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VIRTUAL POWER LINES

INNOVATION LANDSCAPE BRIEF

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ABOUT IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future and serves as the principal platform for international co-operation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity. **www.irena.org**

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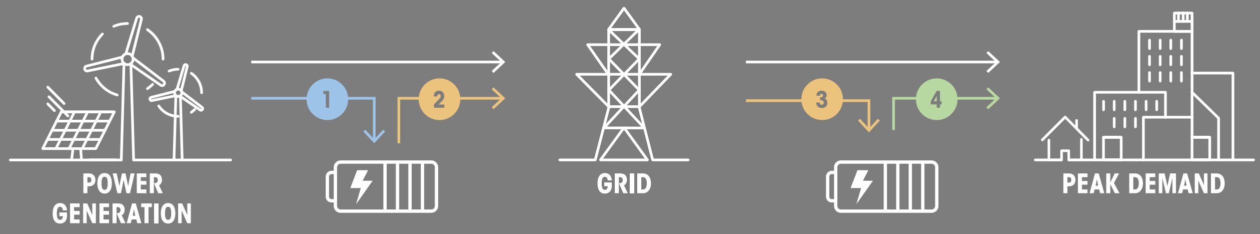
1 BENEFITS

Virtual power lines (VPLs) allow large-scale integration of solar and wind power without grid congestion or redispatch, avoiding any immediate need for large grid infrastructure investments.



Supply-side-storage

1. Charges based on previous renewable generation avoid congestion and curtailment
2. Discharges to demand-side storage system whenever grid capacity is available

Demand-side-storage

3. Charges when renewable-based generation and network capacity allow
4. Discharges to address peak demand

2 KEY ENABLING FACTORS

- Regulatory framework for energy storage systems
- Multi-service business case for storage systems
- Digitalisation

3 SNAPSHOT

- ➔ VPLs provide 3 GW of installed storage capacity worldwide
- ➔ Global needs for network investment deferral could reach 14.3 GW by 2026.
- ➔ Australia, Italy, France and the US are piloting VPLs to reduce renewable power curtailment.

What are VPLs?

VPLs consist of utility-scale storage systems connected to grid at two key points:

- One on the **supply side**, storing surplus generation from renewables that could not be transmitted due to grid congestion.
- Another on the **demand side**, charged whenever grid capacity allows and then discharged when needed.

VIRTUAL POWER LINES

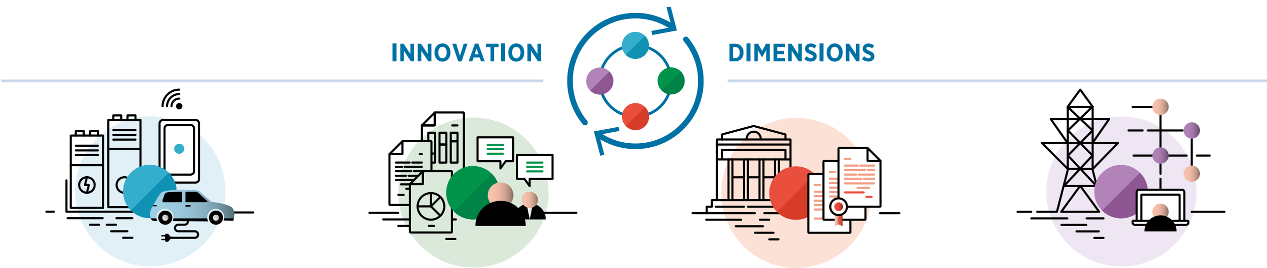
Storage systems used as VPLs complement existing infrastructure and offer a technically sound, financially viable alternative to reinforcing the power grid where additional capacity is needed.

ABOUT THIS BRIEF

This brief forms part of the IRENA project "Innovation landscape for a renewable-powered future", which maps the relevant innovations, identifies the synergies and formulates solutions for integrating high shares of variable renewable energy (VRE) into power systems.

The synthesis report, "*Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables*" (IRENA, 2019a), illustrates the need for synergies between different innovations to create actual solutions. Solutions to drive the uptake of solar and wind power span four broad dimensions of innovation: enabling technologies, business models, market design and system operation.

Along with the synthesis report, the project includes a series of briefs, each covering one of 30 key innovations identified across those four dimensions. The 30 innovations are listed in the figure below.



ENABLING TECHNOLOGIES

1 Utility scale batteries
2 Behind-the-meter batteries

3 Electric-vehicle smart charging
4 Renewable power-to-heat
5 Renewable power-to-hydrogen

6 Internet of Things
7 Artificial intelligence and big data
8 Blockchain

9 Renewable mini-grids
10 Supergrids

11 Flexibility in conventional power plants

BUSINESS MODELS

12 Aggregators
13 Peer-to-peer electricity trading
14 Energy-as-a-service

15 Community-ownership models
16 Pay-as-you-go models

MARKET DESIGN

17 Increasing time granularity in electricity markets
18 Increasing space granularity in electricity markets
19 Innovative ancillary services
20 Re-designing capacity markets
21 Regional markets

22 Time-of-use tariffs
23 Market integration of distributed energy resources
24 Net billing schemes

SYSTEM OPERATION

25 Future role of distribution system operators
26 Co-operation between transmission and distribution system operators

27 Advanced forecasting of variable renewable power generation
28 Innovative operation of pumped hydropower storage

29 Virtual power lines
30 Dynamic line rating

This brief provides an overview of virtual power lines (VPLs)[1] – the innovative operation of energy storage systems (ESSs), particularly utility-scale batteries, in response to the increased integration of renewable energy in capacity-constrained transmission and distribution networks. The brief highlights examples of battery storage systems deployed with the primary objective of deferring conventional grid reinforcement, and explores innovative ways to operate batteries to enable VRE integration in different power system contexts.

