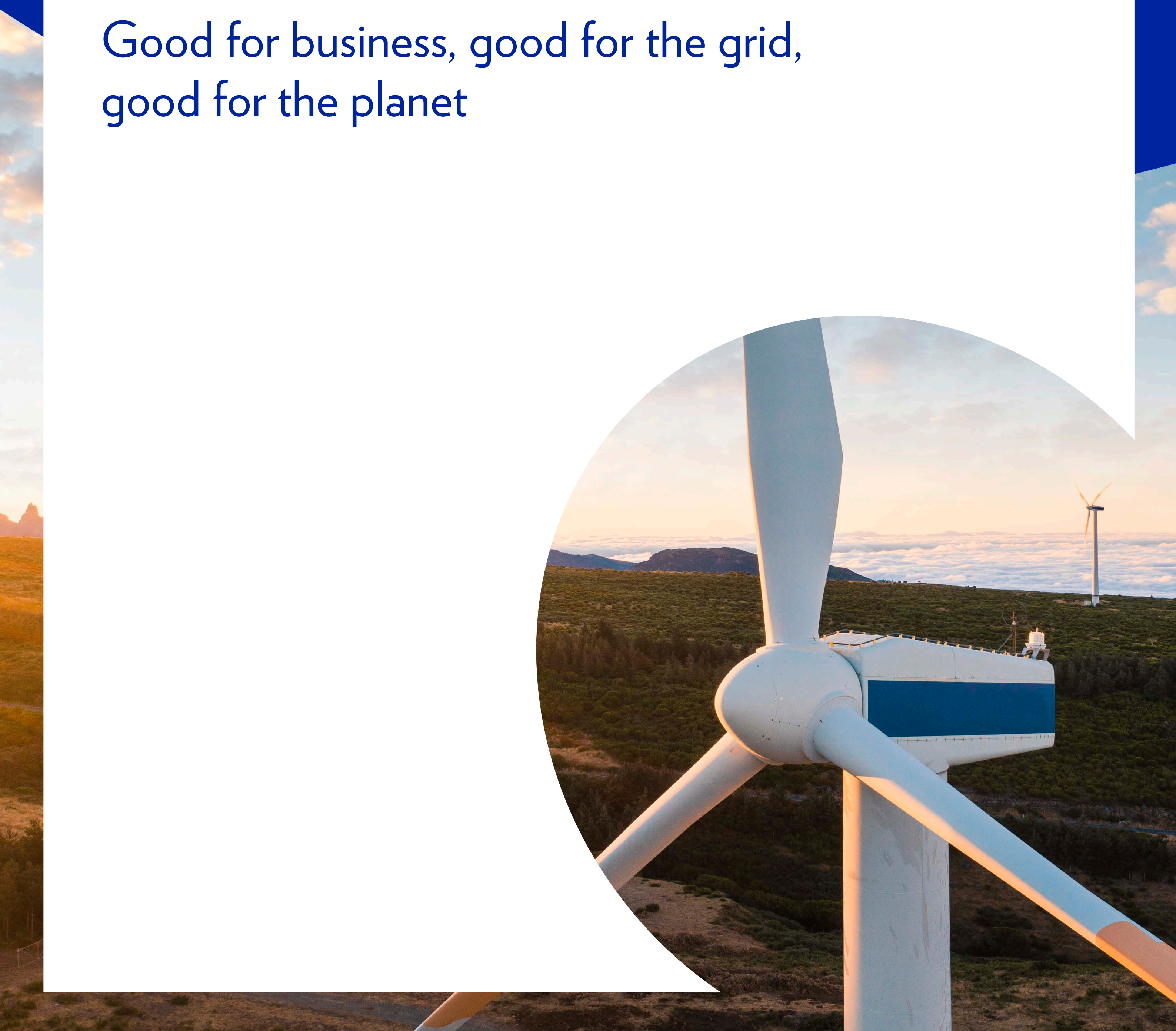
DISTRIBUTED ENERGY STORAGE

Distributed Energy Storage

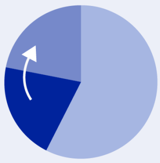
Good for business, good for the grid, good for the planet



The energy transition by numbers… and the critical role of storage

1.5°C

Under the 2015 Paris Agreement the world agreed to cut greenhouse gas emissions "to limit the temperature increase to 1.5°C above pre-industrial levels". The major component of that change is the energy transition from fossil fuels to renewable sources of energy such as wind and solar.



22% to 42.5%

EU 27 target for proportion of total energy generated by renewable energy in 2030 compared to actual figure for 2022.

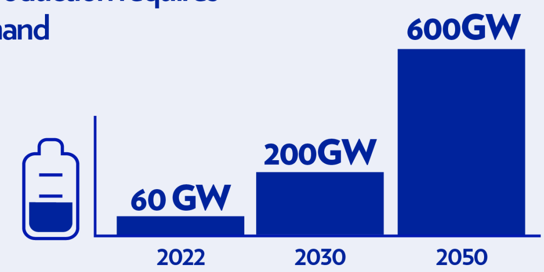
30GW per annum

New wind energy required to meet EU target.

A growth in share of renewable energy in electricity production requires growth in storage capacity to balance supply and demand

24% / 719 Twh & 30%/ 2189 Twh

The flexibility required as proportion of total electricity demand in EU 27 by 2030 and 2050 respectively.



