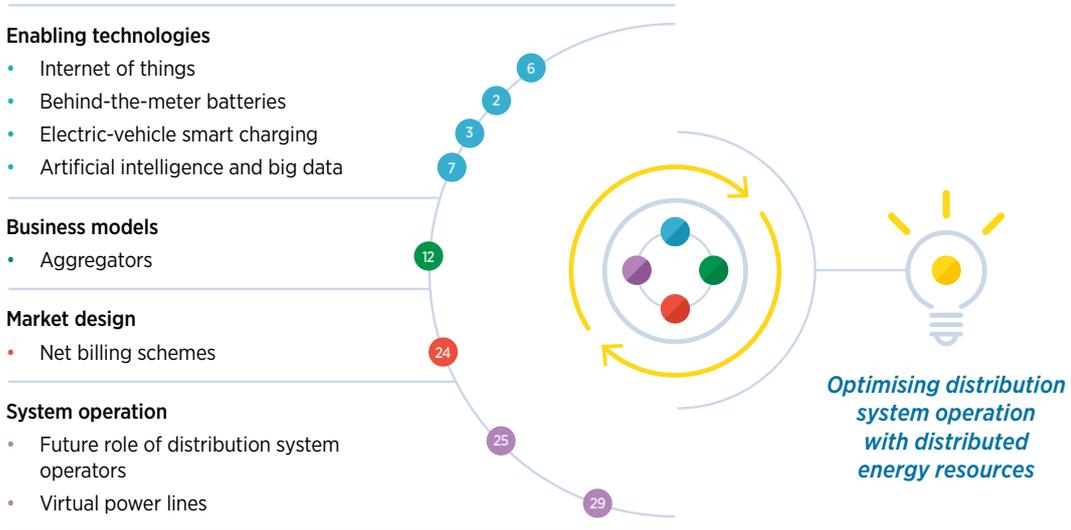


SOLUTION IX

**Optimising distribution system operation with distributed energy resources**

**Figure:** Synergies between innovations for optimising distribution system operation with distributed energy resources



The increasing penetration of distributed generation has led to an unpredictable and reverse flow of power in the system, which can affect the traditional planning and operation of distribution and transmission networks. To effectively manage the distributed energy resources connected to the distribution network, distribution companies need to become active system operators instead of being mere network managers, much as the transmission system operators are. As distribution system operators, these companies should be able to procure flexibility services from their network users, such as peak shaving and voltage support. By mandating distributed energy units to comply with certain communication requirements and dispatch signals, distribution companies can actively operate these technologies, or at least send them price signals, in order to undertake peak load and manage the congestion in the network.

● With the deployment of **enabling technologies**, such as EVs, and the new load that they connect to the grid, distribution system operators also can manage EV charging stations smartly to leverage on the extra storage capacity connected to the

grid. Optimal combinations and harnessing synergies among different distributed energy resources can greatly increase system flexibility. Battery storage systems, deployed by end consumers, can store the surplus energy produced from renewable sources such as solar PV or can be charged using grid electricity when it is cheap. Batteries can then be discharged at the request of the distribution system operator, during peak time intervals, to fulfil demand. (*Key innovations: Electric-vehicle smart charging; Behind-the-meter batteries*)

Meeting peak demand through locally stored energy reduces the need to draw power from the transmission system operators, thereby decreasing grid congestion and deferring network investments. Using distributed energy resources to avoid investment in the grid is also known as “virtual power lines”. For instance, UK Power Networks, a distribution network operator in the UK, recently announced its plan to create London’s first virtual power plant, comprising solar panels and a fleet of batteries across 40 homes in the city. A trial concept was conducted in February 2018,

