DERMS
Looking ahead

Key considerations in managing distributed energy resources through the transition from passive distribution networks to active digital networks

The transition to low-carbon energy, transportation and heating systems is continuing at a rapid pace in many countries.

The associated proliferation of distributed generation (DG) such as rooftop photovoltaic (PV) and small-scale commercial wind generation, as well as the predicted uptake of electric vehicles, electricity storage systems, heat pumps, and other connected systems such as microgrids and virtual power plants, is likely to have a transformational impact on electricity distribution network operations.

The need for more cost-effective operations may have many distribution system operators (DSOs) looking to customers to engage in network management directly or through third parties as operators take advantage of the distributed energy resources (DER) on their networks. This is happening around the world, with DER management being trialled by DSOs in some countries, while DER management is already business as usual in others.

Transitioning from passive distribution networks to digital technology-based active networks will require network control software that can help distribution system operators communicate with DER and make operational decisions to provide safe, reliable and cost-effective services to all customers. As the number of DERs to be managed increases, distributed energy resource management systems (DERMS) will go from ‘nice to have’ to ‘need to have’.

Key conclusions in this paper:

- The DSO has a central role in facilitating access for customers to value pools for demand and generation flexibility to support the DSO and TSO, including existing and future ancillary support services and, potentially, wholesale electricity markets.
- The circumstances that influence the need for a DSO to employ a DERMS are numerous and vary across countries and states. These may include government or state policies that influence renewable generation development, electrification of transport and heat; and DSO regulations that influence network investment and innovation.
- The future use of network capacity, particularly peak-use requirements that traditional electricity networks have been designed to cater for, is now often much more difficult to forecast over long-term horizons. The increased deployment of DG, energy storage systems and electric vehicle (EV) charging is difficult to predict. The risk of network reinforcement investments becoming partially stranded increases where forecast system use profiles change over the asset lifecycle due to disruptive influences. This, along with the recognition of the benefits of flexible DER and the need to minimise costs for customers, means that DER as a non-wires alternative solution to network reinforcement is becoming a more attractive proposition for transmission system operators (TSOs), DSOs, regulators and customers. There are business-as-usual and trial use case examples in some countries illustrating the use of DER flexibility by network operators that may point to the way ahead for wider-scale uptake of DER flexibility solutions.

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ACRONYMS IN THIS PAPER:

ADMS: advanced distribution management system
AFR: advanced feeder reconfiguration
AMI: smart metering infrastructure
ANM: active network management
BESS: battery energy storage systems
CBA: cost/benefit analysis
CHP: combined heat and power
DER: distributed energy resources
DERMS: distributed energy resource management system
DESS: distributed energy storage systems
DG: distributed generation
DSM: demand side management
DSO: distribution system operator
ESCO: energy service company
EV: electric vehicle
FLISR: fault location, isolation and system restoration
GenCo: generation company
IPP: independent power producer
OPF: optimal power flow
PV: photovoltaic
RES: renewable energy sourced
SCADA: supervisory control and data acquisition
TSO: transmission system operators
VPP: virtual power plant
VVO: volt-VAr optimisation

How distributed energy resources are disrupting the grid

Distributed energy resources (DERs) are electricity-producing resources or controllable loads that are directly connected to a local distribution system or connected to a host facility within the local distribution system. This includes all forms of distributed generation (DG), distributed electricity storage systems (DESS) and controllable demand.

The rise of distributed generation

Over the last two decades, government policy in many countries has been aimed at addressing climate change through carbon emissions reduction, often driven by global or regional agreements. This has seen traditional large-scale hydrocarbon-based generation connected to electricity transmission networks partially replaced by smaller scale distributed, largely renewable based distribution network connected generation. Domestic, industrial and commercial rooftop solar as well as industrial, agricultural and commercial wind generation can now be found connected to distribution networks in many countries. The scale and connection of DG into the distribution network can range from a few kilowatts on domestic properties connected to low-voltage networks, to tens of megawatts on commercial generation schemes connected at the higher distribution system voltages such as 33kV.

Figure 1 illustrates the annual installation of new residential photovoltaic (PV)-based generation in the United States (US) from 2010 to 2023. Over the coming years, the installation of new residential PV will be substantial and this is reflected in other countries.

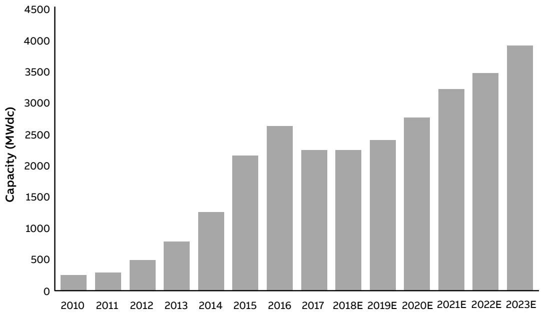


Figure 1: Annual residential PV installation forecast (US, 2010-2023E)

The impact of distributed generation on the grid

The continued transition to DG has seen issues developing around the capability of distribution networks to host new generation, which has led to the trial of distributed energy storage systems (DESS), DG control and demand side management (DSM) in many countries as non-wires alternatives to expensive network reinforcement. This will see the potential market for DESS, DG control and DSM products rapidly increase in future years, driven by the continued connection of predominantly renewable energy sourced (RES) distributed generation, which are characterised by variable or intermittent power outputs.

The future uptake of electric vehicles and heat pumps in many countries will see an increased focus on DSM to mitigate against major network reinforcement requirements. The forecast need for DSM will see increased demand for aggregator services by DSOs and potential benefits for customers of new aggregator offers to provide demand flexibility.