EU Energy storage capacity forecasts from 2022 to 2030 and 2050.

The Scale of the Distributed Energy Storage opportunity for telcos

CO_2

20,000t

Elisa expects to remove up to 20,000 tonnes of CO2 system-wide across its Finnish network annually, based on marginal emissions calculations.

15GWh

The potential capacity in Europe's radio access networks

>50%

Elisa estimates that the combination of revenue opportunity and cost savings from DES add up to more than half an operator's current electricity costs.

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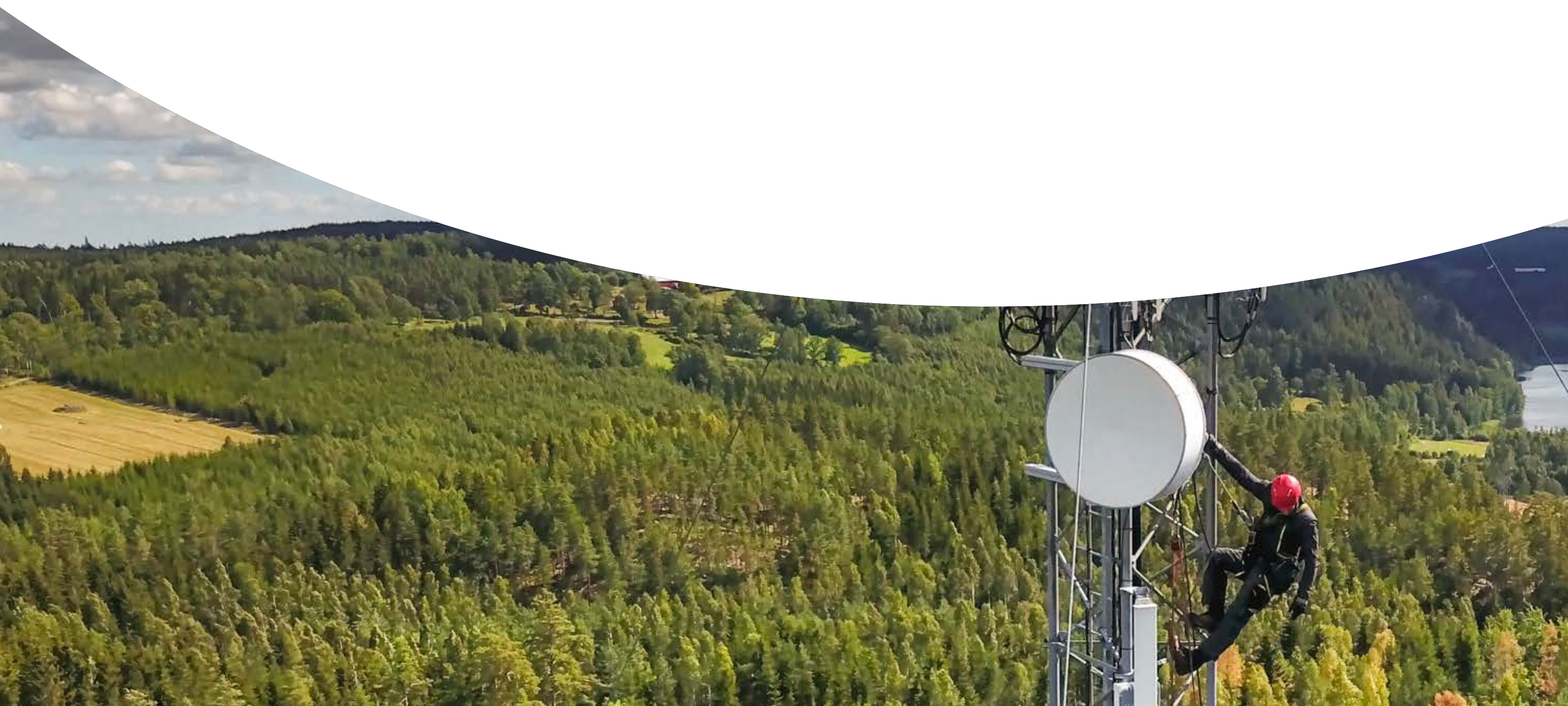


Foreword - Henri Korpi

Elisa's mission is a sustainable future through digitalization, and our people work every day to find solutions for our customers, our company and for society that deliver on that ambition.

It is evident as the world experiences another summer of unprecedented heat that addressing the threat of climate change is a pressing challenge for us all. At Elisa we are proud of our efforts in addressing our carbon footprint but never complacent. We continuously search for innovation that can mitigate our environmental impact.

One of the key areas for us to address is our energy consumption – both in terms of reducing overall usage but also increasing the proportion of it derived from renewable and sustainable sources. Elisa's Distributed Energy Storage (DES) project was born of that quest, and we are genuinely excited about the potential it has to provide a clean, green energy solution capable of serving both telecommunications networks and electricity grid operators.

As countries across the world seek to increase the proportion of electricity they derive from renewable and intermittent sources such as wind and solar, finding a reliable and smart way to store and distribute energy will be critical.

The Radio Access Network (RAN) is a natural place to look for that solution. As providers of critical infrastructure, many operators are already mandated to maintain an alternative energy supply to ensure service in the event of disruption.

