The challenges of integrating DER

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***Abstract*-- As the network operators move to more dynamic ways of operation, there will be new solutions which will help to ensure best use is made of flexibility, demand side response, storage and renewable generation at all network levels, helping to support decarbonisation ambitions and delivering an efficient, resilient and future proofed energy system. This paper will consider how increasing capacity of existing assets, introduction of flexible connections and real-time control will increase the hosting capacity and help ensure that distributed energy resources can be added to networks that would otherwise be considered "full" without running the risk of exceeding operational limits. This approach will also be applicable to future networks, and will be illustrated with example case studies.**

***Index Terms*-- Active Network Management, ANM, Latent Capacity.**

I. Nomenclature

ANM – Active Network Management
DER – Distributed Energy Resource
DNO – Distribution Network Operator
DSO – Distribution System Operator
FDIR – Fault detection, isolation & restoration
LIFO – Last In First Out
RTU – Remote Terminal Unit

II. Electricity grids are changing

The traditional electricity grid was characterised by one way power flows from transmission to distribution. We have 'grown-up' with a transmission network that does most, or pretty much all of the work for balancing the system. Transmission companies balance the electricity supply and demand in close to real time, because electricity could not be stored and had to be produced at the time of demand.

Energy networks are changing and the way we generate, distribute and consume electricity is changing. More renewables are being connected on the distribution network which will displace the larger transmission connected generation. New low carbon technologies such as wind, solar, electric vehicles etc., are changing the way suppliers generate energy, and the way consumers use energy, making the system more complex and variable. Furthermore, renewable energy resources are being located closer to consumers.

Networks are becoming smarter and more active [1]. Figure 1 is a map of the Western Power Distribution network area in the United Kingdom; they operate 4 licensed areas. These networks were designed and built to accommodate the single [winter] peak demand, as shown for each of these regions. Over the past decade this network has seen embedded generation come to dominate the peak power flows on distribution networks. Traditional investment planning may not be able to deal with these new scenarios as utilities will have to accommodate temporary constraints on the networks, a diverse range of generation and rapid clustering, such as electric vehicles and PV installations. To accommodate the growth in energy usage and the diversity of the energy sources, traditional DNO would require substantial investments in a passive grid infrastructure, which would be underutilised most of the time.

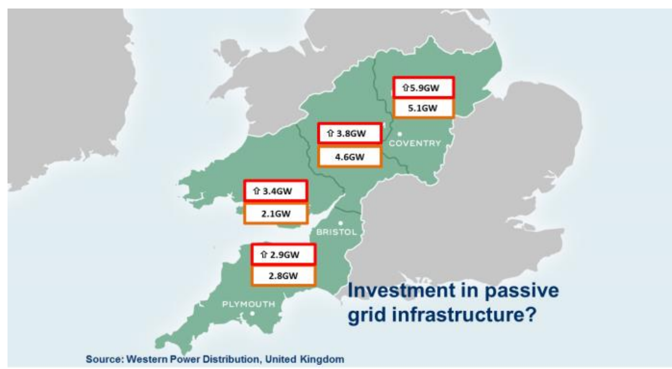

Figure 1: Growth in DER

III. Smart alternatives to network upgrades

Network and System operators need to find smart alternatives to network upgrades. Asset replacement and network reinforcement will need to be supplemented by increasing the agility of networks and enabling customers to deliver additional flexibility when required. A network operator will need to exploit information & communications technology to deliver a network that makes optimal use of capacity. It does this through smarter network solutions such as Dynamic Asset Rating (DAR), Automated Load Transfer (ALT), Meshing of networks, Active Network Management

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(ANM), and inter-tripping. Additionally, this enables Non-network solutions such as demand side response (DSR), distributed generation (DG), energy storage (ES) and other services.

IV. The Path to a Flexible System

Utilities have used control techniques to manage the distribution network safely and to reduce interruption times to consumers. The majority of traditional network automation schemes using SCADA, as well as the more recent FDIR schemes have been implemented with the purpose of restoring supply after a fault has occurred. However, a complementary smart approach is to manage the distribution network assets and distributed energy resources to prevent the occurrence of entering into abnormal running arrangements and avoiding the network from operating above safe operational limits. This may be achieved through functionality such as timed connections, operational tripping and constraint management. As utilities progress from timed connections through to constraint management the system does become more complex.

A. The role of network system operator

The role of network system operators is to balance supply and demand in real-time while maintaining stability, quality of supply and availability of power. To deal with complexities of measuring, monitoring, control and management of power and energy across networks, multiple control room systems have evolved. Network and system operators rely on systems such as SCADA, EMS, DMS, ADMS, GIS, and OMS and more. Control room systems often have substation level sub-systems such as SAS and SCS. For energy retail and wholesale operations another family of systems evolved such as advanced metering infrastructure (AMI) and automated meter reading (AMR).

B. The new role of the Distribution System Operator

The Distribution Network Operator is now becoming a Distribution System Operator, a DSO. With increased penetration of renewables and other DER, the development of new control room applications for system operators and DER operators has evolved.