The brief is structured as follows:

1 *Also referred to as virtual transmission lines or non-wire alternatives.*

I. DESCRIPTION

The increasing share of renewable electricity in power systems, especially from variable sources, requires efficient management of transmission and distribution networks to prevent congestion. The traditional approach to increasing grid capacity is reinforcing the system with additional network components (*e.g.* adding overhead lines) or by upgrading existing lines or cables to address thermal or voltage constraints.

As an alternative to expensive upgrades to the transmission and distribution infrastructure for VRE grid integration, non-wire alternatives – also called virtual power lines (VPLs) – are being rolled out. Instead of reinforcing or building additional transmission and distribution systems, energy storage systems (ESSs) connected at certain points of the grid can support the existing network infrastructure and enhance the performance and reliability of the system. VPLs are a particular application of batteries. In this case, batteries are usually owned and operated by system operators (for more information about batteries' applications see *Innovation landscape brief: Utility-scale batteries* [IRENA, 2019b]).

VPLs include ESSs connected in at least two locations. The first is on the supply side, close to the renewable generation source, which stores surplus electricity production that cannot be transmitted due to grid congestion. Such storage averts the need for curtailment. The other. on the demand-side, can be charged whenever transmission capacity is available. In this second case, the ESS is used to meet demand during periods when there is insufficient transmission capacity, using batteries charged during previous periods of low demand and free transmission capacity.

Ultimately, a VPL is the application of ESSs to help manage congestion without interfering in the balance between demand and supply. Figures 1 and 2 illustrate how VPLs work.

Used as VPLs, utility-scale battery storage offers a technical alternative to adding electricity grid capacity, while also increasing system reliability and security. The aim of using VPLs is to make additional electricity capacity available much faster and, in some cases, at a lower cost than pursuing a conventional infrastructure reinforcement or expansion. VPLs provide a particularly cost-effective solution when network congestion occurs during specific rare events, such as extremely high temperatures during the summer, and when costly upgrades to network capacity would be underutilised. Furthermore, if regulations permit, the ESS can also support the system by providing ancillary services such as frequency regulation, voltage support and spinning reserves.

