Low Latency

The on-demand resource allocation requires minimum latency between the data collection that characterizes the current state of the system, the execution of the decision-making process, and the implementation of the corresponding action in the network.

Low latency in this observation-reaction cycle leads to a responsive network adaptation to traffic changes that ensures a minimum power consumption without impacting the user experience. For instance, when user traffic starts to increase significantly, then additional radio resources are seamlessly enabled.

Dynamic and Multivendor Orchestration

Another advantage of this ideal approach is the continuous orchestration of the different possible actions to take. The selection, sequence, and timing of actions is essential to maintaining the goal of optimally reduced energy consumption with no impact on the customer network quality.

Furthermore, an open orchestrator approach allows any MNO to implement their own power saving strategy, such as e.g. different levels of aggressiveness between technology and frequency layers.

Lastly, multivendor management is key to both simplify the power saving process, and to measure continuously the performance of the OEMs. In fact, multivendor approach has already proved to improve OEMs' proprietary software for Power Saving Features.

Given that the latency and the mitigation of any customer-impacting issues are the primary concern, the next chapter will dig deeper into low latency considerations for the AI-based power saving system.

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Key latency considerations

Following with the characteristics of the ideal solution, the **latency** of the end-to-end process is a relevant topic to analyze.

This latency is strongly linked to the "distance" between the location of the final solution and the RAN elements.

To further explain the importance of the latency factor, let's analyze three scenarios:

External solution

This scenario assumes the solution does not belong to the RAN architecture. It is completely built outside the network.

To implement the observation-reaction cycle described in the ideal solution section, this solution type faces a significant lag between the observation collection and the corresponding implementation of the solution reaction.

Let's assume the network observation is based on Performance Management (PM) counters (although other data sources have similar characteristics), where each of the following milestones adds extra delay:

- PM counters are a measurement collection that is produced every 15min. If a traffic pattern significantly changes, the expected lag (i.e. mathematical expectation) until its corresponding PM counters are produced) is half that period (7.5min).
- The PM counter files are collected by the corresponding OSS servers.
- That information is typically transferred to the external solution through intermediate systems (SFTP, Kafka,...).
- The solution must make a decision or action (assuming that it can make it with just one traffic sample, which typically it is not statistically relevant enough), and;

- Eventually, the solution sends the selected action to an intermediate system to implement the action

The overall delay depends on implementation of those multiple stages, but it may take several tens of minutes, or even more than an hour to react to a traffic change.

RAN Built-in solution

This solution refers to the OEMs' PSFs described earlier. This approach represents a significant improvement in terms of latency of the observation-reaction cycle.

Since the decisions are made by the same node that is handling the user traffic, the amount and quality of information about the performance observation are much richer and more frequent (milliseconds) than the PM counters.

The drawback of this approach is that these algorithms must be light enough in order not to impact the performance of the corresponding network elements where they are running. This leads to relatively simple algorithms that cannot cope with the complexity of the overall task.

RAN Built-in configured by non-real time external solution

This solution could be seen as an intermediate approach. It follows a similar philosophy as the non-Real Time RIC in Open RAN.

There are two main sub-processes involved: OEMs' Power Saving Features and an external system that continuously configures them in a cyclic, non-real-time manner.

On the one hand, the PSFs ensure rapid execution of the observation-reaction cycle. This would be an ***inner-loop control***.

On the other hand, the non-real time external system configures those radio features in such a way that the power savings are maximized in each network element, keeping the user experience. This would be an ***outer-loop control***.

