Telcos and virtual power plants

Green energy, green profit

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Driving the use of renewables

An emerging area of focus for net zero is energy production and its supply to the power grid. A key strategy has been to boost the production and availability of energy from renewables such as solar, wind and hydro.

Several countries have espoused and drafted policies to increase the use of renewables. Notable among these is the European Union (EU), which further accelerated its already ambitious targets for renewables following the outbreak of the war in Ukraine. The conflict has disrupted the energy supply chain from Russia. In 2022, more than 40% of the EU's electricity supply was generated from renewable sources, double the 2020 figure of 20%. The goal is to drive use of renewables to account for a majority of the energy used by all sectors.

It is increasingly important that investment is made in transmission networks and overall management of the grid, with a view to balancing energy across the whole network. To achieve this, increased power generation has to easily flow into the power grid through new access mechanisms; otherwise, there will be bottlenecks. Today's emerging smart grids also have energy reserves that are built up and stored for backup power. However, there needs to be a way to store surplus power affordably and then make it available as needed. This requires a new approach that is software-led, as opposed to the more hardware-focused and siloed traditional methods.

Harnessing virtual power plants

With virtual power plants (VPPs), mobile network operators can leverage existing base station batteries – normally used as a source of backup power – to integrate with the national grid. Operators can do the following using the VPP architecture:

- **Energy purchasing and distribution –** Purchasing and distribution works by using AI to determine a site's power status. Operators can take advantage of the peaks and troughs of electricity prices to purchase at off-peak rates, such as in the early morning. They can also use energy storage to discharge electricity when prices are high, such as in the afternoon and evening, so as to reduce their electricity bills. Operators can also use energy storage to balance the peaks and troughs in power availability for energy sourced via power purchase agreements (PPAs). In the long term, operators can use their own sites to feed electricity back into the power grid for sale when the energy is at a sufficient level.
- **Load balancing –** Load balancing involves leveraging stored energy (such as at a base station or data centre) to participate in power-flexible auxiliary services. These include power grid frequency modulation, peak shaving, capacity reservation and other services that balance out grid fluctuations or shocks. These capabilities also rely on AI in batteries to monitor charging and discharging, and to schedule and coordinate with the grid. Revenue is earned by operators on the power sales.

The net effect of these functions is more stable power capacity for mobile networks and the national grid, and more efficient use of renewables overall. For operators, there is also a financial incentive in the form of cost savings on the reduced power wastage, and revenue from power services to the grid.

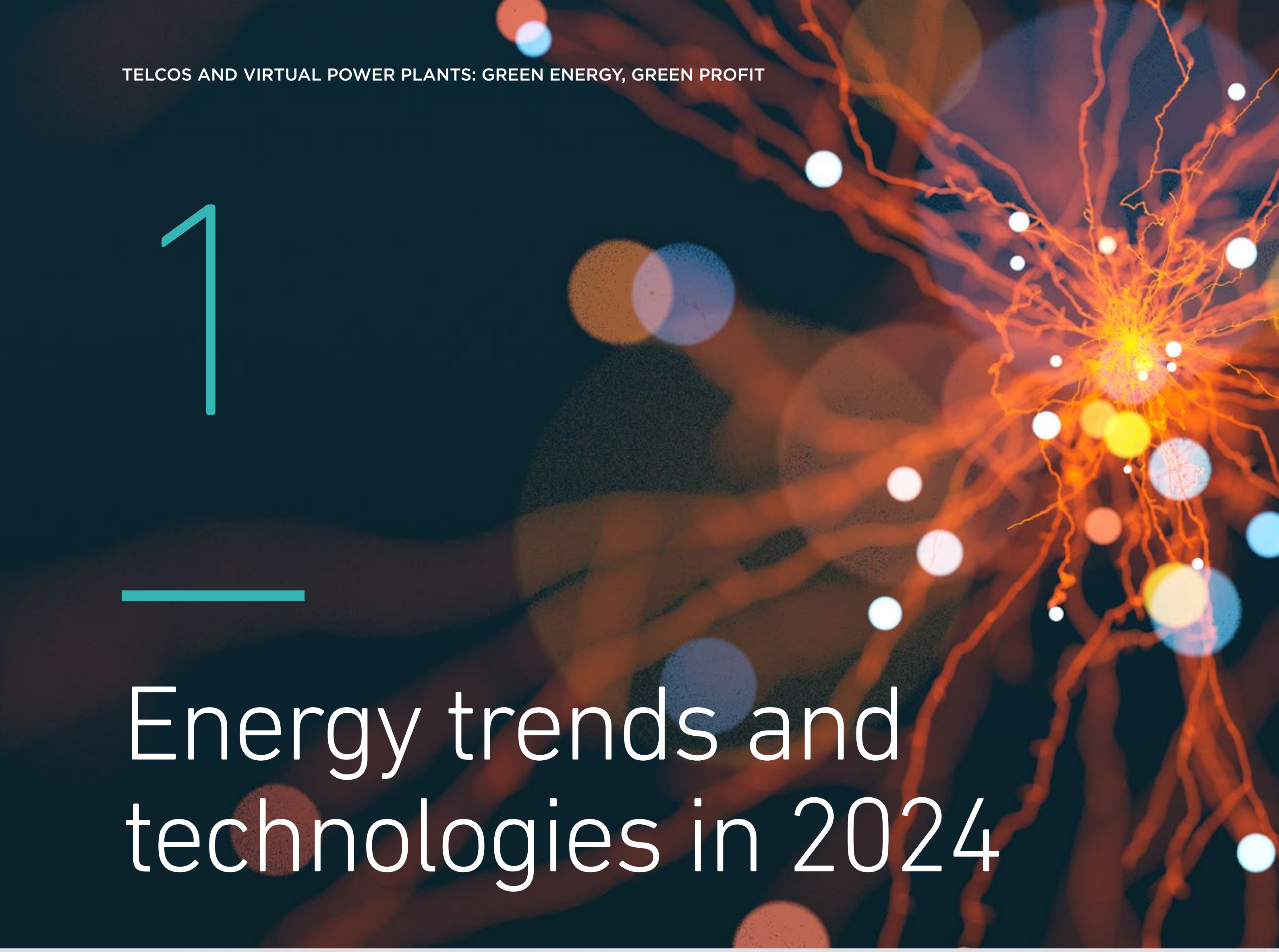
Revenue comes from providing flexible ancillary services to the grid or reverse-selling excess power to the grid through cell-site energy storage. This relies on having a trading platform in place along with other upgrades. The uplift is potentially significant. For example, a mobile network with 10,000 sites, each consuming an average of 30–40 MWh per year (using a European figure), translates into total power usage of around 18,000 MW. The excess power required for backup presents a sizeable reserve that can be used to substitute some of the mains power. It can also be used to provide ancillary services or sold back to the grid.