Figure 1 The concept of VPLs

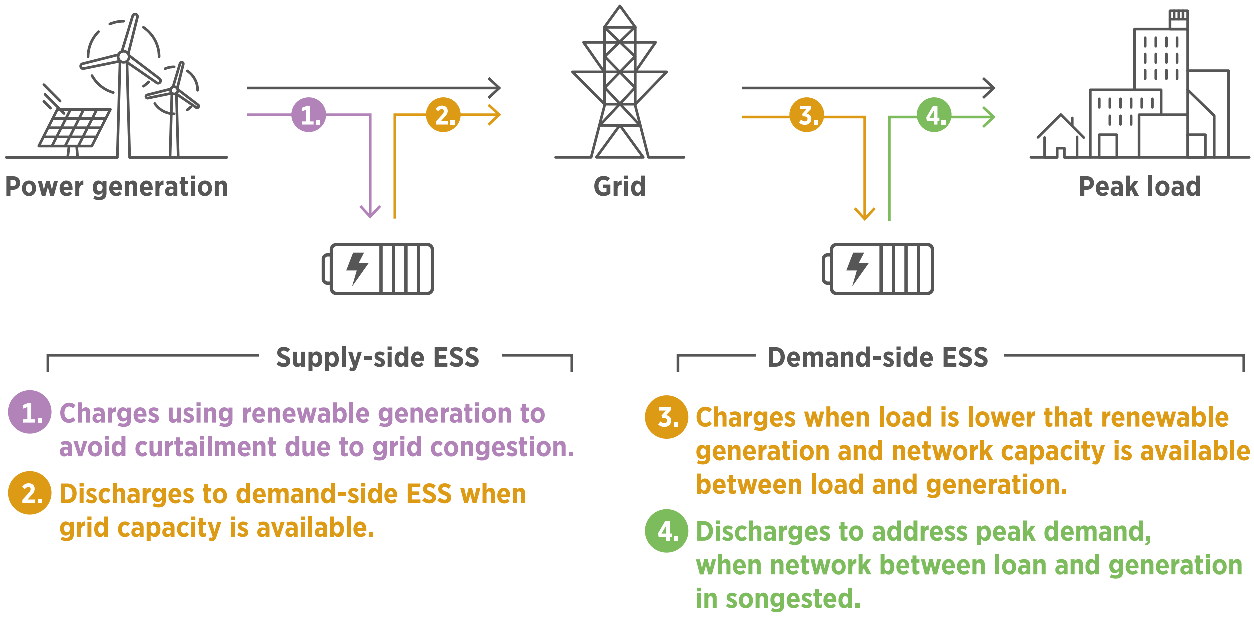
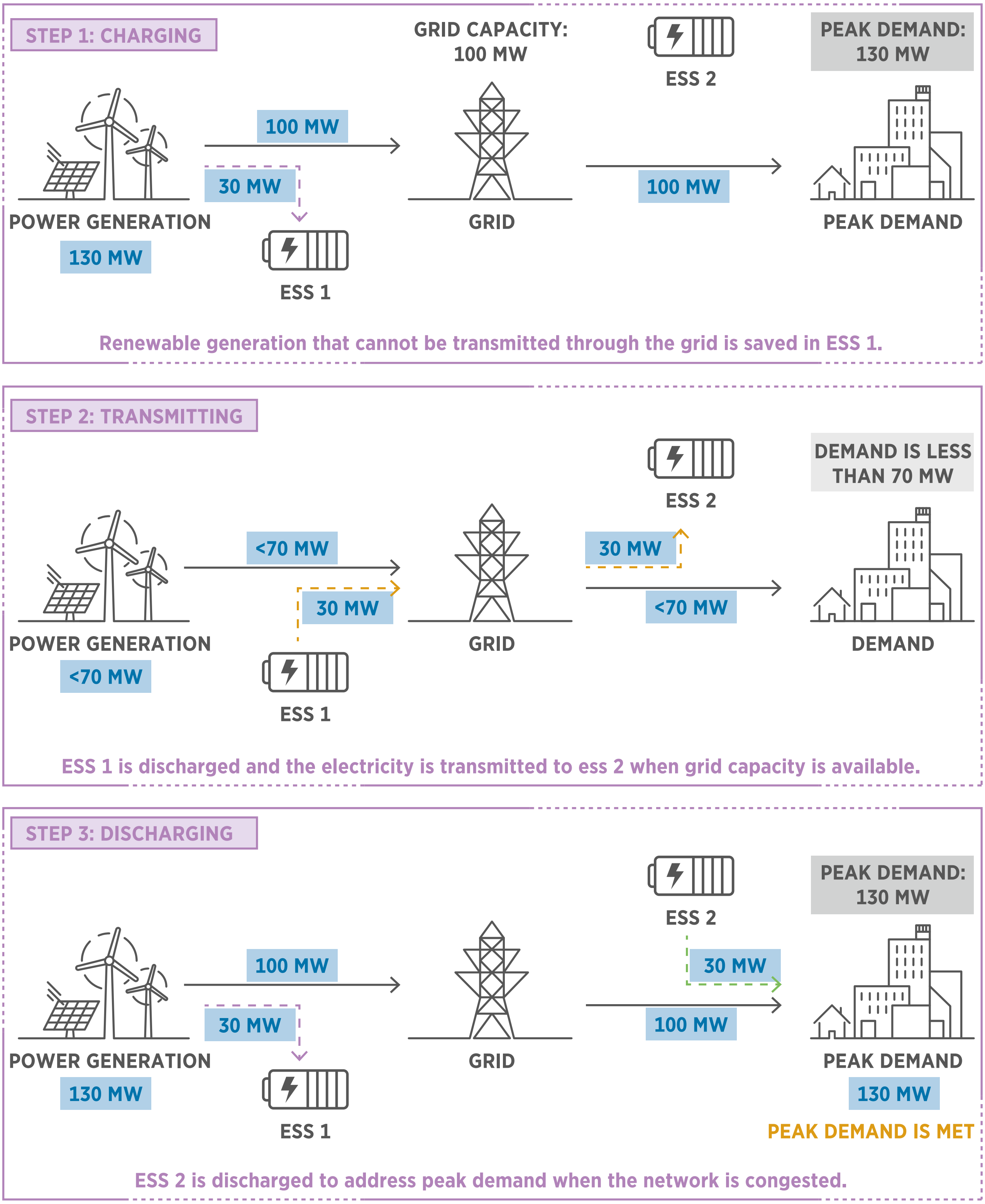


Figure 2 illustrates the flows in a practical example of how a VPL works.

Figure 2 Example of the functioning of a VPL



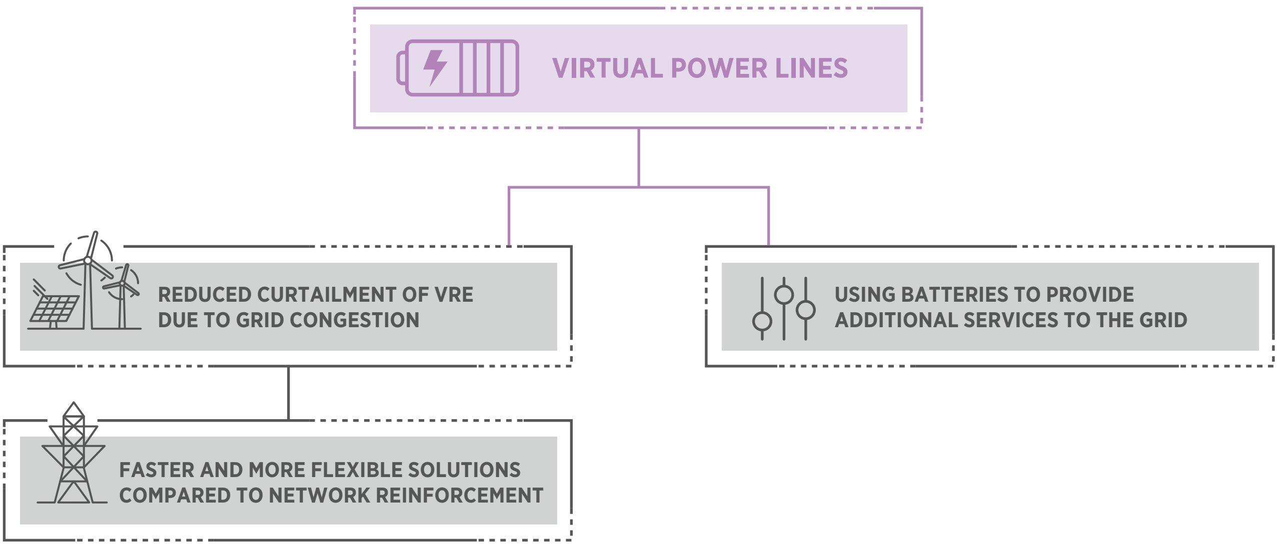
Note: MW = megawatt.
Source: Adapted from ENTSO-E (2016).