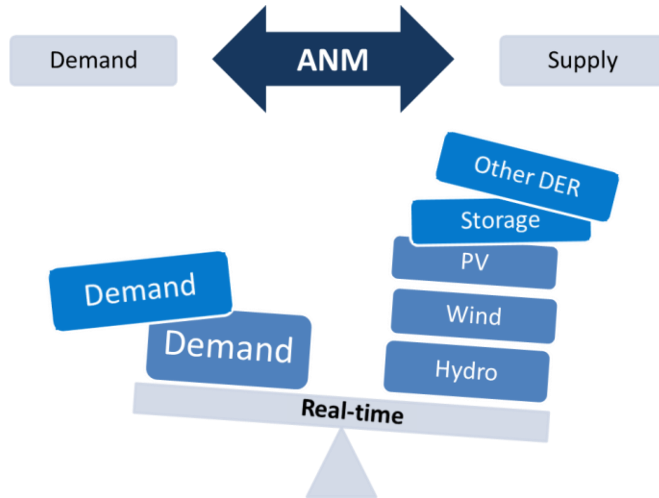


Figure 2: Managing capacity

Utilities now have to manage demand, and the supply from various generation sources, at a distribution level in real-time. Demand may increase, and more or different energy sources may become available, on a variable basis. Equally they may not be available because the network is constrained and cannot support any more generation. The distribution network has to be managed in a similar way to the transmission. Collectively these applications are termed Active Network Management (ANM) or in some markets Distributed Energy Resource Management Systems (DERMS), as illustrated in figure 2.

V. Maximising Hosting Capacity

The conventional approaches to integration of DER have been to plan for the maximum secure hosting capacity, with fast acting protection tripping off the generation in the event of any network outages. This 'fit & forget' approach limits additional DER due to the costs of reinforcing the network, and also limits the hosting capacity as it only considered the worst case conditions.

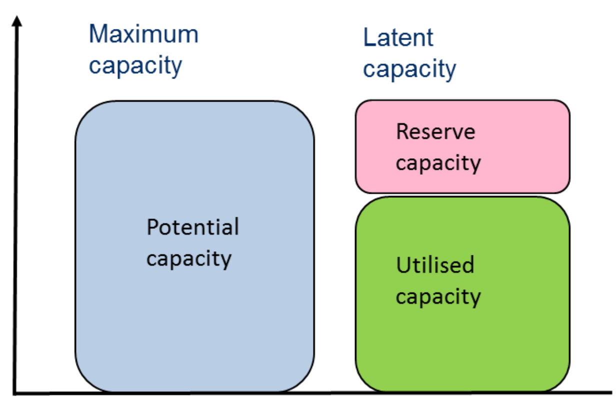


Figure 3: Maximising Hosting Capacity

These existing approaches avoid "constraints" and the possible curtailment of DER. This leaves reserve or latent capacity in the network for the majority of the time, as shown in figure 3. To release this latent capacity, ANM systems are used to monitor the real time capacity of the grid and reduce distributed generation output only when the grid is actually under stress. Two constraint management schemes that help manage this capacity; Timed Connections, and Centralised ANM shall be considered.

A. *Timed Connections*

Timed connections [2] help reduce the level of upstream reinforcement required to facilitate new connections. By doing so it allows the network operator to offer faster and cheaper connections to the network for distributed generator customers.

Consider a connection to a renewable energy source as shown in figure 4. Customers will be permitted to export/import at set times and not at others, or may have a fixed limit imposed on their output at certain times.

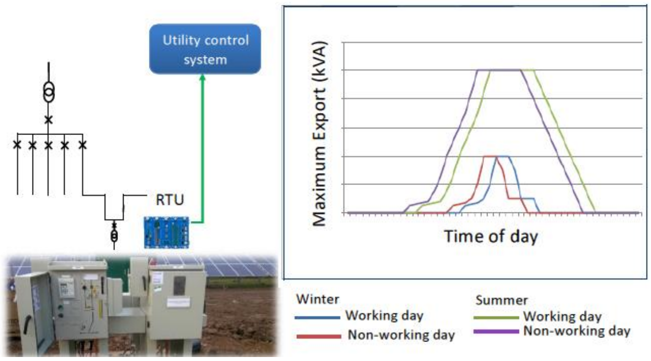


Figure 4: Timed Connections

This schedule will be enforced primarily through local control mechanisms on the customer side, and by the DNO through the monitoring of power flows at the point of connection. The local DNO RTU will monitor the connection and in the event that constraints are breached sends a failsafe signal to the customer control system to reduce the import/export to the agreed level. If the customer control system does not comply, the logic will send an alarm to the Network Management System (NMS), and a configurable option within the logic will allow the relevant circuit breaker to be opened to disconnect load/generation/storage (as applicable) if required.

B. *Centralised ANM*

The timed logic approach can be extended by using active network management techniques to manage the output of multiple and dispersed generation. This is real-time control with feedback loops handled by an Active Network Management ANM system.