Battery energy storage systems (BESS) both behind and in front of the meter are forecast to play an increasing role for DSOs and customers. Customers can potentially benefit financially from control of their power import from the grid and export to the grid where they also have generation. DSOs can benefit from this customer DER flexibility where commercial mechanisms for services to manage local network constraints are put in place. Commercial arrangements could include direct service contracts or the development of flexibility markets and trading platforms, which are used in some US states and are under development in the United Kingdom (UK).

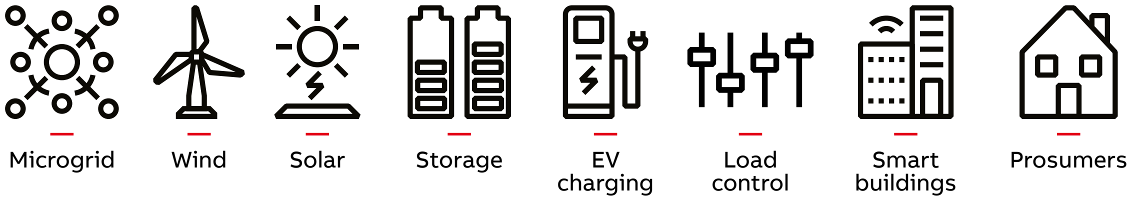


Figure 2: Distributed generation resources come in many forms…and now, consumers do too.

The need for DER management

The need for control of DER to ensure safe and reliable distribution network operations without major network reinforcements exists now in some countries such as the UK and several US states. Other countries will be faced with this issue in the future as renewable DG increases and demand from the electrification of heat and transport put pressure on existing distribution network capacity. In these countries, where regulatory policy is suitable, the option to have greater control of DER as an alternative to network reinforcement may be adopted.

The future uptake rate of DER technology such as PV, EV and BESS is the subject of great debate amongst experts and forecasts vary across countries, regions and cities from modest to disruptive levels of uptake. The impact, and timeline of any impact in particular, from DER uptake on electricity networks is therefore difficult for network operators to predict and plan for. The cost of technologies such as BESS and PV continue to fall rapidly and are forecast to continue this trend. The cost of EVs also continues to fall as mainstream car manufacturers bring new EV models into production. There is a risk that as the cost of these technologies continues to reduce, an economic tipping point will be reached where customer uptake of new technology such as PV, BESS and EV accelerates faster than DSOs and TSOs expect.

Network operators typically do not want to risk investing in network reinforcements where costs will not be recovered. Regulators also typically do not want customers paying for a lifetime or part-lifetime of stranded asset capacity. DERMS can enable network operators to take advantage of distributed energy resources already on the network rather than investing in expensive new infrastructure. In particular, DER management systems that combine available network measurements and network modeling could offer DSOs and TSOs a network-wide control room solution. This network-wide DER management can be supported by other energy supply chain players such as DER aggregators, virtual power plant owners, microgrid and community energy scheme owners by opening up new markets for DER flexibility. A pre-planned DER management system (DERMS) mitigation strategy could be key to maintaining economically justified network services to customers.

Whilst DER uptake may vary across regions and countries, it is clear that the need to manage DER exists now in some countries and, in many, some form of DER management will be required in the future. DERMS is a term that is widely used to describe systems related to DER management. It can take many forms, including systems that manage demand-side response or DG only, to systems used by aggregators or virtual power plant and microgrid owners, to DSO or TSO systems that manage electricity networks within their technical limits by controlling available DER flexibility either directly or via other energy supply chain players.

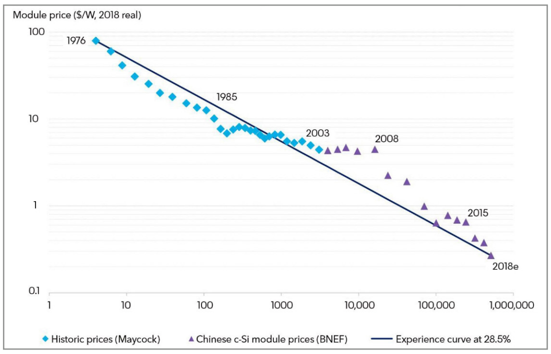


Figure 3: BNEF experience curve for crystalline-silicon PV module prices (source: Bloomberg NEF)

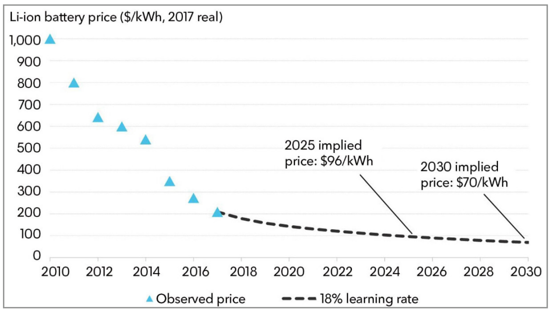
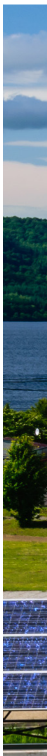


Figure 4: Lithium-ion battery price, historical and forecast (source: Bloomberg NEF)



Benefits of DERMS for the entire power value chain

For this discussion, ABB defines DERMS as any system related to managing any form of distributed energy resources (DER, as defined in the previous section) to ensure safe and reliable public utility electricity network operations. In this context, the DSO is viewed as the central operator of a DERMS with other players linked to this, e.g., retail customers, larger demand customers, aggregators, VPP/microgrid operators, generators, market traders, the TSO, etc.

Market segments that benefit from DERMS deployment

There are five distinct market segments that benefit from DERMS deployment to different degrees: In this section, we take a closer look at the role DERMS can play in each segment.