II. CONTRIBUTION TO POWER SECTOR TRANSFORMATION

As mentioned, VPL provides a particularly cost-effective solution when network congestion occurs in specific rare events, such as extremely high temperatures during the summer, and when costly upgrades to network capacity would be underutilised.

In this case, ESSs can enable the integration of higher shares of wind and solar electricity without any need for large capital investments to expand transmission infrastructure. Additionally, with the adoption of necessary regulations, the ESS can provide ancillary services to support the operation of the power system (Figure 3).

Figure 3 Key contributions of VPLs



Reduced curtailment of VRE due to grid congestion

Grid congestion tends to happen when network components reach their thermal limits due to excessive generation or demand, or because of a requirement to keep synchronous generation online. Traditional methods adopted to counter it are reinforcing the grid, redispatch, demand response, generation curtailment and other power flow control measures.

Reinforcing the grid is an option that requires significant time to be implemented, may face public acceptance issues and is relatively expensive when congestion happens only rarely. Redispatch refers to shutting down generating units behind the congestion and starting power units beyond the congestion instead, closer to the demand. This option comes at a cost for the system, as actors involved need to be rewarded or compensated. Demand response can be employed to alleviate system congestion by motivating interaction between power system dispatchers and power consumers. However, such an approach presents challenges as it requires both technical and economic considerations.

Curtailment of generation means disconnecting renewables whose generation cannot be controlled. ESSs can be used to absorb the renewable energy generation that would otherwise have been curtailed due to grid congestion. Such batteries must be located at points close to the most frequent congestion points caused by the excess renewable generation.

For example, in Chile the independent power producer AES Gener has submitted a proposal for two 200 MW energy storage projects to the Chilean regulator for inclusion in Chile's National Transmission Expansion Plan. If approved, the two virtual transmission projects will relieve congestion in a transmission line where 700 MW of renewable generation is set to come online (Kumaraswamy, Cabbabe and Wolfschmidt, 2019).

Faster and more flexible solution compared to network reinforcement

The implementation process for traditional investments in transmission upgrades often takes several years and cannot react to rapidly changing demand and generation patterns. Where demand is growing steadily, traditional grid reinforcement investment can be carried out in large increments. This is more difficult in places where demand is flat or declining, such as in Europe, where the need for greater transmission capacity results from the move towards increasing shares of renewable energy and thus changing the location of generation, not higher demand.

Battery storage can provide an immediate solution to congestion on certain lines, especially when congestion occurrences are rare – exceptional events rather than regular ones. With a small amount of storage capacity, the necessary expansion in transmission infrastructure can be deferred up to a point in the future when the cost of the transmission upgrade is lower than the cost of using storage (Eyer, 2009; Eyer and Corey, 2010).

The existing transmission and distribution infrastructure is designed for peak load that only occurs for a limited period. Additional investment to manage variability from increasing VRE could potentially lead to even lower utilisation. Conversely, investing in an ESS will simultaneously result in improved utilisation of both transmission and distribution infrastructure and the VRE generation assets (E2Tech, 2015). Unlike poles and wires, battery-based energy storage is modular and can be scaled to fit the need. Therefore, the storage technology and size most suitable for network needs should be selected to ensure an efficient, reliable and secure operation of the system.

Table 1 summarises the benefits that the VPL can provide as a solution to the need for costly and time-consuming network reinforcement.

Table 1 Summary of network upgrade challenges and benefits brought by VPLs

Network upgrade challenges	Benefits of VPLs
Lengthy (multi-year) planning, permitting and development process	Storage systems can be designed and built, and be operational, in several months to defer transmission upgrades or at least provide resilience for the network through the lengthy development process.
Uncertain load growth rates and demand patterns	VPLs with the ESSs can be deployed in small modular capacity increments, avoiding oversizing and stranded assets.
Single function of transmission capacity	When not needed for transmission and distribution network deferral, ESSs can have multiple uses such as generating revenues and reducing grid operation costs by providing frequency regulation, voltage support, spinning reserves and other services, provided regulations allow them to provide such services.
Local community opposition	The ESSs could have a smaller impact on nearby property values compared to transmission lines, as the ESS are often installed at substations or existing grid facilities.