Finish operator Elisa trialled a VPP solution in 2022 and reports an interesting set of results. The trial involved 200 sites, or 10% of its network footprint. According to its calculations, cost savings averaged around €5,000 per site per month, with (new) revenue of €44,000 per site per month. Applying similar ratios to other operators in Europe, the GCC and Asia gives a view of the potential uplift. If we take only the impact of cost savings, assuming an operator designated 75% of its sites in a country to VPPs, network electricity costs could be reduced by 5–10%. Adding the revenue contribution to the cost savings, the overall offset on electricity costs is estimated at 50–80% across these operators, with differences reflecting the prevailing energy prices in each country.

VPPs are worthy of consideration for operators, in large part because they do not require significant capital investment as they reuse existing infrastructure. Most of the upgrades are software-based to incorporate AI, so that cell-site coordination, ultra-high-speed response, precision and existing network functions can be preserved.

Meeting targets and building resilience

There is significant movement on the policy front, as governments and regulators become increasingly aware of the potential of VPPs. VPPs are crucial not only in achieving their officially committed net-zero and sustainability targets, but also in building the necessary resilience into power grids and planning processes. This resilience can help mitigate the impact of extreme weather-related events, conflicts arising from geopolitical issues, and security breaches. In many cases, regulators are learning on the go and tweaking policies to help industry meet net-zero commitments. Small steps can go a long way.



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Energy trends and technologies in 2024

A core public policy imperative

Sustained growth in communications and internet connectivity, as well as rapid digital transformation across industry verticals, is helping shape a 'digital century'. As investment continues apace to drive digital transformation, increasing attention is being paid to creating sustainable practices that can help mitigate the impact on climate change.

In 2015, the Paris Agreement represented a landmark moment for the climate change movement. Global stakeholders agreed to work together to limit temperature increases to 1.5 degrees Celsius above pre-industrial levels. Beyond verbal commitments and statements of intent, the Paris Agreement also laid the foundation for "appropriate mobilisation and provision of financial resources, a new technology framework and enhanced capacity-building" to enable policy changes to be implemented in developing countries too.

Several years later, sustainability is a core public policy imperative for governments and enterprises around the world. The goalposts for climate change have shifted. The target is net zero by 2050, with an increasing focus on reductions in greenhouse gas (GHG) emissions. COP28 in Dubai noted significant progress but underlined that more needs to be done.

Energy production and carbon reductions

An emerging area of focus for net zero is the production of energy and its supply to the power grid. A key strategy has been to boost the production and availability of energy from renewables such as solar, wind and hydro.