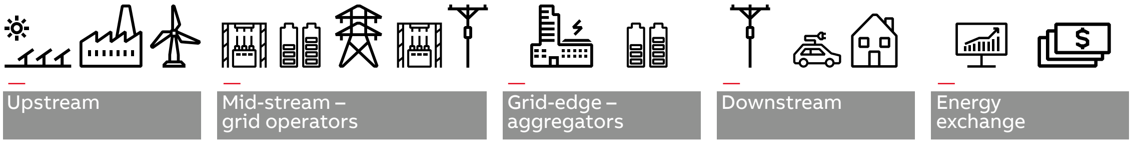


Figure 5: Market segments that may benefit from DERMS deployment

Upstream participants

Examples of upstream participants include generation companies (GenCos) and independent power producers (IPPs) that manage their own assets, either separately or as a distributed portfolio. In general, GenCos and IPPs see limited application of DERMS in their operations and rely mainly on already existing software.

Grid operators

Grid operators (TSO and DSO) can be either network operators, responsible only for the infrastructure and energy delivery, or vertically-integrated utilities, owning and managing infrastructure as well as selling energy to end customers. With the displacement of conventional transmission-connected power plants with renewable energy source (RES)-based distributed generation (DG), TSOs will look increasingly to the DSO and distribution customers for support services. DERMS will play a key part in enabling these services to the TSO and potentially provide an additional revenue to DSOs and participating customers.

It is anticipated that future revenues for DSOs will no longer be concentrated in just the physical asset base of core grid infrastructure (e.g., wires, poles and substations). DERMS will enable additional revenue opportunities in operating markets for DER flexibility. For TSOs, DERMS can facilitate or provide support services for real and reactive power, fast frequency control, and potential new TSO markets for black start and inertia support. DERMS can also provide DG customer access to wholesale markets.

The potential changing business model will compel DSOs to introduce more sophisticated software solutions potentially supported by DERMS. Examples include:

- Volt-VAr optimisation (VVO) applications
- Optimal power flow (OPF) applications
- Advanced distribution planning software
- Upgraded power flow models that extend to the grid edge
- Power quality monitoring & analysis applications
- Grid visualisation platforms
- Market trading and bidding platforms
- Advanced DER modelling and analysis software

Machine learning and artificial intelligence applied to historical data will improve the forecasting of DER availability and network operational margins on an intra-day, daily, weekly or longer-term basis. This may also see a move to cloud platforms for such data storage and intelligent analytics.

The increase in behind-the-meter DG and distributed energy storage systems for community energy schemes and domestic prosumers can lead to decreasing use of system revenues for DSOs. This could result in the development of new, sustainable business models to maintain reliable supplies. The current approach in continental Europe to charge the costs of grid reinforcement by increasing per-kWh use of system fees is likely to be unsustainable, as it will encourage more customers to install DER, creating even more pressure on the grid operator.

In parallel, new players are entering and developing the new energy ecosystem with innovative solutions in areas such as:

- Distributed storage
- B2B energy management
- Electric vehicle charging stations
- Smart infrastructure (platforms to optimise decentralised power flows, smart distribution and transmission grids)
- Solar photovoltaic
- Community energy
- Virtual power plants (VPP)
- Heating and combined heat and power (CHP)

The DSOs need to recognise the behaviors of these new grid edge energy ecosystems and utilise their demand/export flexibility where necessary to optimise the distribution network performance. A DERMS can be a major asset in helping to manage the impact of these ecosystems and other DERs on the DSO network. In particular, a centralised control room DERMS with advanced network modelling and AI-assisted analytics for performance forecasting may be beneficial to the DSO.

Aggregators

Aggregators operate at the grid edge, acting as VPPs that can be distinguished in supply-side, demand-side or mixed. Supply-side VPPs operate a portfolio of third-party assets (often with various vendors) and/or storage capacity for reserve and load curve optimisation. Demand-side companies aggregate flexibility on the demand side for peak load management. Demand/supply-side aggregators manage a mixed portfolio of third-party assets on both the demand and supply side. Many new internet-enabled domestic products that can be remotely controlled have appeared on the market, opening up new customer and aggregator opportunities.

Aggregators have a broad portfolio of services, of which peak demand is currently the most common. First-generation aggregators and energy service companies (ESCOs) manage peak demand reduction with the goal of reducing overall load or peak demand. This market is mature in Europe for industrial power consumers. The utilised processes are continuous, independent of time, outdoor temperature, etc. Second-generation aggregators and ESCOs rely on more complex optimisation such as smoothing the load curve whilst maintaining overall demand or adjusting demand to fit RES power output patterns. This constitutes a developing market across North America, Europe and Australia mainly for households and commercial power consumers. Unlike before, the utilised processes are now discontinuous and therefore depend on time, outdoor temperature, etc.

Downstream participants

Downstream participants include retailers and ESCOs. Retailers are end-customer suppliers of energy with close to none owning infrastructure. ESCOs constitute a broad portfolio of companies that provide grid edge services like energy optimisation, operation and maintenance of DER, etc. Retailers and ESCOs are typically looking into specific market functions such as responding to price signals, transaction settlements and total demand optimisation, to name a few.

Energy exchange markets

Energy exchange markets are where energy producers sell energy and retailers buy it. They are local or regional systems that manage transactions and price setting either in centralised or direct, peer-to-peer models. The main markets within an energy exchange for electricity are the spot market, for short-term trading (e.g., day ahead and intra-day trading), and the forward market, where the physical delivery takes place at a future date.

DER management is sometimes required by DSOs and TSOs to provide future economically-efficient utility services to customers by avoiding expensive network upgrades. In such cases, new markets for DER flexibility (e.g., DG curtailment or demand-side response) may be introduced.