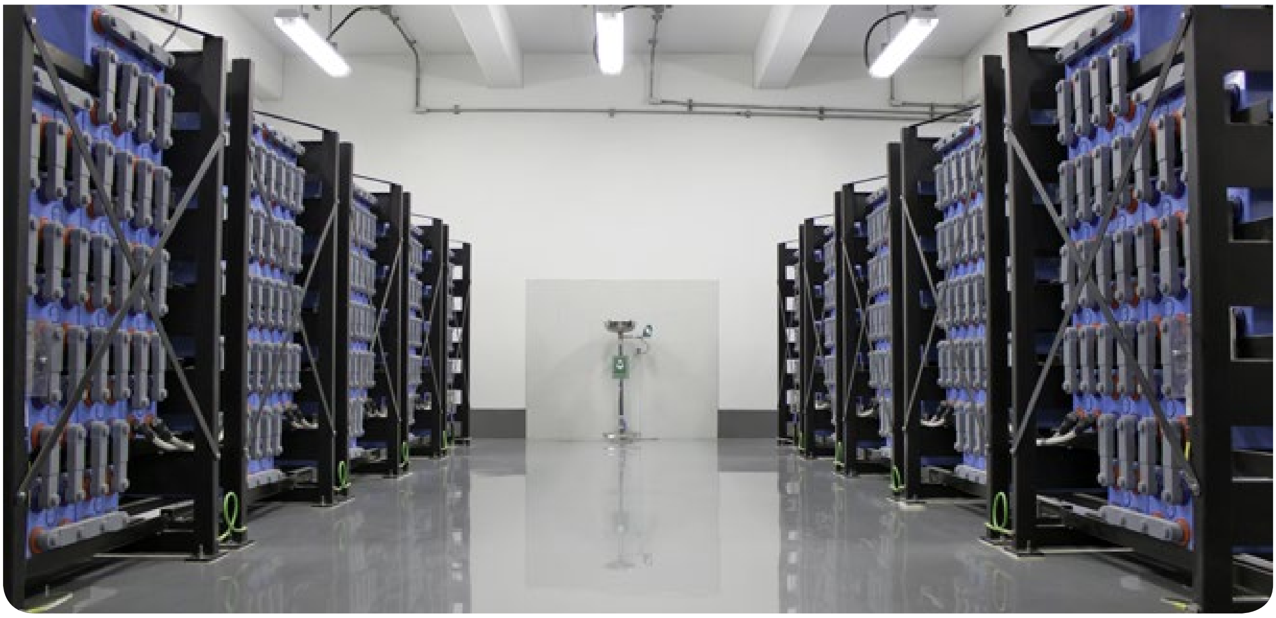
Source: Eller (2017).

Using batteries to provide additional services to the grid

In addition to enabling greater dispatchability of VRE generation, storage can also provide reactive power, enabling network operators to better preserve system performance in the event of temporary transmission outages or, in more extreme circumstances, prevent blackout. VPL projects are also well-suited to providing a range of ancillary services. Batteries can provide fast frequency response, which could replace peaking gas power plants.

They can also offer system inertia, traditionally provided by coal-fired plants, for which synchronous condensers have become the main requirement, and flexible ramping (see *Innovation landscape brief: Utility-scale batteries* [IRENA, 2019b]).

However, the regulatory framework dictates whether batteries used as VPLs can also participate in the wholesale and ancillary service markets, where such markets exist. Moreover, the optimal use of the battery itself should also consider the number of charges and discharges per day and the life span of the battery.



III. KEY FACTORS TO ENABLE DEPLOYMENT

Efficient use of utility-scale battery storage as non-wire reinforcement of network capacity requires regulations that position the battery either as a network asset, as a market player, or both. Communications and control systems are also key for the optimal operation of batteries as VPLs.

Establishing a regulatory framework for ownership and operation of ESSs

Clear regulations regarding the ownership and operation of the ESS are essential for enabling their operation, either as a market participant or as a network asset. For example, if the ESS is classified as a market-based asset, transmission and distribution operators may face restrictions on owning or operating the asset for grid reinforcement deferral. If it is classified as a network asset and used as a VPL, it might not qualify for providing services in a competitive market-based environment.

Therefore, clear regulations are needed to guide the use of ESSs while maximising the benefits for both the system and the ESS. The cost-benefit analysis for storage systems should incorporate benefits offered to the wider power system rather than only considering benefits directly offered to the ESS owner.

Energy storage plays a key role in the transition towards a carbon-neutral economy and has been addressed across different jurisdictions.

The EU "Clean energy for all Europeans" package seeks to define a new regulatory framework that allows energy storage to compete with other flexibility solutions, such as demand response, interconnections, grid upgrades and flexible generation. Directive (EU) 2019/944 on common rules for the internal market for electricity states that network tariffs should be cost-reflective and transparent, while ensuring security of supply and not discriminating against energy storage. As per this directive, generally, distribution and transmission network operators are not allowed to own energy storage assets. However, it provides for certain specific circumstances in which regulated entities, distribution system operators (DSOs) and transmission system operators (TSOs), are allowed to own and operate energy storage facilities (European Commission, 2017). Such situations are:

- If these assets are considered "fully integrated network components"[2], and the regulatory authority has granted its approval.