Several countries have espoused and drafted policies to increase use of renewables. Notable among these is the European Union (EU), which further accelerated its already ambitious targets for renewables following the outbreak of the war in Ukraine. The conflict has disrupted the existing energy supply chain from Russia. In 2022, more than 40% of the EU's electricity supply was generated from renewable sources, double the 2020 figure. The goal is to drive use of renewables to account for a majority of energy used by all sectors.

However, a number of challenges continue to hinder the consistency and predictability of energy supply via renewables. Unpredictable and variable energy supply from renewable sources has negative implications for the power grid in terms of stability and complexity.

For example, a renewable strategy centred on solar is constrained by the availability of sunlight, which is at best available for 10–12 hours each day, notwithstanding weather conditions on a specific day.

A strategy centred on wind power can also be hostage to unpredictable climate patterns, which would see significantly lower wind patterns and make planning and forecasting difficult. Intermittency forces a reversion to the traditional costlier sources of energy based on fossil fuels.

A sustained period of high winds could generate a lot of electricity, but without reliable and accessible storage the surplus is wasted if the power grid is not engineered to handle all the supply. To mitigate such challenges, one approach is to increase the capacity of existing power grids. However, a more sustainable option would be to develop and increase storage capacity, with energy tapped on-demand by the power grid.

The intersection of utilities and telecoms

The telecoms sector has been a major consumer of electricity. The deployment and operation of cellular networks, in particular, has required significant electricity. The majority of consumption occurs in the radio access network (RAN), where base transceiver stations (BTSs) are deployed in a distributed architecture to achieve coverage of populated areas. The traditional network architecture has relied on direct supply from the power grid for the RAN, while hard-to-reach areas were typically powered with generators and/or renewables.

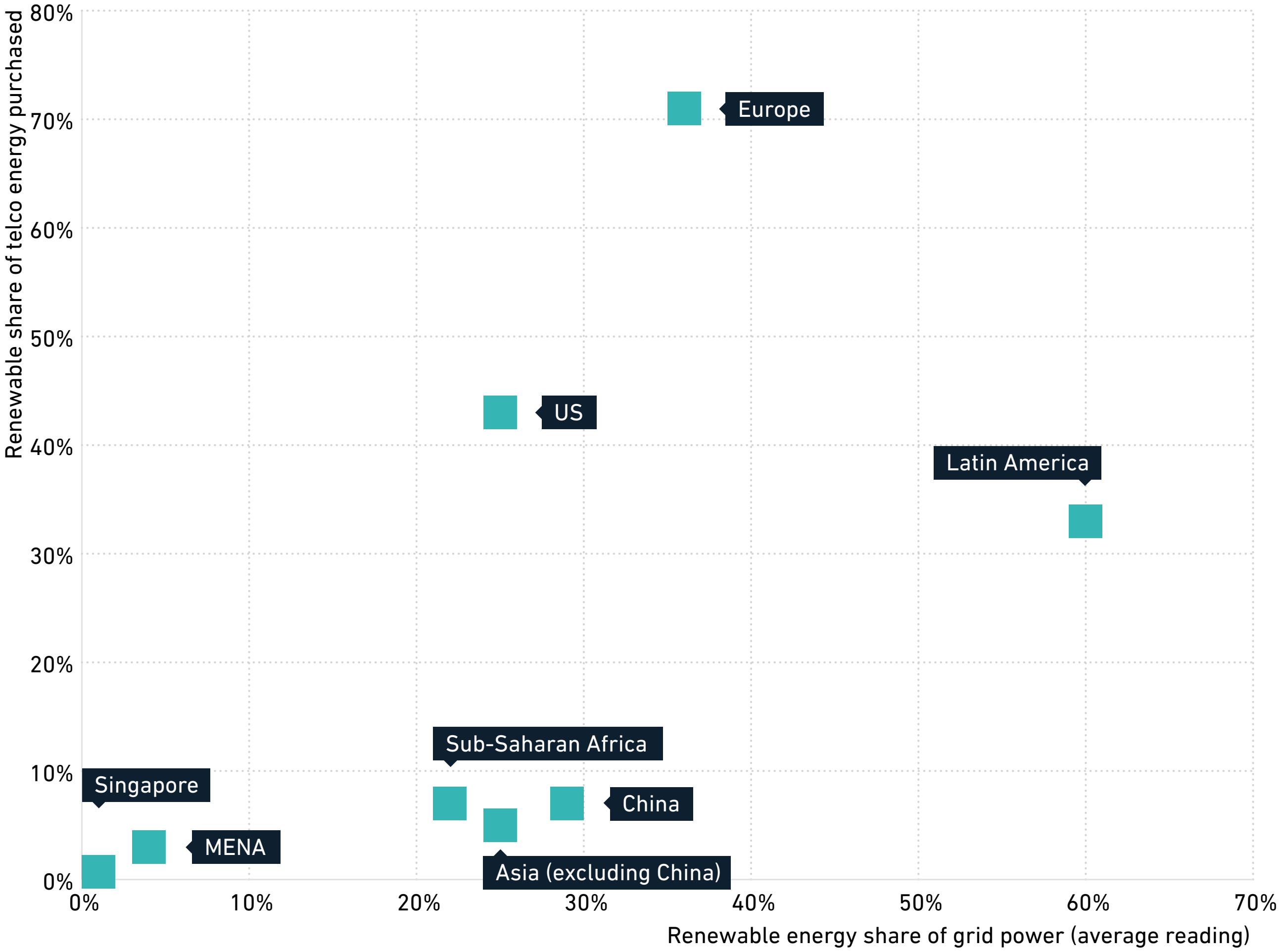
In emerging markets, the lack of a reliable and extensive power grid has posed challenges to the expansion of telecoms networks, with BTSs having to rely on diesel generators as back-up. This leads to a significant increase in opex for the operator.