The transition from transmission-connected large synchronous power stations to smaller-scale distribution network-connected and typically non-synchronous intermittent-output power plants has created new ancillary services markets to maintain stable electricity systems. These ancillary service markets are typically operated by the TSO for voltage and frequency control-related services. In the future, the need for black start and inertia support services may also be required as the electricity production transition continues in many countries. Delivering these TSO ancillary services will require DER management and potentially new trading and transaction service arrangements operated by the TSO or the DSO or third parties.

Regulations influencing DERMS adoption

DERMS as a non-wires alternative

DERMS is potentially a lower-cost, 'non-wires' alternative to network reinforcement to accommodate new demand and generation. DERMS can defer network reinforcement requirements or replace it entirely, depending on demand and DG growth forecasts, and the availability of flexible demand and generation to the DSO. This also includes services provided by distributed energy storage systems (DESS).

Distribution networks have traditionally been designed to accommodate peak demand that may occur for only a few hours each year. Outside of daily peak demand times and high seasonal demand times, distribution networks operate well below their 100% design capacity. And at higher distribution voltages, where there may be capacity redundancy, circuits are likely to operate well below 50% capacity most of the time.

The DERMS effectively moves the demand for system use from peak demand times to times when capacity is available, thus making more use of the existing network capacity and avoiding the need for expensive reinforcements.[1] However, the regulatory regime needs to recognise that there are alternative solutions to demand or DG-related network reinforcement requirements.

Global regulatory regimes

The regulations that govern distribution network operational and development spending vary from country to country. Regulatory regimes that are performance-based or based on incentivised outputs are more likely to allow for alternative solutions to traditional demand-related network reinforcement. Regulatory regimes that do not encourage economically-efficient investment are more likely to focus on traditional demand-related reinforcement investments. The table in figure 6 provides a high-level guide to regulatory regime characteristics found globally.

It should also be recognised that government policy plays a hand in setting regulatory objectives and regulatory change. UK government policy, like many other countries, is to reduce carbon emissions across electricity production, heat systems and transport, all of which affect electricity transmission and distribution networks. UK government policy is also to minimise the cost impact to electricity consumers, including minimising the investment in electricity networks. This requirement has shaped changes to UK regulatory requirements and behaviour. DSOs in the UK are incentivised to consider the lowest-cost solution to accommodate new generation and demand, including advanced network automation and DERMS-related solutions.

Figure 6: Comparison of various regulatory regimes around the globe

	Cost plus	Light-handed regulation	Performance-based rating	Output & incentives
Description	• All operator costs are covered • Limited incentives to improve (some wiggle room exists)	• The distribution utilities set the network charges to customers • The resulting tariffs are subject to the scrutiny of the regulator who may require mandatory changes	• Initially (at year one of tariff), all operator costs are covered, including fair cost of capital • In following years, a cap (on revenues/unit cost) is applied to incentivise efficiency	• Utilities and the regulator agrees on the target outputs and the measures to achieve them • Utilities can benefit from incentives and extra efficiency vs. plans
Assessment	• Does not encourage efficiency (no benefit for customers) • No benefit/upside for operators	• Need for careful regulator monitoring • More flexible, but uncertain	• Forces efficiency • Creates upside (if efficiency is higher than the cap)	• Allows to target new emerging needs on networks • Needs, trust-based relationships between operators and regulator
Example countries	• Some US states • India	• Germany (pre-1995)	• Western Europe • Some US states (Maine, Massachusetts)	• UK • Italy (from 2020)

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[1] It should be noted that changing network time of use can impact the rated network capacity where this has been based on traditional cyclic design ratings, reducing the peak design rating.

The regulations that govern distribution network operational and development spending vary from country to country. It should also be recognised that government policy plays a hand in setting regulatory objectives and regulatory change.

Essential features and requirements

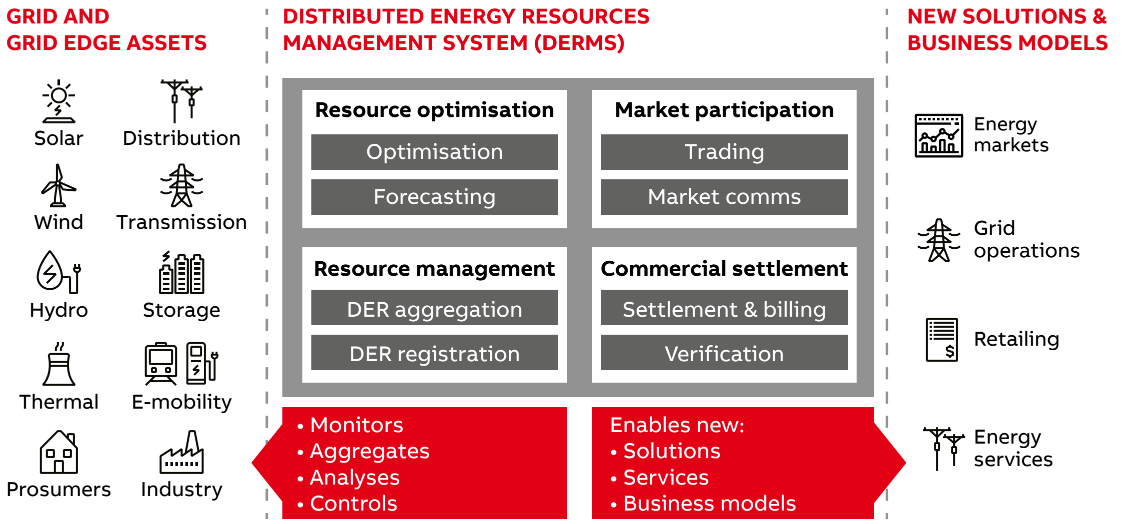
The many faces of DERMS

Typically, the requirement for DERMS is driven by the need to accommodate new DG onto existing distribution networks without passing on expensive network reinforcements to customers that would act as a commercial barrier. However, the forecast uptake in the electrification of transport (particularly electric vehicle charging) and the electrification of heat in some countries (i.e., the transition from gas boilers to electric heat pumps) may see the need to manage demand in some distribution networks. The potential for distributed energy storage systems (DESS), particularly the forecast uptake of battery energy storage systems (BESS) to assist in the management of demand and generation, adds to the potential DER sources to be managed.[2]