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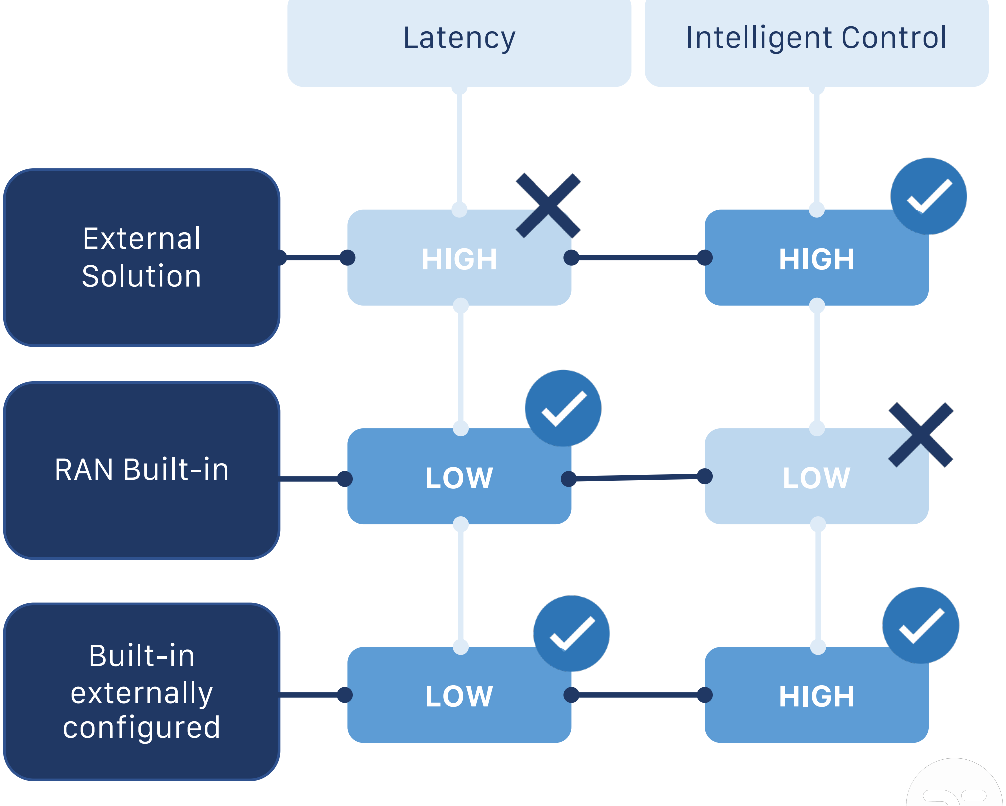
Which of these strategies is the preferred approach?

There are two key criteria to assess which approach is the best:

- Latency: Assessment of the time it takes for each approach to react to traffic pattern changes by activating or deactivating RAN resources.
- Intelligent Control: Ability to adapt the energy saving decisions to the characteristics of each network element to maximize the overall energy reduction.

Based on the performance of the different approaches in terms of these criteria *(see figure 4 below)*, **the authors establish that the last strategy above (built-in configured by non-real time external solution) is the optimal strategy from the point of view of low latency and high level of intelligent control which will lead to more energy savings, and better network performance and customer experience.**

Figure 4: Comparison of energy savings strategies based on latency and intelligent control.



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Power Savings control by AI case study: VEON Kyivstar

Kyivstar's Challenge

Kyivstar was looking for a power saving solution that could fulfill certain requirements, mainly guaranteeing no impact on the customer experience, but also having a transparent system where engineers could verify the AI-based decisions: a system to provide anomaly detection on any deviations on KPIs and customer experience, and automatic actuation scripts for activation/deactivation of the power saving features. Last, but not least, the solution needed to be able to operate in their multi-vendor and multi-technology environment.

Solution

Tupl's **Power Saving Advisor (PSA)** solution is designed to maximize efficiency of RAN Vendors' PSFs in the network while minimizing impact on the end-users by using advanced machine learning (ML) algorithms.

PSA leverages MLOps capabilities together with an Action Manager component to minimize time-to-action. It constantly computes energy consumption at multiple aggregation levels and decides changes to the PSF configurations. PSA is a true multi-vendor and multi-technology solution. PSA also incorporates ML Explained, providing Situation Contextual Analysis for every decision made by the ML models, empowering domain subject matter experts to supervise the operation and decision-making at any time.