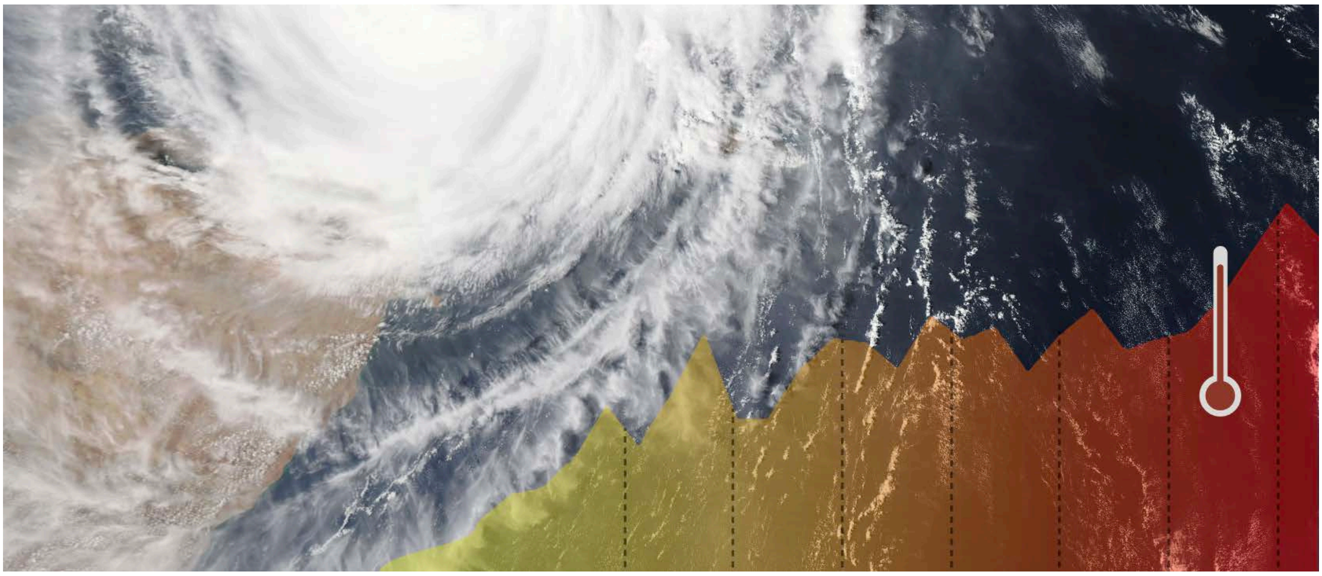
Much of that is provided by battery power. With an upgrade to lithium-ion batteries and the application of the DES smart management solution, the RAN can be turned into a Virtual Power Plant (VPP) capable of optimizing energy consumption in the network and providing balancing services to grids.

The pilot programs we've run in our own networks in both Finland and Estonia have proven the solution can not only deliver on its sustainability promise, reducing our emissions, but can also help to cut Opex and generate revenues.

Our conservative estimate is that the combination of cost savings and revenue opportunities add up to more than half an operator's current electricity spend: a huge opportunity.

Small wonder then that since the launch of DES earlier this year we've fielded enquiries from operators across the world about what it could do for their networks. We're pleased to launch this white paper to help people understand the huge potential of the solution.

Henri Korpi is Executive Vice President, International Digital Services at Elisa



1.5 Degrees and The Renewables Revolution

At the heart of the battle against climate change is the energy transition – the systematic shift from fossil fuel based energy production to a supply that is clean, sustainable and reduces the emission into of the carbon dioxide particles causing atmospheric global warming.

The shift from coal, gas and oil to renewable energy sources such as wind and solar has gathered momentum in the past decade. At the COP21 UN climate conference in Paris in 2015, governments signed a historic accord seeking to limit the global temperature increase to 1.5 degrees above pre-industrial levels.

Governments across the world have responded to the threat of climate change and to the challenge of the Paris Agreement by outlining ambitious targets for the roll out of renewable energy, with the deployment of wind farms and solar parks gathering pace.

There is also an economic imperative behind the rush to renewables, as the costs of renewable energy has fallen sharply in recent years, making them more competitive than ever with fossil fuels and with the potential to reduce bills for industrial and domestic consumers.

Russia's invasion of Ukraine in February 2022 added further impetus to the energy transition with a surge in gas and oil prices in subsequent months. Many European countries previously reliant on imports of Russian energy looked to renewables to provide an alternative source that is independent and secure from geopolitical disruption, stimulating a new round of commitments to solar and wind power.

Renewables deployment is set to accelerate

In 2022, more than 40% of the European Union's electricity supply was generated from renewable resources[1], including hydroelectricity, a significant rise from 19.6% in 2010. During that period solar capacity in the EU grew from 29GW in 2010 to 198GW in 2022, and wind from 84GW to 205GW. Targets for the future are even more ambitious, however, with the EU seeking to extend the use of renewables beyond electricity to all energy usage, including hard-to-electrify sectors of the economy. By 2030 it is seeking to generate 42.5% of all energy from renewables[2] .