DERMS addresses the need to control the access of demand or generation customers connected to the distribution networks. It is especially beneficial at times and at specific locations where the distribution network assets could otherwise experience stress, either thermal or voltage-related. At such times, a DERMS would control the level of generation power export or demand import (or possibly both) to avoid local network stress.

A DERMS can take many forms, depending on the goal. An example might be a localised active network management (ANM) scheme where DG associated with a single primary distribution substation is directly controlled to limit export when needed to avoid stress at the primary substation. Alternatively, a DERMS might be a commercial arrangement with demand customers to limit demand at certain times. A centralised DERMS as part of a distribution system control room could potentially cover a DSO's full distribution network, controlling demand, storage and DG.

Figure 7: The many applications of DERMS



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[2] DESS can provide other ancillary service support to system operators such as fast frequency control.

Key requirements for a DERMS

Regardless of the application, there are some key requirements for a DERMS. These include:

- Visibility of the network to identify operational margins available
- The ability to enrol DER in available programs for operational controls
- The ability to forecast likely operational margin issues
- The ability to forecast DER capacity that can be utilised for control purposes
- The ability to operate in a hybrid environment of distributed and centralised intelligence
- The ability to make decisions and send out optimised control instructions to controllable DER
- Commercial arrangements to compensate DER for the provision of services (e.g., contractual terms or market trading arrangements)
- Accurate measurement and verification, settlement and record keeping of DER participation in network control
- Ability to store historical data and perform data analytics to optimise DERMS performance
- Secure protection against cyber risks and the provision of safe network operations and secure supplies to customers

DERMS as part of a greater ecosystem

In terms of network operational visibility, smart meters are predicted to have an important role to play by providing power and voltage measurement at the low-voltage network extremities. Technical control systems and commercial systems are required to operate together in real time to ensure network limits are adhered to at the optimum commercial rate and considering the challenges presented by unplanned network outages (outages due to faults or extreme weather).

The adoption of SCADA-based advanced distribution management systems (ADMS) to improve network availability and operational safety can support the provision of a centralised DSO control room DERMS. A typical ADMS will be supported by a live system network model that can carry out load flow and fault level modeling to support power and voltage control functions; fault location, isolation and system restoration (FLISR); and advanced feeder reconfiguration (AFR), etc. In terms of DER management, the control algorithms not only have to consider the DER real and reactive power but also other automated controls on the distribution network such as transformer tap changers, line voltage regulators and compensating capacitors. Controlling the network power flows within the network limits can therefore be complex and a combined ADMS and DERMS system with advanced algorithms may have advantages over a non-model-based DERMS solution. Potentially, a SCADA-based ADMS/DERMS would also require grid edge communications and sensing to extend the visibility of the network, possibly supported by predictive analytics to substitute for missing sensor or model data. Advanced data analytics, artificial intelligence and machine learning can be applied to forecast network capacity and DER capacity to assist in supporting the DSO. There are a few SCADA-based ADMS/DERMS products on the market today, with ABB Ability™ Network Manager providing an advanced offering to DSOs.

It should be noted that as DER management becomes a relied-upon non-wires alternative to traditional network reinforcement, network planners will require new tools and sources of data to develop reliable solutions. A model-based ADMS/DERMS solution and associated historical data repository with data analytics can be an enabler for this.

DERMS for transmission and distribution operators

Benefits of DERMS for TSOs

The benefits of managing DER have long been recognised by transmission system operators (TSO). In addition to non-wires alternatives to transmission reinforcement, DER management can be used to help maintain the required continuous balance between electricity production and consumption to maintain system frequency. System frequency control becomes more onerous as variable renewable energy sources displace conventional synchronous power plants.

The displacement of conventional transmission-connected power plants with DG also affects the reactive power control requirements on transmission networks, impacting system voltage control and reducing system inertia.[3] In the future, TSOs will look more and more to distribution-connected customers via the DSO for DER support services such as demand side management (DSM), reactive power services, fast frequency, frequency, inertia, black start and generation curtailment services, etc. DERMS is an enabler that would allow the DSO and/or other players like aggregators to provide the TSO with access to DER-based TSO support services whilst ensuring their distribution network remains within design and statutory performance limits.

DERMS could also be used by the DSO and/or aggregator to enable distribution-connected customers to trade in wholesale power markets as well as TSO ancillary services markets. In some countries, these DSO-facilitated services are now being considered by DSOs, TSOs, technology investors and regulators. It should be noted that the DSO network itself can support TSO voltage control via transformer tap changers, line voltage regulators and capacitive compensation on the DSO network, as well as voltage control support from DER. The combination of an advanced distribution management system (ADMS) and integrated DERMS can assist the DSO in providing voltage control support to the TSO.