- If other parties, following a transparent tendering procedure, have not been awarded the right to own and operate storage or cannot do so at a reasonable cost within the given timeframe.

2 Fully integrated network components are those integrated into the transmission or distribution system and are used only for the purpose of reliable operation of the system.

In addition, these facilities must be necessary for DSOs or TSOs to fulfil their obligations, and are not used to buy or sell electricity in electricity markets. In all other situations, energy storage services should be market-based and competitive under the new European electricity market design.

Some TSOs have started naming this solution – using batteries as integrated network components – as VPLs. Certain EU member states have already implemented regulations at national level to enable storage operations as VPLs. In Italy, transmission and distribution network operators are allowed to own and control battery systems if the operator can prove the monetary benefit of energy storage over other alternatives, including the cost of investing in expanding network infrastructure. However, storage systems should not negatively impact competitive market functioning (Castagneto-Gissey and Dodds, 2016). Such regulations enabled Italy's TSO, Terna, to launch projects using grid-connected battery ESSs to integrate renewables and boost transmission capacity.

Outside Europe, countries are also investigating ways to redesign their regulations to enable energy storage as a transmission asset. In September 2019 Australia's Energy Security Board (ESB) called for submissions to inform the redesign of the rules governing the national electricity market. The rules must incentivise storage and other dispatchable generation in the future renewables powered system. The ESB aims to set new rules by 2022 and for them to be implemented by 2025 (PV magazine, 2019).

In the United States, the Federal Energy Regulatory Commission (FERC) Order 841 directs grid operators across the country to develop market rules for energy storage to participate in the wholesale energy, ancillary services and capacity markets by treating storage as a generation resource.

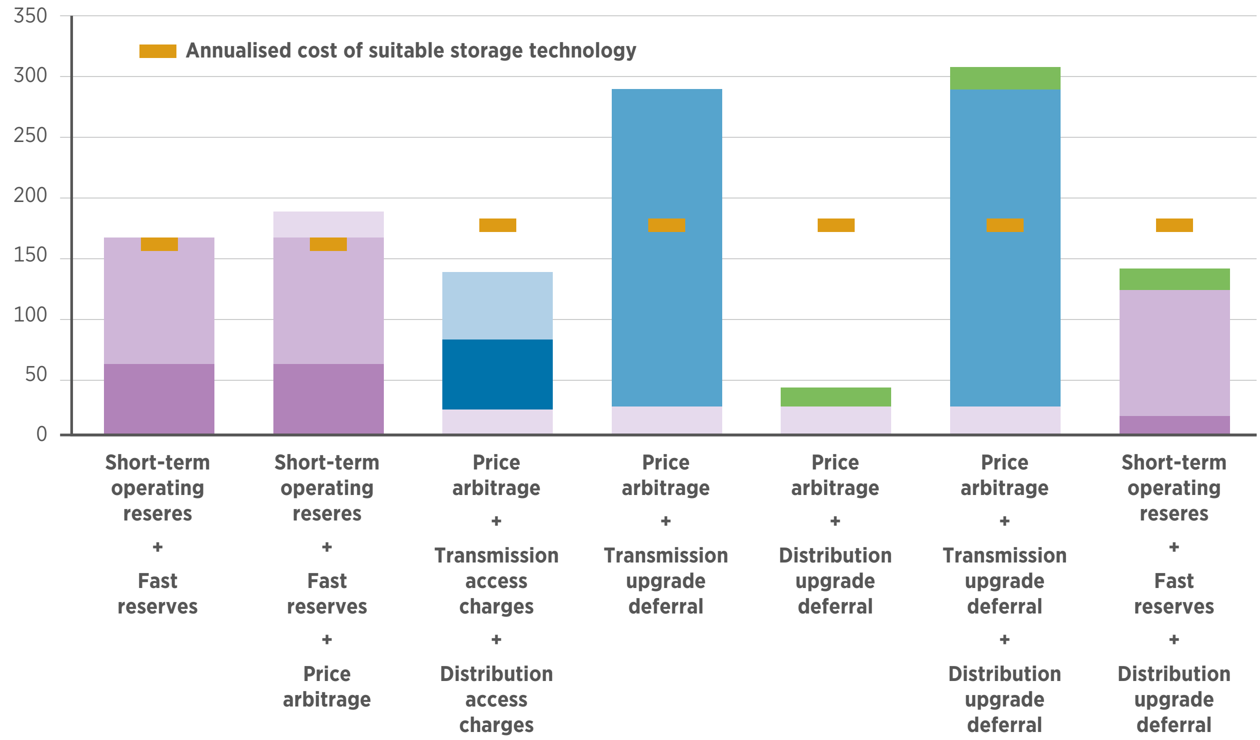
FERC organised a technical workshop stakeholders in November 2019 to explore ways to address challenges and support the deployment of grid-enhancing technologies, including energy storage as a transmission asset. FERC is currently reviewing all the inputs from the workshop, with a view to issuing its position (FERC, 2019; Konidena, 2019).

Implementing the multi-service business case

In a multi-service business case approach, multiple stakeholders are jointly involved in the ownership, development, management and/or operation of a VPL with two or more ESSs to maximise its social welfare by fully deploying all the services the storage system can deliver. This approach reflects the ownership provisions laid out in Articles 36 and 54 of the Directive (EU) 2019/944 on common rules for the internal market for electricity in European Union.