The coming decade will then see a further acceleration of the deployment of wind and solar. The Global Wind Energy Council forecasts an average of 136GW of annual wind power deployments between 2023 and 2027[3]. The solar energy industry predicts even more rapid growth. Having generated an estimated 1.289TWh in 2022, Solar Power Europe says "the world could be installing 1TW of solar annually by the end of the decade – hitting up to 800GW per year already in 2027"[4].

While such rapid decarbonization is welcome, the intermittent nature of wind and solar – the former isn't available when the weather is still, the latter at night – continues to be an obstacle for the energy transition.

Addressing intermittency

Unlike fossil fuel generation, renewable energy is unpredictable and variable. As it becomes an ever more important source, it brings with it issues such as grid stability and complexity. The months of November and December in the UK show just how variable renewable sources can be. During one day in November 2022, more than 20GW of electricity was produced by wind for the first time, representing 70% of electricity generated during that day and highlighting the potential of wind generation[5]. Indeed the UK produced a record 74TWh in 2022, enough energy to heat 19m homes.

[1] https://ember-climate.org/insights/research/european-electricity-review-2023/
[2] https://ec.europa.eu/commission/presscorner/detail/en/IP_23_2061
[3] https://gwec.net/globalwindreport2023/
[4] https://www.solarpowereurope.org/insights/market-outlooks/global-market-outlook-for-solar-power-2023-2027-1
[5] https://www.nationalgrid.com/stories/energy-explained/how-much-uks-energy-renewable#:~:text=In%20 2022%2C%20individual%20renewables%20contributed,electricity%20generated%20on%20that%20day..

Illustrating that problem of intermittency, however, was a period of calm the following month. Earlier in what was a cold December[6], and during a time when wind energy would be expected to be strong, the wind failed to blow. Over the course of the whole month in the UK average wind generation fell below 10GW per day, forcing a renewed reliance on expensive gas imports.

The most promising of all potential solutions is to increase storage capacity for renewables, and this is where there is an intersection between the energy and telecommunications industries that holds great potential for both.

The European Commission acknowledges the criticality of energy storage technology in providing stability and flexibility in future energy supply: "System flexibility is particularly needed in the EU's electricity system, where the share of renewable energy is estimated to reach around 69% by 2030 and 80% by 2050."[7]

Harnessing renewable energy for sustainable and affordable electricity

Sustainability factors alone were never going to be enough to drive the transition to renewable energy. Electricity sources such as wind and solar also had to be competitive on price to gain traction in the market.

Advances in technology – bigger more efficient wind turbines, for example – combined with growing volumes have driven renewable energy costs lower. "Renewables are by far the cheapest form of power today," concluded Francesco La Camera, DG of IRENA, launching a report that showed that even with rising commodity costs, "almost two-thirds or 163 gigawatts (GW) of newly installed renewable power in 2021 had lower costs than the world's cheapest coal-fired option in the G20."

[6] https://blog.metoffice.gov.uk/2022/12/30/cold-december-concludes-warmest-year-on-record-for-uk/
[7] https://energy.ec.europa.eu/topics/research-and-technology/energy-storage/recommendations-energy-storage_en

> **Renewables are by the far the cheapest form of power today... 163 GW of newly installed renewable power in 2021 had lower costs the cheapest coal-fired option in the G20.**

The main purpose of the electricity market is that producers can sell and users buy energy efficiently. To maintain grid frequency every second of every day, grid operators buy flexible production and consumption to keep the lights on continually.

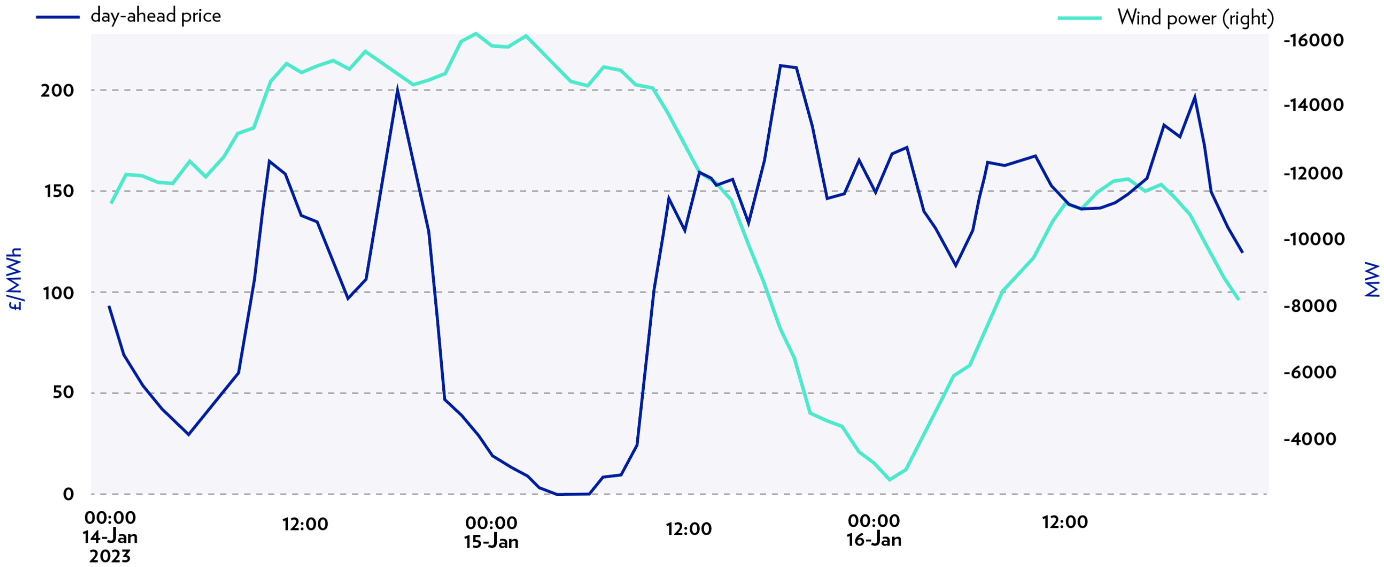
The way in which many electricity markets work – with a 'marginal pricing methodology' that ranks sources in a merit order according to cost – is critical for their adoption. Grid managers buy from those sources that are cheapest from the marginal cost perspective first, starting typically with wind, solar or hydropower when available through to higher price natural gas, coal and oil plants.[8]