VEON КИЇВСТАР

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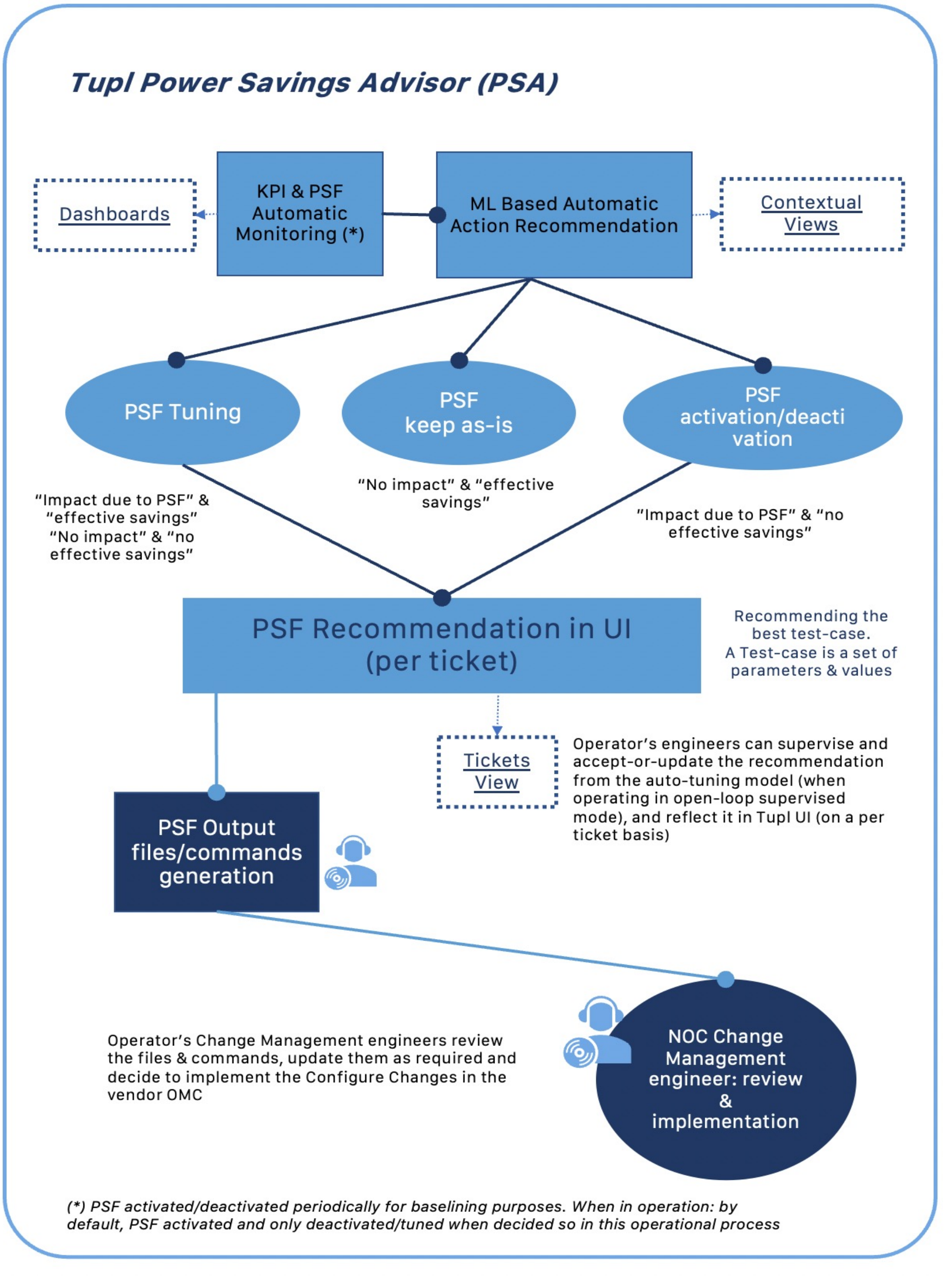
Solution Architecture

The architecture *(figure 5)* follows the non-real time external solution approach introduced in the previous section, in which the outer system optimizes the settings of the available radio Power Saving Features (PSFs) implemented by the OEMs.

This way, the radio PSFs are in charge of the fast response to traffic pattern changes (inner loop) while PSA is in charge of optimizing, on a daily basis, every network element to maximize the results (outer loop).