ESSs should be permitted to provide a range of services including storage to reduce congestion, which would help to defer network investment, as well as ancillary and balancing services, such as frequency and voltage regulation. Allowing the stacking of multiple revenues is key to improving the business case for storage and maximising its social welfare. If considered individually, most of the services provided by energy storage facilities do not continuously mobilise 100% of the power/energy capacities of an ESS or do not generate enough revenue to reach profitability (EASE, 2019). This is illustrated in the UK case in Figure 4.

Figure 4 Annual cost-benefit of storage applications in the United Kingdom



Source: EASE (2019).

Where unbundling rules do not permit TSOs and DSOs to own and operate energy storage assets, market players may be able to operate such assets and thereby participate in balancing and ancillary services markets to maximise storage utilisation. A "hybrid" model could be envisaged where storage assets are developed, owned, operated and maintained by a regulated entity. The regulated entity would dispatch the storage asset for infrastructure services while pursuing its primary goal of ensuring a safe and reliable electricity system.

A market player could be responsible for providing and monetising market-based value streams, such as arbitrage and frequency regulation. If the asset is not used for infrastructure purposes, it could be used fto provide market-based services to avoid the suboptimal utilisation of the asset, maximise social welfare and reduce costs for consumers. The revenues the regulated owner would receive from the market players would be deducted from the amount that the regulated entity may include in its cost base (EASE, 2019).

Digitalisation

Digitalisation is critical to employing an ESS effectively as VPL. Communication systems need to be deployed together with energy management software, possibly with artificial intelligence. Digital technologies, such as artificial intelligence, can be used to better predict and make decisions on the management of the ESS. In the case of a multi-service business case, communication between various players involved in the operation of the ESS is key (for more details see the *Innovation landscape brief: Artificial intelligence* and big data [IRENA, 2019b]).

Identifying and agreeing upon the most important interoperability standards will allow for a seamless and secure connection between batteries and system operators. Interoperability standardisation would mark an important step towards the integration of battery storage for energy services and harness the full potential of a flexible, reliable electrical grid system (Dodge-Lamm, 2018).

IV. CURRENT CONTEXT AND ONGOING INITIATIVES

Over the years, the price of grid-connected battery storage has steadily declined and is expected to decline even further in the coming years. For instance, the price of lithium-ion batteries has fallen by over 30% in the past five years (Bullard, 2018). This has made it an affordable non-wire alternative to large capital investments in transmission and distribution network infrastructure.

French TSO, RTE, is implementing its first 40 MW VPL pilot project named RINGO, with the goal of increasing grid integration of renewable energy and optimising electricity currents on its network. A German grid development plan, produced by all four TSOs in the country, has proposed 1.3 gigawatts (GW) of energy storage to ensure grid stability and lower network costs.

The Andhra Pradesh Transmission Company, a publicly owned utility in India, proposed between 250 MW and 500 MW of energy storage to add capacity to its transmission network with an innovative cost recovery mechanism. The plan, put forth in early 2019, includes allocating costs between renewable power developers and distribution companies that have an obligation to serve load.

In the United States, Pacific Gas & Electric selected a 10 MW energy storage project as part of a portfolio of transmission solutions during its regional transmission planning process, the first such project chosen to provide congestion relief in US markets. In addition, in 2018 the US PJM Interconnection market received proposals for multiple 25–50 MW battery-based storage projects to help relieve network congestion issues (Kumaraswamy, 2019). in Australia, projects using battery-based storage as virtual transmission are being considered alongside traditional poles and wires to add capacity on key interstate transmission lines (Kumaraswamy, Cabbabe and Wolfschmidt, 2019).

Some of the key indicators suggesting the growing use of ESSs for deferring investment in network infrastructure are shown in Table 2.

Table 2 Key indicators about VPLs

Description	Key facts
Countries where VPL projects are being piloted	Australia, France, Germany, India, Italy, United States[1]
Storage capacity of VPL projects currently being considered or constructed (as of 2019)[2]	**Globally:** 3 GW **US:** 62.5–87.5 MW (3 projects) **France:** 40 MW **India:** 250–500 MW **Chile:** 400 MW **Germany:** 1 300 MW **Australia:** > 1 000 MW **Italy[3]:** 35 MW
Expected growth in battery storage for transmission and distribution investment deferral	~ 14 300 MW by 2026[4]
Estimated savings from transmission and distribution investment deferral	USD 100 million project deferred by five years would result in savings of about USD 29 million (assuming discount rate of 7%)

Sources: [1]Kumaraswamy (2019); [2]Kumaraswamy, Cabbabe and Wolfschmidt (2019); [3]Musio (2017); [4]Navigant Research (2017).

Examples of VPL projects

RINGO project, France

The French TSO, RTE, has deployed a pilot project called RINGO that involves placing ESSs at three various locations in the network to manage congestion. The ESSs will be deployed so that while one battery absorbs renewable energy generation in excess of transmission capacity, another will be connected to the demand centre. Each battery in this system will have a capacity of 12 MW/24 megawatt hours (MWh) and is expected to be operational in 2020, for a test period of three years. The batteries used will be lithium-metal-polymer batteries at one location, and lithium-ion batteries at the other two locations.