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[3] Reduced system inertia results in faster rates of change of frequency when events such as loss of generation or faults occur on the network. This can increase the risk of system frequency stability issues. The system-connected generation and associated rate of change of frequency (ROCOF) protection need to be capable of dealing with faster rates of frequency change. Alternatively, the TSO must procure alternative sources of inertia support, e.g., synthetic inertia from converter-based technology associated with DESS, static var compensation systems, synchronous or hybrid condensers, etc.

DERMS control and commercial arrangements

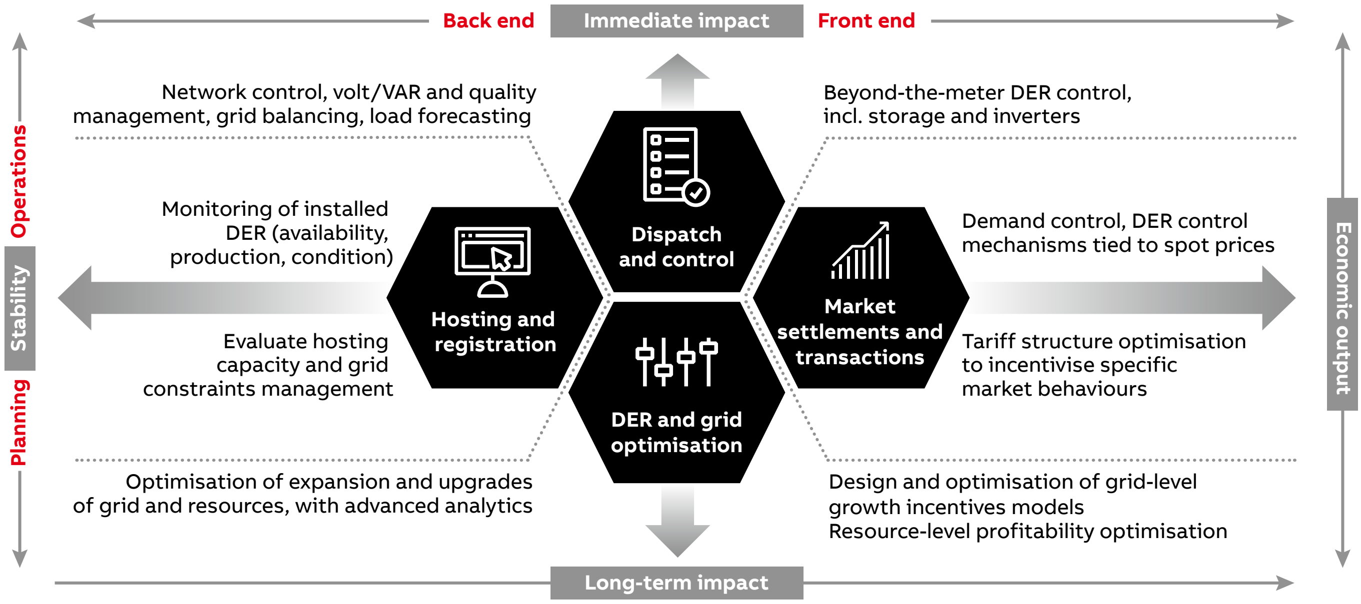
DER control can take numerous forms. A DERMS identifies when and where network constraints will occur and sends out instructions to DER that will avoid such network constraints. Depending on the DER's registered characteristics, real and reactive power import and export may be controllable. Instructions to control DER can be sent through various media including the DSO's communication system to a customer interface controller or via other routes such as the internet. Control instructions or requests may be sent to third parties such as aggregators who then control the DER as instructed. The concept of issuing price signals via smart metering infrastructure (AMI) has also been proposed.

DERMS control may be local (e.g. active network management (ANM) at specific primary substations on the DSO network), centralised in a control room where the DERMS monitors the whole DSO network or it could be a hybrid of both these system types.

The commercial arrangements for DER management are important and need to consider the incentive for DER participation to address forecast DER requirements and the economic benefits compared with other network constraint solutions. There is a requirement to forecast network constraints long-term with no intervention as a baseline and to forecast network constraints and DER capacity for operational purposes, which could be monthly, weekly, daily, intra-day, etc.

The development of suitable commercial trading arrangements for DER flexibility could include bilateral agreements with customers or aggregators, new trading platforms for flexibility services or other arrangements based on blockchain concepts. These commercial arrangements are continuing to develop in several countries as DER management is utilised as a non-wires alternative to network reinforcement, or for support services to TSOs from the distribution networks as DG displaces transmission-connected power plants.

Figure 8: An effective DERMS can have positive impacts in many areas.



Benefits of DERMS for DSOs

The largest value pools for advanced DERMS capabilities for DSOs are found in improved grid planning and the reduction of grid reinforcement needs.[4] Data gathering and advanced analytics combined with cost/benefit analysis (CBA) allow for optimisation of grid reinforcement planning. The use of load and generation curtailment for a limited number of hours in the year can maintain networks within their thermal and statutory voltage limits, avoiding or deferring the need for expensive reinforcements to accommodate new DG such as PV and demand such as EV. This is particularly true for higher-distribution voltages where the network may have designed in redundancy to allow for the unexpected loss of a circuit. Where redundant capacity is used for peak hour operation rather than building more network capacity, the need for demand or generator curtailment would only occur when there is an unexpected circuit outage during peak operational hours, which is likely to be a low-risk occurrence. Depending on the regulatory system in which the DSO operates, this alternative to network reinforcement can offer financial benefits to the DSO and customers.

Available policy options include flexibility procurement and tariff setting. These policy options provide both supply- and demand-side flexibility including renewable energy sourced (RES) curtailment schemes that avoid reverse power flow issues and enable peak supply shaving and load shifting and reduction.
In addition, the policy covers increasing demand when supply is high to provide peak flow shaving. Since information is a prerequisite for the activation of flexible demand schemes, data handling policies for technical data from smart meters allow for better investment planning.
The above results in deferring or avoiding grid investments by increasing hosting capacity rather than reinforcing existing infrastructure.