While there are multiple factors that can cause changes to electricity pricing, there is demonstrable correlation in many markets between the availability of wind energy and the cost of electricity.

The graphs below show Germany and the UK through a period in January 2023 where the day ahead pricing moves in concert with wind. Correlation is evident in both although more pronounced in Germany. Where production moves towards wind capacity in these markets, the price falls and vice versa.

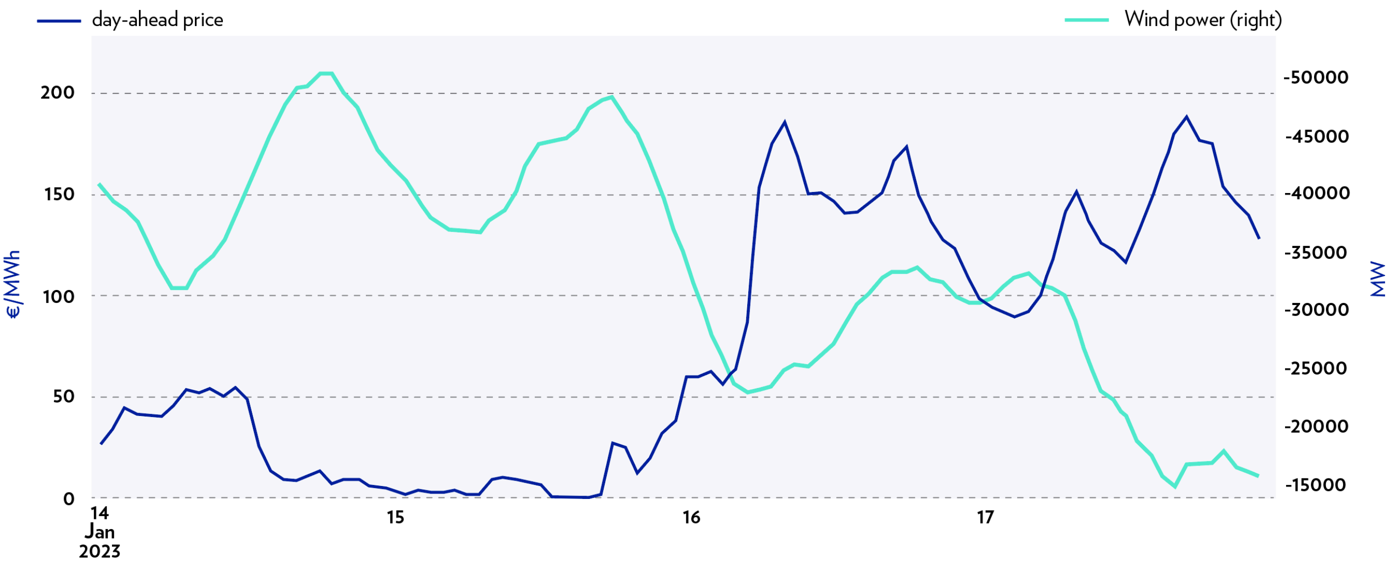
While it is clear that increased renewable energy in the mix helps to bring down prices as it is cheaper that fossil fuels, it also increases volatility. Without wind or solar prices rise, with surpluses prices can even go negative, with producers paying for production and customers being paid for consumption.

UK wholesale (day-ahead) prices (£/MWh) and wind power production (MW) in January 2023



[8]https://www.irena.org/news/pressreleases/2022/Jul/Renewable-Power-Remains-Cost-Competitive-amid-Fossil-Fuel-Crisis

German wholesale (day-ahead) prices (€/MWh) and wind power production (MW) in January 2023



Alongside the intermittency of wind energy there is the issue of curtailment, where power is "wasted". Curtailment refers to the deliberate reduction or restriction of wind power generation often due to grid constraints or operational considerations. It involves the decision to not produce electricity at its full potential, even when the wind conditions are favorable for power generation. It is estimated that the UK curtailed 6.5TWh, enough to power a million homes, between January 2021 and April 2023, a time at which gas prices were suffering record volatility.[9] While grid development could alleviate much of that, an increase in storage capacity would also bring huge benefits.

This is where there is an intersection between the energy and telecommunications industries that holds great potential for both.

Within the marginal pricing system, addressing the intermittence of renewable sources is critical, both ensuring availability of power when there is no wind or sun and capturing excesses of both for future use. That can be addressed with the addition of smart energy resources, including distributed energy storage solutions.