Figure 5: Tupl Power Savings Advisor (PSA) solution overview



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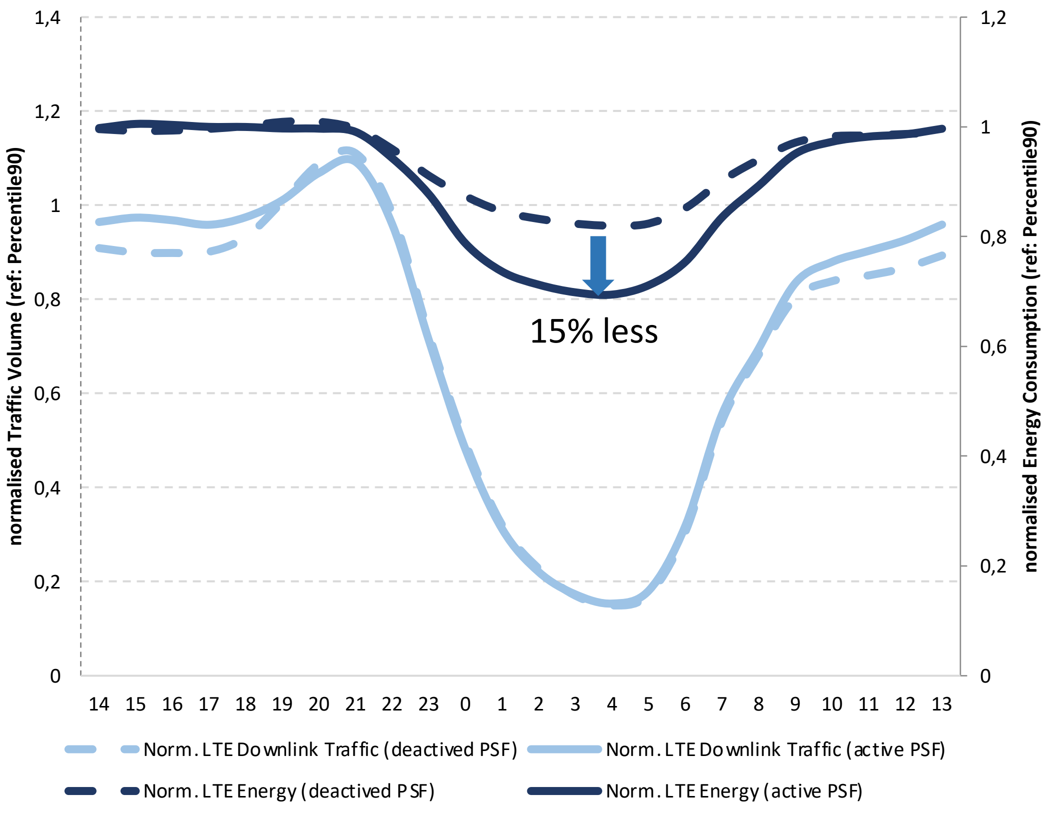
Results

Using Tupl's Power Saving Advisor solution, Kyivstar achieved 7% of power savings just within the first implementation phase with absolutely no impact to KPIs. The activation scope included more than 85% of the network.

After PSFs were activated, the hourly shape of the energy consumption decreased by more than 15% compared to the baseline *(see figure 6 below)*.

Periodical baselining of KPIs and energy consumption are recommended, as networks continue to expand.

Figure 6: RAN Energy Consumption (normalised KWh) vs Data Volume (normalised MB)



Still, the energy shape is not as abrupt as the traffic reduction. There was (and is) room for more power savings since not all possible power saving features got activated. Considerably higher savings have been achieved in the consecutive iteration phases of AI proposed PSF configurations.

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Customer Feedback

Valentin Neacsu, Former Kyivstar CTO

"There are fantastic features for Power Savings provided by pretty much all the big radio OEMs, and more than 70% of power is consumed by base stations!. However, activating these features may have some unwanted degradations for the customers, and we wanted to be 100% certain on no impact."

"My engineers are really happy about being able to incorporate their Power Savings strategies on the fly: one can test different aggressiveness levels and system is automatically monitoring and creating roll-back actions if need be. So, really happy about the system functionalities."

"In regards to savings, even with low level of aggressiveness, we have achieved already 7% of power savings with absolutely no impact to KPIs"

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Conclusions & Recommendations:

It is clear that the telecommunications industry is starting to consider energy efficiency more seriously and taking steps to reduce the impact of high energy consumption, such as using renewable energy sources.

Also, we can see several global RAN vendors such as Ericsson, Nokia, Huawei, Samsung, and ZTE investing significant R&D efforts in their proprietary RAN Power Savings Features.

We can conclude that artificial intelligence is and will be the key technology enabling power savings. The AI-driven software approach will be the catalyst of the fundamental change in this domain, ensuring control and reduction of energy consumption. All of this needs to happen without impacting the customer experience.

It is already possible today to achieve this with proven technology: AI-based solutions are available on the market for immediate implementation. Every month that passes is a lost opportunity to serve the planet and serve the shareholders of the MNOs.

Let’s act now!

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TUPL

Founded in 2014 by telecom, big data and AI veterans, Tupl is a pioneer in digital transformation in the telecom industry through AI-powered automation of network operations. Its AI engine, TuplOS, utilizes machine learning and other features to enable faster innovation cycles for network and customer care operations with wireless operators across the US, Japan, Mexico, and Europe. Tupl is headquartered in the U.S. in Bellevue, Washington with offices in Spain and Japan, and is continuing its rapid global expansion in 2021.

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