With the advent of 5G, operators face a surge in energy requirements as they continue to expand coverage but also grow capacity through further investment in compute resources. Added compute will mean increased energy consumption and higher demands on electricity supply. It is no surprise that operators are committing to net-zero targets as they look to implement a new roadmap for sustainability across their networks and operations. Beyond the environmental imperative, there are further benefits to the telecoms industry from an increased focus on sustainability. Decarbonisation changes made in the network will generate positive externalities within the telecoms domain, with a cascading effect for other industries and the greater goal of fighting climate change.

Telecoms has seen a surge in energy consumption drawn from renewables in recent years. The EU is a leader in this regard, though other regions have shown progress in renewables too.

Figure 1

Europe continues to lead on renewables usage



Note: data based on survey responses in October 2022 from mobile operators representing approximately 50% of global market share (by subscribers).
Singapore data based on Singtel reporting
Source: GSMA

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Defining virtual power plants and how they work

A potential win–win

The move to electrification is intensifying across various industries beyond telecoms, as digital transformation gathers momentum. The shift to digital presents new requirements to governments and enterprises, necessitating fresh approaches along with new, cross-border, cross-industry partnerships. The International Solar Alliance (ISA) is an example of this. It aims to generate 1,000 GW of energy by 2030 and mitigate 1,000 million tonnes of CO_2 emissions every year that would otherwise have come from the use of non-renewable sources.

Despite such impressive projects and billions of dollars of investment into power generation, it is increasingly important that investments are made in the transmission networks and overall management of the grid, with a view to balancing energy across the whole network. To achieve this, increased power generation has to easily flow into the power grid through new access mechanisms; otherwise, there will be bottlenecks. Today's emerging smart grids also have energy reserves that are built up and stored for backup power. However, there needs to be way to store surplus power affordably and then make it available as needed. This requires a new approach that is software-led, as opposed to the more hardware-focused and siloed traditional methods.

Telecoms networks can play a key role in this regard. They are already large consumers of electricity, but they also have large storage capacity, which is mandated for backup purposes (at least in developed markets with reliable power supply). This storage capacity is mostly untapped, meaning it can be shared with the power grid in situations where there is a deficit in the mains supply.

Operators are already experimenting and shifting away from traditional lead-acid batteries towards use of newer, lithium-ion batteries that have significantly better characteristics in terms of storage and lifespan. The ability to integrate the telecoms network with the wider power grid and enable dynamic flows of energy between the two would be a win–win for both industries while making a significant contribution to carbon reduction.

Defining a virtual power plant

With VPPs, mobile network operators can leverage existing base station batteries to integrate with the national grid. Mobile operators use non-battery sources of power for most of their operations. Average site energy usage is 30–40 MWh per year in Europe (slightly lower in other regions). Data from GSMA Intelligence energy efficiency research in 2023 suggests the mains grid still meets the highest share of this requirement at 73%, with renewables (21%) and diesel (6%) rounding out the mix. Diesel is predominantly used in emerging markets for rural sites with limited or no access to the grid.

In most countries, there is a legal requirement for uptime of mobile network sites (99.999%, or 'five 9s') so that emergency and essential services are contactable 24×7. This means sites must have backup power sources online in the event of a mains power outage – in much the same way a hospital would. Batteries support most of this, with diesel generators fulfilling the role in limited instances.

As shown in Figure 2, battery power supplied to existing base stations can, through targeted upgrades, be linked to the grid, which is run by a transmission service operator (TSO) or distribution service operator (DSO).