A second value pool may also be available to DSOs by providing support services to the associated TSO. Based on earlier discussions, TSOs in countries transitioning from fossil fuel generation sources to renewable generation are likely to require support services from the DSO network and the flexible DER customers on that network. Support services can include reactive power for transmission voltage control and real power for frequency control. Where conventional, transmission-connected, synchronous power plants are displaced by renewable DG sources such as wind and solar, the TSO may also have future requirements for black start and inertia support, some of which may be sourced from the DSO network. DERMS is an enabler that would allow the provision of support services to the TSO and could offer commercial benefits to the DSO as an aggregator or facilitator of support and ancillary services to the TSO.

Finally, regardless of whether the value pool is from avoided or deferred distribution system reinforcement or support services to the TSO, advanced insights into consumption and production patterns allow forecasts that are more accurate and will improve the effectiveness of DERMS based solutions and services.

It should be noted that DER management can also avoid or defer expensive transmission network reinforcement for the TSO. The relationship between the TSO and DSO in many countries is becoming more important in terms of the economics of delivering power to customers where DG is displacing traditional transmission connected power plants. The rules that govern this TSO/DSO interaction may require amendment in some countries to ensure overall economic benefit to customers of the electricity networks.

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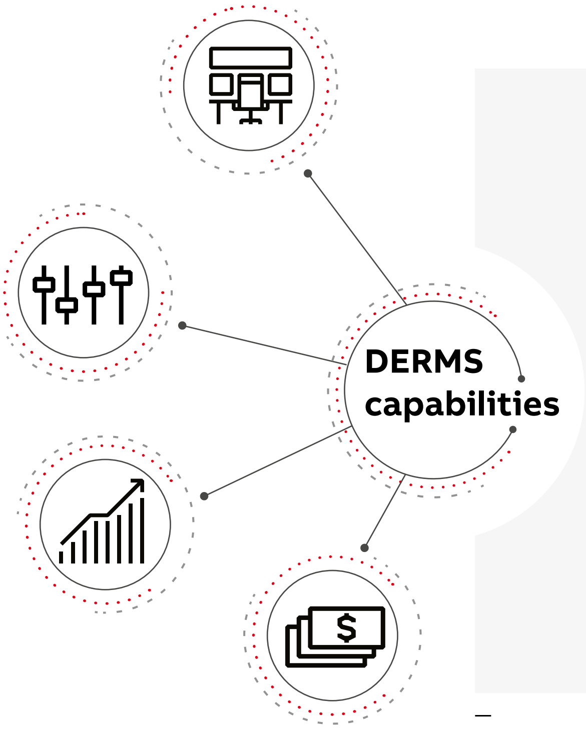
[4] There is a difference between grid expansion and reinforcement. Expansion relates to extending the reach of the network for new connections whilst reinforcement is increasing the capacity of the existing network. DERMS can avoid reinforcement but not expansion.

DERMS use cases and pilot projects

Based on original research conducted for ABB, there are DERMS use cases for the various market participants; the most common is related to the ability to correctly forecast loads (demand) and distributed generation (supply). In addition to forecasting, most DSOs identify applications for DER registration as well as communicating signals towards other market participants like aggregators, retailers and ESCOs to control DER as key.

In general, GenCos and IPPs see limited application of DERMS in their operations and rely mainly on already existing software. Aggregators and retailers, on the other hand, are looking into specific market functions such as responding to price signals, transaction settlements and total demand optimisation, to name a few.



1 | Resource management
Provide registration, visualisation and aggregation per market and grid areas

2 | Resource optimisation
Forecast demand and generation capability
Optimise and dispatch DER portfolio

3 | Market participation
Aggregate DER to offer and settle energy and ancillary services in wholesale markets

4 | Commercial settlement
Confirmation that the services were provided and their financial settlement

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Figure 9: DERMS capabilities across four broad categories

DER registration

DER registration and the ability to observe it on the grid has been identified as the most pressing need for utilities across all geographies. The use case has been prioritised in a 'plug-n-play' model where basic requirements include location, type, and supply/demand profile. This core functionality is crucial in multi-vendor, residential markets (e.g., Germany, California).

Among additional functionalities, American utilities identified hosting capacity analysis and grid constraints forecasting. For example, American utilities in California, where constraints caused by DER are more prominent, indicate a need to better and more frequently analyse hosting capacity of specific feeders and forecast potential future constraints. European DSOs did not prioritise this use case due to better overall condition of the grid, fewer constraints and lower congestion. Market DERMS use cases are de-prioritised in favour of grid control/dispatch among utilities. To make market-centric use cases more urgent, a regulatory push is necessary to achieve higher participation in energy exchange. It should be noted here that in the European Union, DSOs are not allowed to act as retailers, limiting their opportunity to monetise DERMS through market settlements and transaction use cases.

Virtual power plants (VPP)

The aggregator market is established in Europe operating IPP and commercial and industrial assets, whilst micro-scale residential installations are only picking up with a mixture of supply and demand flexibility and an increasing number of technologically diverse portfolios. US and Australian markets are less mature; most of the aggregator projects rely on subsidies and serve as technology/mechanism demonstrations. Core use cases for VPPs are the ability to precisely forecast supply/demand and execute schedules through direct control of assets. As a second priority, VPPs identified participation in ancillary markets and more flexible aggregation programs.