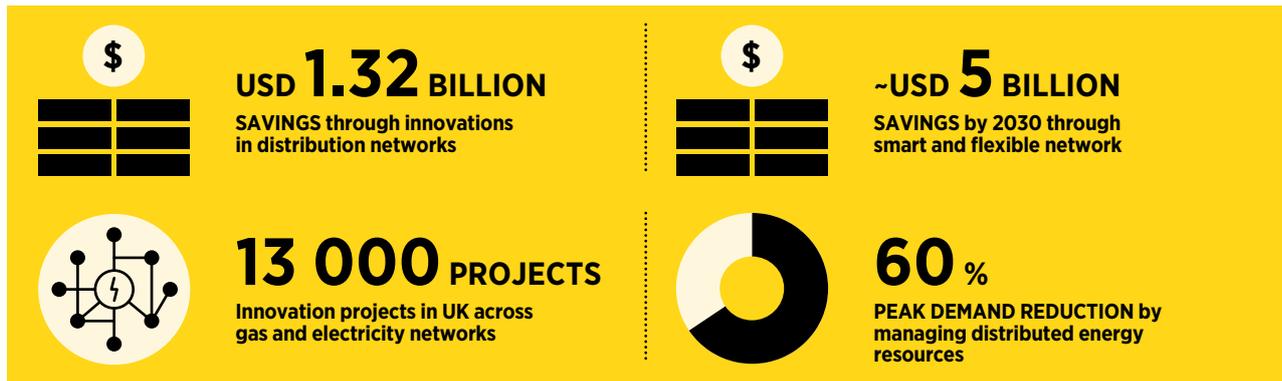
wherein a fleet of 45 batteries was used to meet peak demand. The project is expected to provide an alternative to the traditional approach of increasing network capacity to meet peak demand (Hill, 2018). *(Key innovations: Virtual power lines; Aggregators)*

Active network management must be adopted as an alternative to conventional grid reinforcement in order to efficiently integrate distributed generation. Regulatory mechanisms that aim to foster the new roles of the distribution companies and their active interaction with distributed energy resources include non-firm connection agreements, bilateral flexibility contracts and local markets. A European Commission proposal from November 2016 mandates Member States to ensure that the regulation enables and encourages distribution companies to procure flexible services from network users (EC, 2016a). This can be done via bilateral contracts between agents and distribution system operators, or through economic incentives (prices with some locational/temporal differentiation). In the UK, a form of variable network access for distributed generation, known as a non-firm connection agreement, allows the distributor to temporarily curtail the power injected or withdrawn by the end-user, for security reasons. *(Key innovation: Future role of distribution system operators)*

A well-designed compensation mechanism to help minimise the negative impacts and maximise the value of distribution generation for the overall system is net billing. Under this scheme, compensation for the injected renewable energy is based on time- or location-varying tariffs. Consumers can respond to price signals and help in grid balancing, thereby reducing grid congestion. *(Key innovation: Net billing schemes)*

To become grid and system operators, distribution companies will need to adopt enhanced use of information and communication technologies and innovative systems to solve network constraints. The emergence of many advanced digital technologies – such as sensors, smart meters, artificial intelligence and robotics – has unlocked new and efficient ways of network management. These solutions comprise, among others, automated voltage control or automatic grid reconfiguration to reduce the loading of a distribution feeder by transferring a part of the distributed generation feed-in to a neighbouring one. Grid networks enabled by such technologies are often referred to as “smart grids”. *(Key innovations: Internet of Things; Artificial intelligence and big data)*





**Impact on cost savings by optimising distribution operation:**

- **USD 1.32 billion in cost savings achieved through innovations in energy networks in the UK.**

Innovations by distribution network operators in the UK – including creating smarter networks, improving transmission-distribution processes related to connections of distributed generation, planning and shared services, assessing the gaps in customer experience and considering changing the requirements of transmission and distribution systems – has enabled close to USD 1.32 billion in cost savings for consumers, which will be realised between 2018 and 2023 (Engerati, 2018). Western Power Distribution, a distribution system operator in the UK, estimates the total cost of the transition to be USD 150 million, considering recurring costs such as licences and new employees (Engerati, 2018).

- **Up to ~ USD 5,16 billions (GBP 4 billion) of savings can be released by 2030 in the UK through a smart and flexible network that enables distribution system operators to easily access flexible assets on the grid.**

Open Utility is developing an online marketplace platform that would allow distribution system operators to access location-specific flexible sources. These operators will play a critical role in actively balancing local smart grids and facilitating the roll-out of distributed generation, storage and EVs. Open Utility’s resource optimisation algorithms, delivered via an intuitive online service, lower barriers to entry and manage the deployment of localised flexibility in a highly efficient and scalable way (BEIS, 2018).

- **Since 2004 over 1 300 innovation projects have been delivered across both gas and electricity networks in the UK,** allowing network operators to better understand how to integrate new energy technologies such as EVs, renewable distributed generation and decarbonised sources of gas into the energy system (Northern Powergrid, 2018).