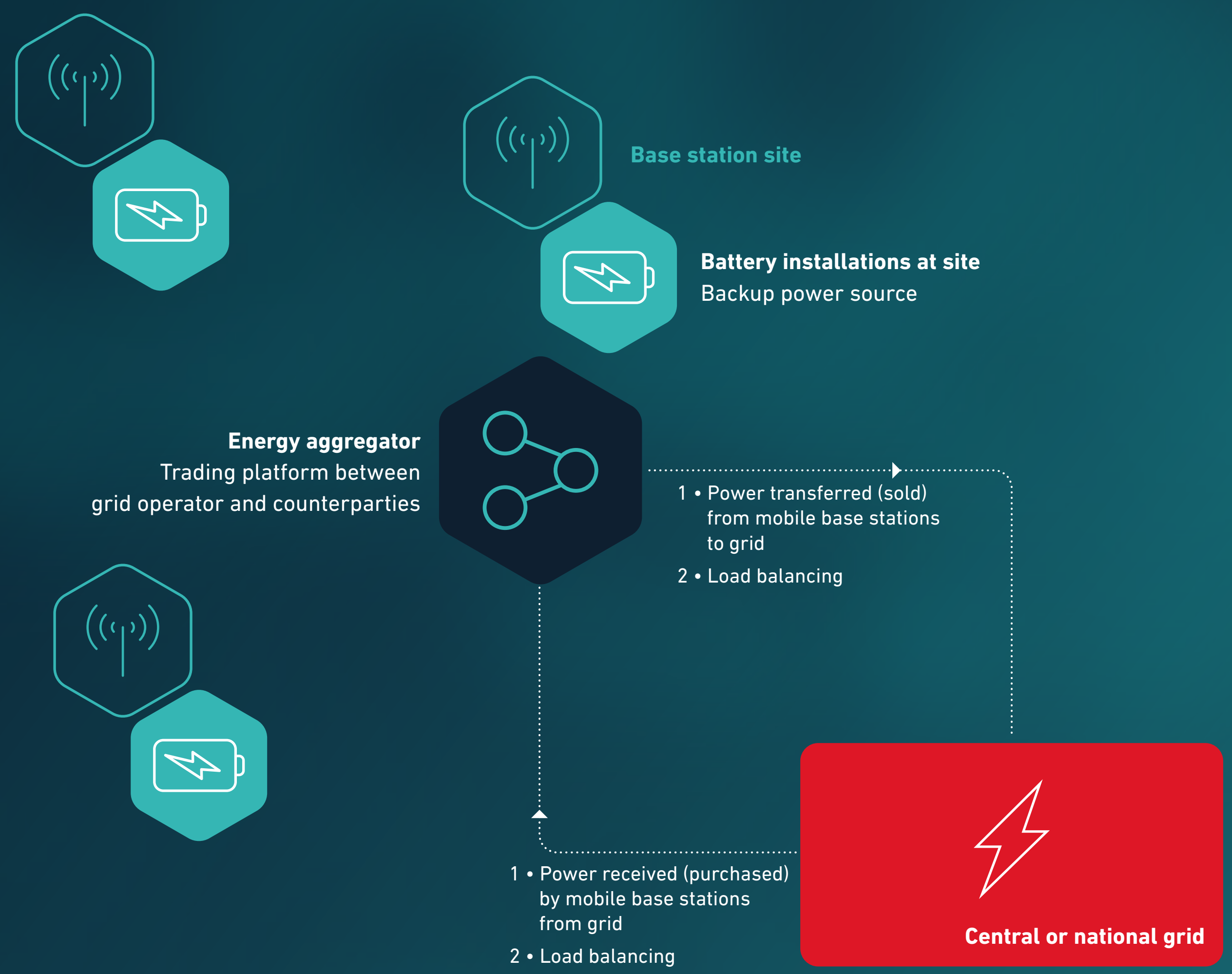
Power can be exchanged bi-directionally (i.e. to and from the grid). Power distribution is typically handled by an intermediary that sits between a telecoms operator and the grid, which manages electricity flows and the trading platform underpinning the energy transactions.

Battery upgrades to lithium-ion and the integration of AI into the network software represent the key changes to site equipment that link the network with the grid. Lithium-ion batteries have a higher storage capacity (three times that of lead-acid), which translates into more resilient charge and discharge, and ultimately a longer usable life. By tapping into data streams emanating from IoT sensors embedded in the batteries, the platform's AI allows for continual monitoring to effect necessary adjustments of energy charge and discharge for each individual site.

Other upgrades and retrofits include a low-latency software control mechanism, having appropriate energy meters at the site level, and network automation platforms (based on ONAP).

Figure 2

Mobile VPPs leverage battery assets to link with the national electricity grid



Note: grid sometimes referred to as transmission/distribution service operator
Source: GSMA Intelligence

The role of VPPs

Operators can achieve the following using a VPP architecture:

- energy purchasing and distribution
- load balancing.