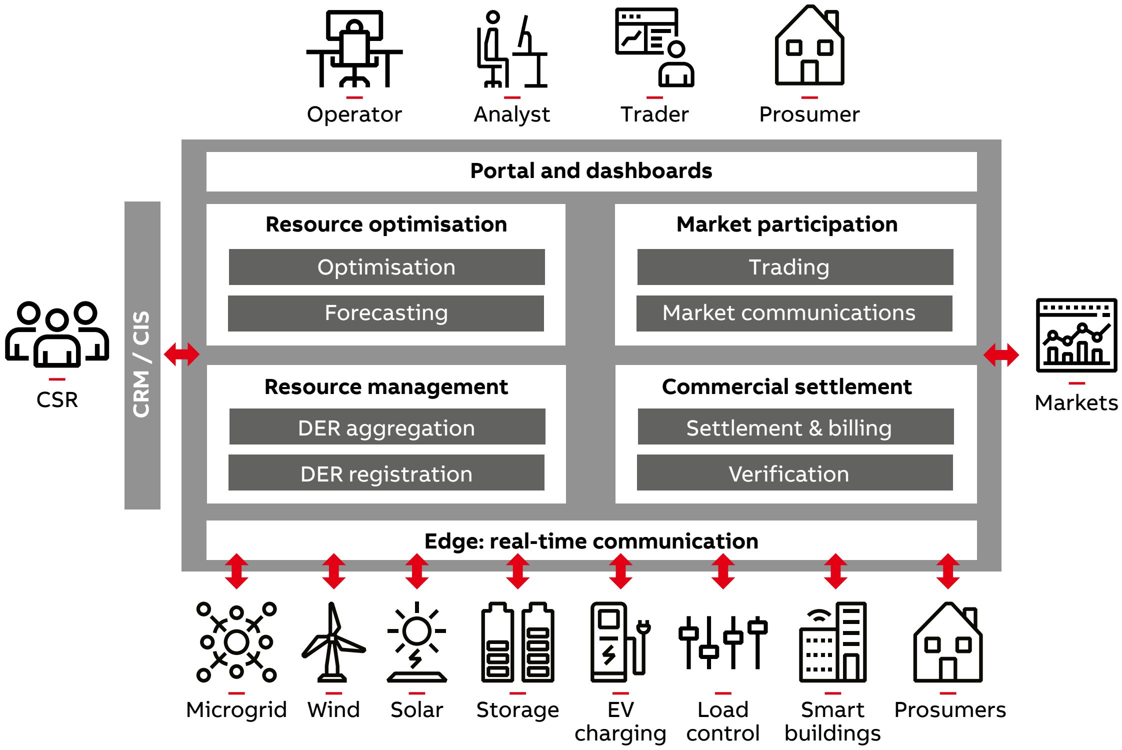

Figure 10: The DERMS ecosystem

DER forecasting

Finally, retailers prioritised improved forecasting as a promising use case, whilst ESCOs would value design and planning applications. Especially in Europe, retailers rely on at least 1-year-long contracts with GenCos, which are supplemented with short-term purchases for balancing.
In Australia, most companies are organised as 'gentailers' (generator–retailers), thus not relying on won supplies . Retailers prioritise integration with other software and market participants, i.e., customer relationship management systems for client interfacing, and distribution management systems, net metering, meter reading systems of DSOs. They are also at risk of losing large parts of their revenue due to a growing prosumers base, necessitating a move to alternative value streams – e.g., multi-fuel energy services. In general, retailers and ESCOs may benefit from a broad range of market specific use cases, though their needs are very geography-specific.

DERMS pilot projects

There are many DER management trial projects ongoing across the globe, and some DER management solutions are now fully operational. There are islands, remote communities and remote industrial facilities that have now facilitated the integration of clean renewable energy sources using battery storage and advanced DER control systems to maintain stable electricity systems.

In these cases, the main economic driver is the reduction of diesel fuel usage and dependence.

Trials of other DER management solutions are also common, particularly in Europe, the US and Canada. A couple of interesting examples illustrating the benefits to DSOs, TSOs and their customers include:

Central Hudson Gas and Electric, operating in New York State, has employed a range of DER control to provide load relief for several transmission circuits to avoid the need for expensive reinforcement.[5] DER has included residential thermostats, air conditioners, backup generators and pool pumps as well as commercial lighting, thermostats and air conditioners. One interesting feature is the domestic backup generators (propane or natural gas powered) – many of these were installed by one company following a storm, and households now pay for these to be maintained but the DER management scheme helps the customers pay for the generator maintenance. Also, the generators are now fitted by the supplier with communications and control capability ready for the DSO DER scheme.

The 'Power Potential' project in the UK is a collaboration between UK Power Networks, the local DSO, and National Grid, the TSO.[6] To enable DERs to provide new services to the electricity transmission system, a management platform is currently being developed that will facilitate communication between DERs connected to the DSO network and the TSO, National Grid. This DER management-based initiative aims to create a new reactive power market for DER and generate additional capacity on the transmission network.

To improve cost-effective operation, many DSOs may look to customers to engage in network management directly or through third parties, as operators take advantage of the DER on their networks. This is already happening around the globe. The transition from passive distribution networks to digital technology-based active networks will require network control software that can help distribution system operators communicate with DER and make operational decisions to provide safe, reliable and cost-effective services to all customers. As the number of DERs to be managed increases, DERMS will go from 'nice to have' to 'need to have'.

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[5] Case study from SEPA webinar on non-wires alternatives, 6 Dec 2018. Supporting report at https://e4thefuture.org/wp-content/uploads/2018/11/2018-Non-Wires-Alternatives-Report_FINAL.pdf
[6] Source: https://www.nationalgrideso.com/innovation/projects/power-potential

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