In short, abundant inexpensive renewable production in combination with storage and other forms of demand flexibility can deliver zero-carbon electricity that is less expensive than traditional electricity production based on heavy use of fossil fuels.

6.5TWh

The amount of wind energy lost to curtailment in the UK between January 2021 and April 2023.

A market structure combining marginal pricing with intermittent sources can lead to temporary pricing peak. That can be mitigated however by the provision of flexible resources such as batteries and other demand responses that can balance production and consumption. As we gradually transform the electricity system towards that vision, all investments into storage capacity help reduce the energy price peaks for all electricity purchasers. In this age of volatility, that flexibility is priceless.

[9] https://carbontracker.org/britain-wastes-enough-wind-generation-to-power-1-million-homes/#:~:text=Overall%2C%20from%20January%202021%20to,of%201%20million%20British%20households.

And with enough cheap, renewable energy capacity in that system, gradually fossil fuel production could be phased out.

For now, though, the cheaper renewables are in the market mix, the lower the overall cost of generation should be, eventually leading to lower tariffs for consumers.

Bringing balance to the Energy Transition

With mobile telecommunications networks across the world designated as critical infrastructure, most already have an obligation to maintain a back-up energy that can kick in to provide continuity of service should there be disruption to energy supply from the grid.

Historically, the telecommunications industry has been the world's second largest user of batteries with many operators depending on battery storage to provide back-up. This gives them the foundations for Virtual Power Plant functionality based on battery storage.

Elisa's DES solution builds on that capacity and facilitates a VPP that controls and optimizes distributed storage energy storage in the RAN, using the flexibility of backup power batteries to control electricity supply in thousands of base stations in the mobile network throughout the day. The DES solution only controls power equipment with no effect on radio devices at the site.

The solution then enables two key outcomes: load-shifting that moves electricity consumption from the grid to different periods in the day and market participation that allows the sale of power back to the grid at times of need.

The DES system optimizes the timing of electricity purchases by scheduling charging and discharging periods for the batteries. For the purposes of reserve market participation, it decides which of the thousands of base station power units should be adjusted in real time.

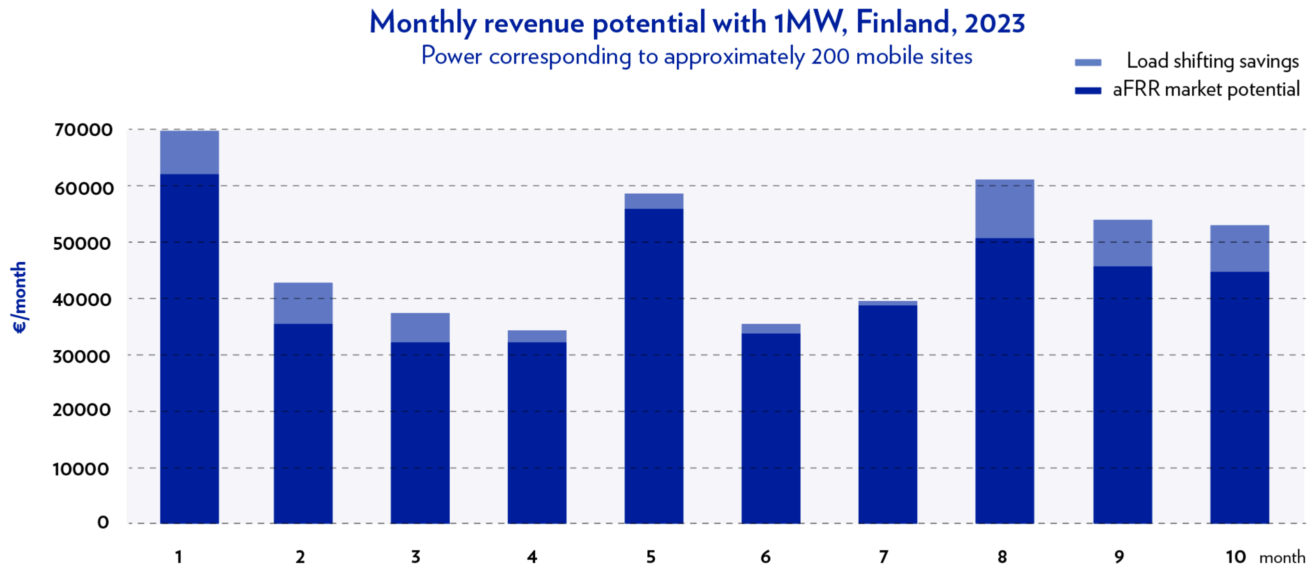
In effect this gives the network "load balancing" capability. From a load shifting perspective, the network has the flexibility to buy electricity based on prices. It takes from the grid when it is cheap and stores it for use at times when power would be more expensive.