Energy purchasing and distribution works by using AI to determine a given site's power status. Operators can take advantage of peaks and troughs in electricity prices to purchase at off-peak rates, such as in the early morning. They can also use energy storage to discharge electricity when prices are high, such as in the afternoon or evening, to reduce their electricity bills. Operators can use energy storage to balance the peaks and troughs in power availability for energy sourced via power purchase agreements (PPAs). In the long term, operators can use their own sites to feed electricity back to the power grid for sale when the energy is at a sufficient level.

The transfer is handled by an intermediary. This relies on lithium-ion batteries that are programmed with AI, allowing operators to monitor the energy usage and capacity of each cell site in real time.

A key change brought about by AI is that power garnered from renewables (mostly wind and solar) can be stored by operators in times of plentiful supply and used in times of high demand and/or weak supply. At the same time, AI can help operators judge the best times to charge/discharge, making better use of storage power. Network software can automate trading requests with the grid too, ensuring the network demand/supply remains in balance.

Load balancing generally involves leveraging stored energy (such as at a base station or data centre) to participate in power-flexible auxiliary services. These include power grid frequency modulation, peak shaving, capacity reservation and other services that balance power grid fluctuations or shocks. Such capabilities also rely on AI in batteries to monitor charging and discharging, and to schedule and coordinate with the power grid. Revenue is earned by operators on the power sales.

While balancing typically comes from large-scale energy users such as factories or campuses, the expansion of IoT and connected energy assets has underpinned the entry of households, electric vehicles and now mobile networks into the marketplace too. Given that telecoms access networks account for around 1% of global energy usage, the power source from operators is material in the context of maintaining the fidelity of grid function.

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Impact on P&L

The net effects of the above functions are more stable power capacity for mobile networks and the national grid, and more efficient use of renewables overall. For operators, there is also a financial incentive in the form of cost savings from reduced power wastage, and revenue from power services to the grid.

Cost savings

Operators still spend around 10–25% of opex on energy. The vast majority (80%) is sucked up by the RAN. Costs have come down from the highs of 2021 and 2022 (driven by the war in Ukraine), but are still high – particularly for operators not able to secure long-term supply contracts or PPAs.

VPPs can reduce costs by decreasing the volume of energy wasted. Backup batteries must be fully charged but are rarely actually used (because shocks are rare). They therefore represent something of a sunk cost to operators. In addition, in countries with high prevailing energy prices, using the high cycle storage feature of lithium batteries, operators can make better use of electricity price differences, reducing costs.

Revenue

This represents the lion's share of the impact on profit and loss (P&L). Revenue comes from providing flexible auxiliary services to the grid or reverse-selling excess power to the grid company through cell-site energy storage. This relies on having a trading platform in place, along with other upgrades outlined in the previous chapter. However, the uplift is potentially significant.

A mobile network with 10,000 sites, each consuming an average of 30–40 MWh per year (using a European figure), translates into total power use of around 18,000 MW. The excess power required to be on hand for backup presents a sizeable reserve that could be used to substitute some of the mains power. It can also be used to provide ancillary services or sold back to the grid.

Overall impact

Finish operator Elisa trialled a VPP solution in 2022 and reports an interesting set of results. The trial involved 200 sites, or 10% of its network footprint. According to its calculations, cost savings averaged around €5,000 per site per month, with (new) revenue of €44,000 per site per month. It is hard to directly read across from one country to the next on the prospects for VPPs because of the differences in climate and electricity markets. The Elisa case study also comes from 2022, when prices peaked. However, they have not fallen that much. In any case, we can make reasonable assumptions to extrapolate what VPPs could look like in magnitude for other operators given their network footprints. These are shown in Table 1 for a selection of countries in Europe, the GCC and Asia.

Taking just the impact of cost savings, assuming an operator designated 75% of its sites in a country to VPPs, network electricity costs could be reduced by 5–10%. However, revenue gains make up 90% of the financial uplift. Adding the revenue contribution to the cost savings, the overall offset on electricity costs is estimated at 50–80% across these operators, with differences due to the prevailing energy price in each country.

These calculations are shown for illustrative purposes. The balance of cost savings versus revenue gains for each operator from VPPs will depend on the climate, how much power each operator sells back to the grid, and the share of energy sold at peak versus non-peak hour prices. In countries with more stable grids (such as the US), power balancing may be less of a requirement, so the revenue uplift for operators would be lower.

We show VPPs using power only drawn from batteries at base-station locations. This does not include power for other network assets such as data centres (that power the core), or potentially the charging network for electric vehicles.