**Impact on peak demand reduction:**

- **60% peak demand reduction from the grid by managing distributed energy resources, achieved by a distribution network in the UK.**

UK Power Networks, a distribution company in the UK, will install a fleet of battery systems on around 40 homes across London that are already fitted with rooftop solar PV arrays. In total a combined capacity of 0.32 MWh will be installed via modules coupled with 8 kWh batteries. The batteries would be aggregated into a virtual power plant, which could reduce the evening peak by 60% through remote discharge of batteries (Willuhn and Brown, 2018). The peak times (a couple of hours per weekday) could account for 93% of the “distribution use of system costs”; encouraging consumers to reduce their energy usage during peak times is key.

*Note: The original figure of GBP 1 billion was converted to USD based on the United Nations operational rate of change on 10 July 2018.*

## IMPLEMENTED SOLUTION

### UK Open Networks project

- Open Networks is a project launched in the UK by the Electricity Networks Association, a national trade association representing transmission and distribution networks. The project is expected to lay the foundation for the transition of distribution network operators to the role of distribution system operators. Its objectives include developing improved transmission/distribution system operator processes, planning of shared services and a need-gap assessment for customers (Engerati, 2018).

Western Power Distribution, a distribution network operator in the UK, has released a four-point plan for its transition into a distribution system operator. This includes expanding and rolling out smart network solutions to higher voltages, contracting with aggregators and customers for various services, transmission/distribution system operator co-ordination, and ensuring the integrity and safety of the lower-voltage networks (Engerati, 2018).

### Piclo online marketplace in the UK

- Open Utility is developing an online marketplace, called Piclo, to enable distribution system operators to access location-specific flexible resources. These operators will play a critical role in actively balancing local smart grids and facilitating the roll-out of distributed generation, storage and EVs. A smart and flexible network could reduce the UK's emissions from electricity generation and realise a savings of up to EUR 4 billion by 2030, but only if the distribution system operators can quickly and easily access flexible assets on the grid. Open Utility's resource optimisation algorithms, delivered via an intuitive online service, lower the barriers to entry and manage the deployment of localised flexibility in a highly efficient and scalable way.

The trial saw good engagement by customers and sellers, with stakeholders logging in regularly to check the details of the electricity transactions. Piclo matches generation and consumption according to preferences and locality, providing customers with data visualisations and analytics. It has provided a transparent, easy-to-use mechanism for its subscribers to offer renewable energy to consumers wanting to source from a renewable generator. Daily, weekly and monthly visualisation proved to be very useful in understanding the energy demand, as well as the "distribution use of system" (DUoS) charges that are meant to cover electricity distribution costs. Understanding that peak times (a couple of hours per weekday) could account for 93% of the DUoS costs encouraged consumers to reduce their energy usage during these times (Open Utility, 2016). Customer feedback showed that distance from the generators, rather than technology, was a key factor in determining the supplier. Customers preferred local suppliers to distant ones. In the context of the Cornish local energy market, four consumers in Cornwall consumed 54% of the Cornish generation.

### New York's Reforming the Energy Vision

- The state of New York has developed a roadmap titled "Reforming the Energy Vision (REV)", under which the New York Public Service Commission has mandated six large investor-owned utilities to undertake several measures to integrate distributed energy resources. These include creating charging systems for EVs, creating online marketplaces for energy products and services, building virtual power plants and enabling the connectivity of distributed energy resources to the grid, and developing storage on demand, among others. The costs of these products and services will be recovered through the modification of tariff structures. Utilities have already launched multiple demonstration projects (New York State, 2018).

**SUMMARY TABLE: BENEFITS AND COSTS OF OPTIMISING DISTRIBUTION SYSTEM OPERATION WITH DISTRIBUTED ENERGY RESOURCES**

Optimising distribution system operation with distributed energy resources	Low	Moderate	High	Very high
<b>BENEFIT</b>				
Potential increase in system flexibility				
Flexibility needs addressed	from minutes to days			
<b>COST and COMPLEXITY</b>				
Technology and infrastructure costs				
	smart meters, ICT			
Required changes in the regulation framework				
	new incentives and regulatory framework for distribution system operators			
Required changes in the role of actors				
	new role of distribution system operators			
Other challenges	• Grid instability management			



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IRENA (2019), ***Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables.*** International Renewable Energy Agency, Abu Dhabi (ISBN 978-92-9260-111-9).

The full report and related materials are available on the IRENA website ([www.irena.org](http://www.irena.org)).

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