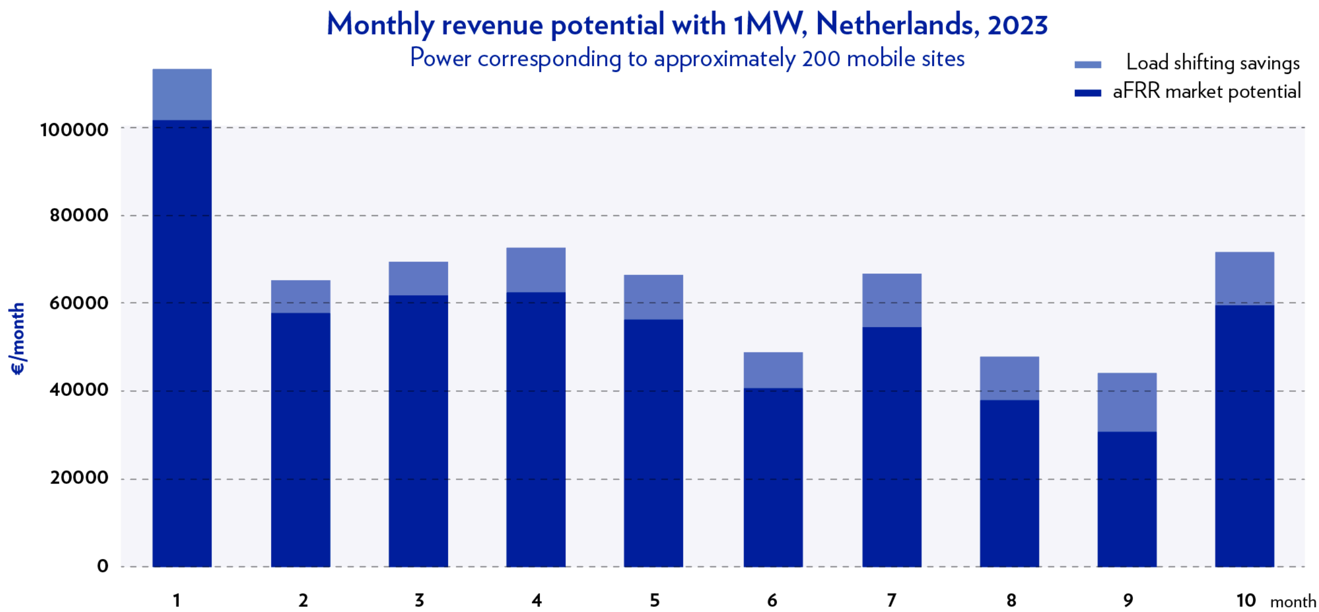
Wind energy, for example, is typically more abundant at night, often producing excess electricity. The DES can then take some of that excess and store it, expanding the capacity for renewable energy generation.

There are essentially two use cases for the operator. The first is procurement optimization – or load-shifting – where the DES enables the operator to benefit from purchasing electricity more cheaply and making the entire system more efficient for all users.

Second the participation in the reserve market helps the TSOs to keep lights on by providing them additional capacity in case of unforeseen or rapid changes.

The DES combines this multi market optimization in an efficient manner.





> **Our calculations show that the returns from the deployment of DES can represent more than 50% of an operator's electricity costs.**

In Finland, following a trial in the summer of 2022 of 200 base Elisa stations across the country Elisa received the technical pre-qualification acceptance from Fingrid (Finland's Transmission System Operator or TSO) for its Distributed Energy Storage solution to provide balancing services in a specific balancing market, the "automatic frequency restoration reserve", or 'aFRR'.

It is believed that this is the first time anywhere in the world that a distributed solution has been approved for the aFRR market which are normally served from hydropower or natural gas plants.

DES requires up front investment for operators in swapping out older lead acid batteries for lithiumion models that improve storage and provide greater longevity. The commercial model for the DES system is operated in a partnership between the two parties with Elisa providing the solution, the customer the controllable assets and infrastructure.

As the first graph above detailing the performance in our own network in Finland clearly shows, there are significant savings and revenues to be earned. The 200 mobile sites represented – 1MW of power – are a tenth of the total sites under management. Overall our calculations show that the returns from the deployment of DES, combining both aFRR gains and load shifting savings, can represent more than 50% of an operator's electricity costs. The second graph shows our projection for DES performance in the Netherlands, where even greater returns are possible.

The load-balancing alone is sufficient to support the business case, and the payback time on the investment is approximately five years. Even with energy prices having fallen from the historic high in 2022, price remains a major issue in the energy sector due to continued geopolitical disruption as well as the need to switch to renewable energy production.

The benefits to the operator are clear:

- Source electricity more cost effectively and reduce Opex
- Develop a revenue stream
- Bring more resilience to the network – up to three hours on average during outages – with an improved back up source of power
- Increase sustainability of operations, by facilitating greater use of renewable energy and reducing emissions.

Putting theory into practice - Ismo Räsänen

By Ismo Räsänen, Senior Development Manager, Elisa Oyj

The starting point for our provision of energy storage is the regulatory requirement we have here in Finland that stipulates that every one of our 2,000 base stations must have back up power for at least three hours. For most of our base stations that back up power is provided by batteries, so we have a huge fleet of batteries that historically have been the lead acid type. This makes them almost purely a cost burden, used only during power outages and most of the time standing idle without providing any benefit.

About two years ago we first started to investigate using lithium-ion batteries instead and that also coincided with our first conversations with the DES team about load shifting, the reserve electricity markets and the new potential for our battery fleet.

There are several benefits to having lithium batteries. They provide as much as three times capacity as back-up and will also endure the charging and discharging better than the lead acid models, leading to a longer lifetime.