Table i

Cost savings and revenue uplift from power sales equate to 50–80% of operator electricity costs

Mobile operator	Country	Number of base station sites (June 2022)	Cost savings ($ thousand)	Revenue uplift ($ thousand)	VPP cost savings as % of electricity costs	VPP total uplift as % of electricity costs*
Vodafone	Portugal	14,645	5,356	44,058	6.1%	56.6%
MEO (Altice Europe)	Portugal	15,787	5,773	47,494	6.1%	56.6%
Nos	Portugal	17,227	6,300	51,826	6.1%	56.6%
Vodafone	Italy	22,946	8,391	69,031	5.4%	50.2%
Bouygues Telecom	France	25,591	9,359	76,988	9.2%	85.0%
Free Mobile (Iliad)	France	25,001	9,143	75,213	9.2%	85.0%
Orange	France	29,370	10,741	88,357	9.2%	85.0%
SFR (Altice Europe)	France	25,397	9,288	76,404	9.2%	85.0%
Vodafone	Qatar	2,250	823	6,769	8.9%	82.5%
Ooredoo	Qatar	3,652	1,336	10,987	8.9%	82.5%
Jazz (Veon)	Pakistan	15,500	5,668	46,630	8.9%	82.5%
PTCL	Pakistan	10,000	3,657	30,084	8.9%	82.5%
Indosat	Indonesia	166,536	60,902	501,007	8.9%	82.5%
Telkomsel	Indonesia	228,377	83,517	687,049	8.9%	82.5%
XL (Axiata)	Indonesia	151,487	55,399	455,733	8.9%	82.5%
Elisa	Finland	2,000	731	5,232	6.6%	60.9%

Assumptions: operators use 75% of their sites for VPPs (energy cost savings and re-sale to electricity grid); cost savings per site per year are $0.37; revenue uplift per site per year is $3.01
Source: GSMA Intelligence, company reports, Statista, Eurostat

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Outlook

The future view of the smart grid recognises that consumers of energy are increasingly different to the traditional mix of users. At the same time, newer technologies would allow these same consumers to produce and store energy surpluses, which can then be sold back to the power grid as needed.

VPPs, while not a new concept, are garnering attention now as the building blocks become available. These include emerging technologies such as lithium-ion batteries, which represent a huge jump on lead-acid, wide-bandgap semiconductor materials that are increasing yield and performance, and improved software platforms that can orchestrate intent-based operations across networks. These technological building blocks, deployed in concert across telecoms and utility networks, help create a dynamic system that enables energy flows on-demand to fill gaps and rebalance electricity loads across the grid.

Go-to-market considerations

Operators should consider the following factors as part of their go-to-market strategy:

- **Coordination between cell sites.** This means investing in software and AI to coordinate energy storage data across an entire national footprint (potentially thousands of sites) and determining which have the requisite reserves to participate in any grid-balancing activity.
- **Ultra-high-speed response.** Grid operators typically require very low response times (seconds) for participants of frequency containment reserves (telecoms operators included).
- **Precision.** Linked to response time, electricity provisioned from battery storage must be a near-identical match to the grid requirements, or vice versa in the case of energy being purchased by operators via an aggregator.
- **Intelligence and quality of service.** Another requirement of the coordination software is to ensure the fidelity of existing network functions for communications use. Operators typically have redundancy built into mobile networks already, with VPPs adding the dimension of energy management to other potential sources of a fault (such as a security hack or physical damage from adverse weather). A set of technical specs based on the energy market in Finland can be consulted as a reference guide.[1]

Beyond emerging technologies, there is also significant movement on the policy front as governments and regulators are cognizant of the potential of VPPs. VPPs are crucial not only in terms of their official net-zero commitments and sustainability targets, but also in terms of building the necessary resilience into power grids and planning processes. This resilience can help mitigate the impact of extreme weather-related events, conflicts born of geopolitical issues, and security breaches.

In many cases, regulators are learning on the go and tweaking policies to help industry meet net-zero commitments. Small steps can go a long way. A recent example comes from India, where the Department of Power amended its Electricity Rules for Green Energy Open Access. Indian operators' BTS sites across the entire RAN are highly distributed. Individually, each one – with an average energy consumption requirement of around 10 kW – would have fallen well below the minimum threshold for green energy access of 100 kW. The amended rules allow for aggregation of energy requirements across a number of sites, provided that they are all drawing "from the same electricity division of a distribution licensee".

The growing imperative to change

Telecoms operators have traditionally faced a number of challenges in shifting away from their traditional models of energy consumption. In several cases where the power grid was reliable, they simply have not had the imperative or incentive to change.