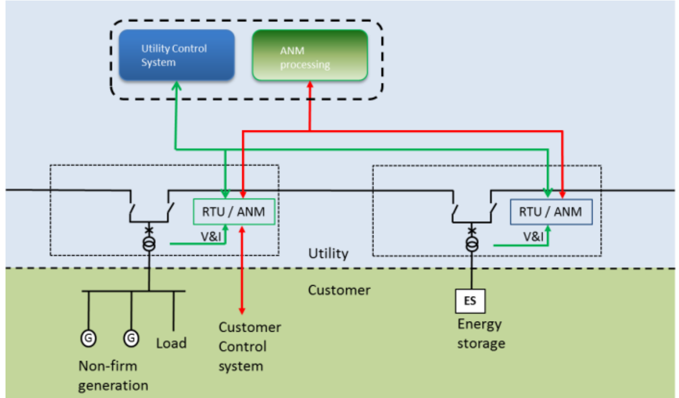


Figure 5: Centralised ANM

Consider we have two industrial customers [figure 5], one with local distributed generation for local consumption, and another that has energy storage. Both are connected to the utility network. The utility has remote control facilities at the point of connection. These are RTUs which have the capacity to run some localised active network management software.

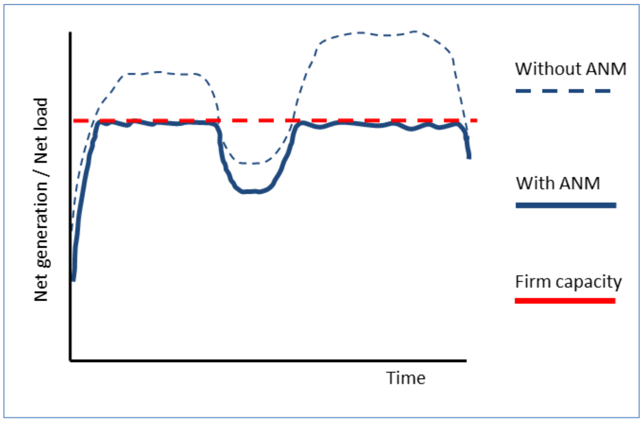
The customer on the left has control of the distributed generation but has agreed to curtail its generation when requested to allow the network to be kept within its firm capacity. The customer on the right has energy storage available.

There is an active network management system running which uses the RTUs to actively manage the distributed generation and the storage without interfering with the operation of the actual utility network. In this application the RTU manages the interface to the switchgear, and ensures only one control is executed at a time, from either the utilities SCADA control system, or from the ANM controller.

Although described as a centralised scheme, this application is closer to a regional scheme as it is managing a collection of DER in real-time with accurate acquisition of distributed measurements. The prime function of this solution is to maximise the utilisation of the network by increasing the generation hosting capability. This ANM control system typically manages multiple generator outputs of up to 70-80 MVA, with multiple constraints, using a meshed wireless network providing the communications between the switchgear and the ANM. In comparison to timed connections, this application has a more complex set of rules such LIFO and pro-rata selection of generation.

C. *Constraint Management Using ANM*

The dotted line in figure 5 illustrates the trace of the network load if there is no ANM running. As can be seen, at times it would exceed the firm capacity of the network. The solid blue line shows that the generation has been curtailed to avoid exceeding the network capacity. By applying this to a few sites, it is possible to release capacity on the network to allow a diverse range of distributed energy resources.



Source: Energy Networks Association

Figure 6: Managing capacity

VI. BENEFITS OF ANM

UK Power Networks have used ANM solutions on their Flexible Plug & Play project [3] which was a project to increase the generation hosting capacity, and to provide cheaper and faster connection of Distributed Generation to constrained parts of the network. This was a trial using smart grid technologies and smart commercial agreements, enabling approximately 100 MW of generation to be added onto the grid making savings of roughly $38m in connection costs.

Scottish & Southern Electricity Networks have used similar ANM schemes on projects both in the Orkney [4] & Shetland Islands [5] to increase the generation capacity of the networks without having to make reinforcement. On the Orkney Islands there was an extra 39MW of generation added, making a saving of approximately $36m in connection costs. On the Shetland Islands there was an extra 8.5MW of generation added which displaced diesel generation making a saving of $1.2m per year.

VII. Conclusions

Techniques for integration of DER are adding value through facilitating the growth of renewable generation, and doing this without network reinforcement, thus reducing the connection costs. Integration of DER is extracting value because it's making available the latent capacity in the network. However, commercial arrangements will need to be in place to manage the enforced intermittent nature of the DER under an ANM scheme. In addition, there may be a risk of nuisance tripping and potential impact to power quality levels on the network.

Utilities need to be clear on the decisions driving investment. It may be necessary to recognise the opportunity to skip a technology, and invest with flexibility as a core element.

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IX. *Biographies*

Tim Spearing is responsible for the product management of the automation business in Lucy Electric. These range from secondary RTUs to complete SCADA and automation solutions. Tim has a BSc (Hons.) in Information Technology, an MBA from Aston University, and is a Chartered Engineer, a Member of the IET, and a key supporter and contributor to IET Developments in Power System Protection (DPSP), the IET Midlands Power Group in the UK, the UK Smart Grid Forum, and EU Smart Grid Task Force.

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