What we also learned very quickly is that where a lead acid battery is “dumb” with no intelligence, the lithium-ion model provides us with useful data about performance across our multi-vendor network. So, we set up the communication system between our rectifiers and our battery management system that provides us with a lot of actionable intelligence and data.

For the first time, we had a unified and real-time view of our power supply situation across the whole network, which is obviously very useful for our business and performance. It also opens a new avenue for potential services, one of which is the network facilitating the creation of a Virtual Power Plant, using the DES solution.

And so last summer (2022) we conducted testing with Fingrid (Finland's electricity transmission systems operator) across 200 of our base stations. It was successful and as a result, in the summer of 2022, we received the technical pre-qualification acceptance from Fingrid for its Distributed Energy Storage solution to provide balancing services in the 'aFRR' balancing market, the "automatic frequency restoration reserve", or 'aFRR'.

> **All the clever work happens invisibly so it's very easy to use in the multi-vendor environment and it makes our network more resilient and our power supply more flexible.**

Trials of the system have also taken place in Estonia.

We are now rolling the system out across our network. Of course, that means there is some investment in the new battery capacity, but with continued volatility in the energy market we think we will get the return on that investment within three years. In addition, based on the latest official Finnish marginal CO_2 emission calculation rates, this distributed energy system is expected to result in annual reductions of up to 20,000 tonnes of CO_2 when fully deployed.

From an operational perspective the system is very straightforward. All the clever work happens invisibly, conducted by the Elisa DES, and so it's very easy to use in the multi-vendor environment and it makes our network more resilient and our power supply more flexible, no longer just a "dumb" cost centre.

Furthermore, I am proud that we have a system that enables Elisa to use more renewable energy in our system, which means we are providing an important benefit to society. If it enables us to be more profitable as well, then so much the better.

DES – Driven by Artificial Intelligence

While the lithium-ion batteries provide the physical infrastructure for electricity storage in the DES, it is the Artificial Intelligence brain in the smart management system that ensure their capacity is used to best financial and operational effect.

The effective operation of highly distributed VPP solutions requires competencies in mathematical optimization, control systems and communication systems. Elisa's heritage in telecommunications in combination with our expertise in data management, AI and machine learning solutions have been instrumental in allowing us to develop an effective solution.

Elisa's DES is composed of three layers of control intelligence powered by AI software, harnessing the electricity and power equipment data to provide actionable intelligence for grid optimization.

The top-level planner uses supply and demand data of different electricity balance markets to perform thousands of simulations that allow it to determine how much capacity to allocate at any given time to load-shifting or grid balancing.

The data-intensive middle layer supervises the flow of electricity and conditions of the base station power equipment to ensure the best use of the assets, including battery longevity over time. Finally, the lowest level controller selects which specific units should be adjusted to respond to changes in load-shifting plans or to TSO grid balancing requests.

It is a hugely complicated process, but one that is simplified and automated by the control system. The combination of the three layers allows to DES to control the charging and discharging of batteries to optimum effect for the purposes of powering the network in the most cost-effective way, as well as supporting the grid with balancing services.

After the successful roll out of the solution in Elisa's networks in both Finland and Estonia, our current focus is to adapt the AI/ML control to allow it to be installed with other operators' critical infrastructure. Further technical work is underway to ensure compatibility in the widest possible multi-vendor environment, for power and battery hardware.

With wind energy production expected to undergo exponential growth in the coming decades as nations target net zero, the demand for storage solutions and grid balancing will grow with it, presenting a huge market opportunity for telecommunications network operators.

The time is right for DES - Jukka-Pekka Salmenkaita

Jukka-Pekka Salmenkaita is VP of AI and Special Projects at Elisa

Necessity is often described as the mother of invention, and so it was with the distributed energy solution. The early years of this decade have presented industry and individual consumers alike with the most challenging energy market experienced in generations.

The combination of a highly volatile geopolitical environment combined with the supply chain disruption that followed the pandemic resulted in prices soaring to historically high levels. In parallel, nature has continued to deliver a series of warnings about the costs of climate change should global warming not be constrained.

In an industry such as telecommunications, where energy consumption is high and electricity such a large component of Opex, it was inevitable that every option would be explored to find new ways to control usage and reduce environmental impact. It was a challenge the AI and Special Projects team was excited to accept.

Elisa has a proud history of innovation in telecommunication, not least in energy consumption. Elisa Polystar's Intelligent Energy Saver has already harnessed the power of AI to deliver significant cuts to energy consumption by targeting savings at the cell level in the RAN.

The DES takes control of energy consumption in a different direction with a solution that enables further deployment of cost effective renewable energy by optimizing storage usage, essentially transforming telecom infrastructure into a flexibility asset for electricity grid balancing.

Reception to the solution has been very positive and we have had discussions with operators around the world who are keen to see how it could help them cut Opex, improve their sustainability credentials and open a new revenue stream by providing balancing services.

Grid regulators too have been interested to understand how DES can support distribution efforts.

Given our heritage and experience in telecommunications it is natural that we focus initially on the operator world, and we look forward to announcing commercial progress soon. We strongly believe that DES has potential beyond the RAN and could ultimately be deployed in a range of distributed environments from industrial to residential. Our engineers are working hard to define those concepts and we look forward to seeing where this DES journey takes us all.

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