Control systems will determine when the energy stored in the supply side battery can be shifted to the demand side battery according to the transmission line congestions, generation and demand patterns. The aim of this battery system is to help manage congestions without interfering in the balance between demand and supply (Energy Storage News, 2018).

From 2020 to 2023, the batteries will be operated solely by RTE as VPLs. From the beginning of 2023, they will be open for use by third parties for potentially multiple uses such as frequency regulation, demand and supply adjustment, congestion resolution and energy arbitrage, among others (Pie, 2018).

This pilot project was authorised by the French Energy Regulatory Commission (CRE) for a period of three years as an experiment to capture lessons learned, also called a "regulatory sandbox" environment. The regulator has approved a budget of EUR 80 million (about USD 95 million) for this project.

Multi-use of energy storage systems, Italy

The rapid integration of VRE into the grid in Italy has not allowed enough time to strengthen and expand the transmission and distribution network. In response to the resulting grid congestion, about 500 gigawatt hours of wind energy was curtailed in 2010. To address the issue, Terna, Italy's TSO, has implemented pilot projects to test the use of battery storage systems to reduce VRE curtailment and solve grid congestion.

As part of a pilot project, Terna installed three grid-scale sodium sulphur (NaS) batteries with a total capacity of 34.8 MW/250 MWh in the Campania region. The aim was for the batteries to store wind energy that would otherwise have been curtailed due to transmission congestion. The stored energy was then transported to northern parts of the country whenever transmission lines are not congested (NGK, 2019). These batteries were also used to provide ancillary services to the grid, such as primary and secondary frequency regulation (Musio, 2017).[3] The net efficiency of the battery systems was found to be 65-80% in continuous operation, providing both primary and secondary frequency regulation services (Musio, 2017).

3 *The Terna example followed specific rules in Italy that limit pilot projects to a specified duration.*

MurrayLink 2.0, Victoria to South Australia, Australia

Lyon Group's large-scale solar and battery storage projects in Riverland and Nowingi, Australia, have created a new virtual grid, providing the option to defer or reduce investment in grid reinforcements. The project provides a combined 180 MW/720 MWh of advanced battery storage, located on either side of the existing 220 MW MurrayLink interconnector, and acts as a VPL providing 15% additional transmission capacity. It allows congestion management to unlock inter-regional Renewable Energy Zones and enables greater utilisation of the interconnector asset.

Australia's first VPL provided the option of lifting transmission constraints ten times faster than the time required to construct a new interconnector and at a fraction of the cost, resulting in reduced electricity prices, and providing long-duration storage to firm renewable generation and fast frequency response to the system (Lyon Group, 2019).

Grid booster project, Germany

A key challenge in the German energy transition is the adaptation of its grid infrastructure to an increasing share of renewables, especially wind and solar. A number of highly energy-intensive industries are located in southern Germany, and as nuclear plants are phased out in the southern states, increasing amounts of electricity need to be transferred from the north to the south of the country. This results in increasing congestion along the north–south transmission line. Reinforcing the grid is a very lengthy process that poses various challenges, including potential impacts on the environment and land acquisition difficulties.

In addition to reinforcing the grid, the German regulator plans to avoid grid congestion via greater digitisation and the use of new technologies. Two innovative pilot facilities for grid boosters under the Network Development Plan were approved at the end of December 2019 (Federal Ministry of Economic Affairs and Energy, 2020). Specifically, two spatially separated energy storage devices are planned to be installed to the north and south of the main grid congestion, to act as source and sink, and thus a VPL, in case of emergency (Tennet, 2020).

V. IMPLEMENTATION REQUIREMENTS: CHECKLIST

TECHNICAL REQUIREMENTS

- Batteries or other ESSs (such as thermal storage systems) with the ability to effectively meet transmission and distribution network requirements. The ESS should be chosen according to the time duration/scale of the congestion, as well as the technical capabilities of the storage to provide the necessary services (batteries being more effective at providing synthetic inertia than thermal storage).
- Control systems to optimise the utilisation of battery and network infrastructure (possibly using artificial intelligence).
- Common interoperable standards (both at the physical and the information communication technology layers) to increase co-ordination between the ESS and the system and network operators.

REGULATORY REQUIREMENTS

- Clear rules on the ownership and operation of the VPL.
- Compensation structures that reflect the costs of the VPL.
- Regulations enabling a multi-service business case, so that the social welfare benefits provided by the ESS is maximised.
- Regulations that enable network operators to consider battery storage systems in network planning, together with conventional investments in network infrastructure.

STAKEHOLDER ROLES AND RESPONSIBILITIES

System operators

- Invest more in pilot projects to evaluate the benefits of VPLs with ESS over conventional network infrastructure.
- Consider batteries and storage solutions in the grid planning process.
- Include in their operational practices the use of batteries to alleviate congestion.

ABBREVIATIONS

CRE	Energy Regulatory Commission
DSO	Distribution system operator
ESB	Energy Security Board
ESS	Energy Storage System
FERC	Federal Energy Regulatory Commission
GW	Gigawatt
MW	Megawatt
MWh	Megawatt hour
TSO	Transmission System Operator
VPL	Virtual Power Line
VRE	Variable Renewable Energy

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