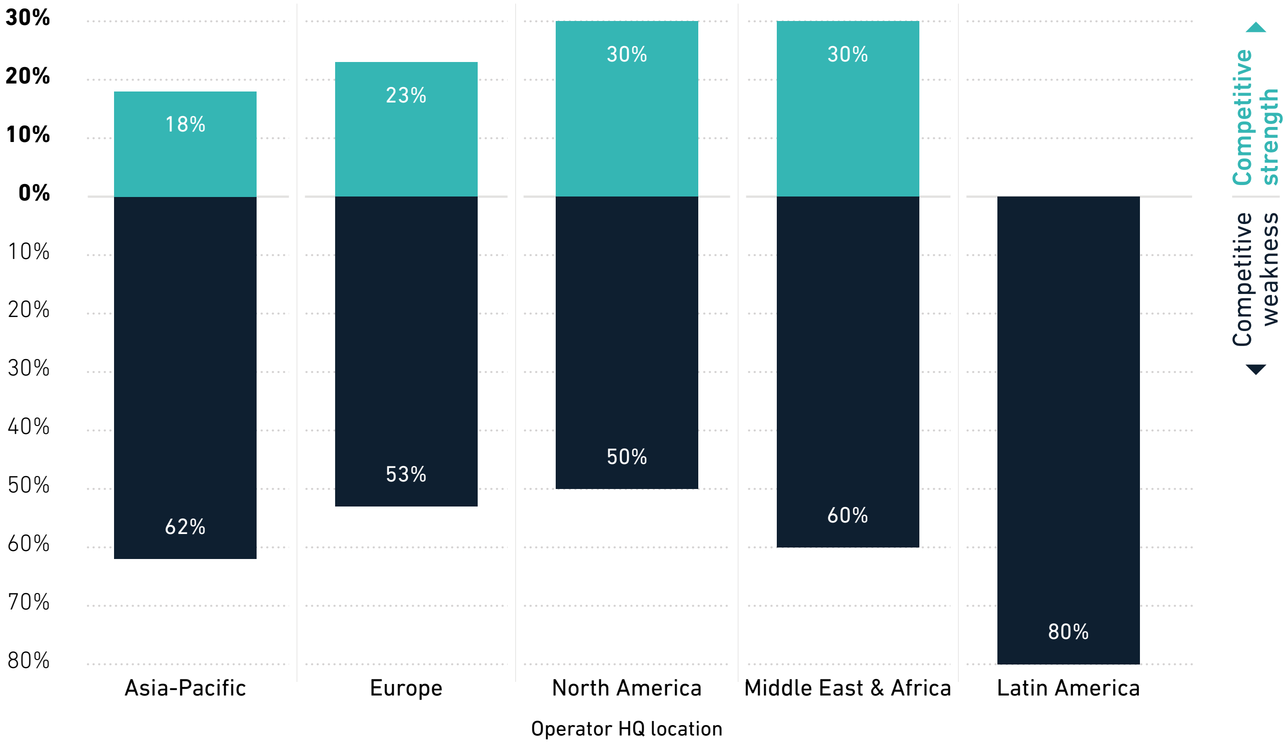
Bigger picture changes in the industry are now placing increasing pressure on revenue generation and profitability, which has forced increasing attention to be paid to opex reduction strategies. Carbon reduction is fundamental to these business imperatives. Most operators are keen to increase their use of renewables and change their operating models. At the same time, they acknowledge they are lagging behind in their execution track record and ability to effect change.

1 Reserve Products and Reserve Market Places, FINGRID, 2023

Figure 3

Most operators see themselves as behind on using energy as a saleable asset

How would you assess the effectiveness of energy efficiency and sustainability in your product marketing?



Source: GSMA Intelligence survey on enterprise edge compute (June/July 2023)

New platforms such as VPPs offer a number of benefits to telecoms operators:

- **Reduced energy consumption.** Increased use of renewables and improved power efficiency can produce significant reductions in electricity use across the network. At a time when energy prices have been rising globally, reduced consumption of electricity will generate opex savings and positively impact the operator bottom line.
- **Improved power efficiency.** Across the network, this can be achieved through the ability to tap into stored energy in batteries and reallocate to areas of the network that are in deficit or have been disrupted. Use of newer lithium-ion batteries with better charge and discharge features will help operators procure additional power as needed, as opposed to bulk purchases at fixed rates.
- **Revenues from the sale of energy.** VPPs position operators to enter uncharted territory –to become an electricity service provider or energy seller. Surplus, stored energy from multiple cell sites across the network can provide flexibility services or be sold to the power grid through interconnect mechanisms in the access networks.
- **Meeting net-zero targets.** VPPs will go a long way to helping operators achieve their net-zero targets. Operators across different regions all have different timelines for their committed shifts to net zero. However, all will follow similar paths in terms of their investments in renewables and new platforms that will allow them to become more efficient energy consumers and produce electricity for sale back into the power grid.

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