DEPLOYMENT OF ACTIVE NETWORK MANAGEMENT TECHNOLOGIES IN THE UK AND THEIR IMPACT ON THE PLANNING AND DESIGN OF DISTRIBUTION NETWORKS

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ABSTRACT

Distribution networks in the UK, as in other developed countries, were designed to operate passively and deliver unidirectional power flows to dispersed end users. The introduction of distributed generation (DG) can render the existing operational philosophy invalid. Active Network Management (ANM) solutions are being developed to enable the increased connection of DG, often on a case by case basis as an economically preferable alternative to network reinforcement

A recent study undertaken by the University of Strathclyde has updated a register of completed and ongoing active management pilots, trials, research, development and demonstration activities. By considering the type and technical focus of each activity, the register demonstrates technical areas where much focus has been directed to date, where solutions have been implemented and where solutions are only now emerging. For solutions which have been implemented, the register provides an overview of the scale and impact of the activity, making the register a valuable resource for network planners. Analysis of the register content provides a snapshot of the current state of ANM, and provides recommendations to the key parties involved in the development and deployment of ANM solutions and technologies.

INTRODUCTION

In the past, the passive operation of distribution networks has been sufficient in ensuring stable network operation, based upon transmission-level centralised generation delivering power through the distribution network to the end customer. Recently, however, as the UK electricity industry strives to meet renewable energy targets, the connection of large levels of Distributed Generation (DG) on the distribution network have resulted in changes to the operation of the network, including in the emergence of technical barriers blocking the connection of DG. The answer to such barriers is often either the costly reinforcement of current network assets, or alternatively the application of novel technologies to control network parameters, keeping them within stable limits.

The concept of an Active Network has been described as the following:

"….a network where real-time management of voltage, power flows and even fault levels is achieved through a control system either on site or through a communication system between the network operator and the control devices" [1].

It is worth noting that there is currently no recognized explicit definition for the concept of active networks, and the description may vary, depending on the context of work. In the context of this paper, and the fore mentioned Active Network Deployment Register study, the above definition is used.

Currently, the main driver for the deployment of ANM in the UK is the need to counteract the network issues which commonly arise alongside the connection of DG, which would otherwise require costly and sometimes controversial network reinforcement [2].

In the UK, technical innovation is encouraged through two financial incentive schemes offered to network operators by the industrial regulator, Ofgem: The Innovation Funding Initiative scheme (IFI) encourages the research and development of innovative grid technologies, whereas the Registered Power Zone initiative offers incentives for DNOs who implement such technologies onto the network, facilitating the connection of DG that has previously been blocked by technical barriers.

ACTIVE NETWORKS DEPLOYMENT REGISTER

A recent study at the University of Strathclyde has produced a register providing clear statements of the status of recently completed, ongoing and planned active network pilot and trial activities, international developments in related areas, and research, development and demonstration activities. Currently in its updated second edition (2007), the register serves to act as a reference document for individuals working in the field of active networks. The analysis of the data gathered in the register gives a snapshot of the maturity or impact of different programmes and technologies, offering recommendations to key players concerning the deployment of such solutions.

Not all projects within the register comply with the definition of active networks previously given, though they have been identified as possessing the potential to play a supportive role in the operation of active networks, although they may not possess 'active' characteristics.

The register consists of 121 entries in a tabular format, an example of an entry is shown in Table 1. The project title, organizations involved, and funding sources (when available) are provided, giving the reader the essential background information on each entry. The Activity Type column allows the maturity of entries in the register to be differentiated by different phases of the development process:

- Research
- Development
- Trial
- Pilot
- Full Deployment

Details of the project timeframes, including the status of the project (Ongoing or Completed) are provided, along with the country where the work has taken place. Due to the large range of projects concerned with active networks, projects within the register cover a wide range of technical areas. 11 key technical areas have been identified, which are assigned to each project. The larger research programmes found in the register may encompass more than one area of technical focus. The areas of technical focus are:

- Active Management Planning
- Communications and Control
- Demand Side Management
- Fault Level Management
- Future Technologies
- Modelling and Analysis
- Power Flow Management
- Power Quality
- Protection Systems
- Storage
- Voltage Control

The register includes a brief summary of the technology concerned or the activity undertaken in each project. Where possible, this is as close to the official project descriptor, but may be adapted by the authors for the purpose of the register.

For projects and programmes which have progressed beyond the research and development phases, and solutions have been demonstrated on the network, the Deployment Summary column summarises the magnitude, timescale and location of deployment. The Impact of Activity column concerns competed projects, and when available, provides short statements measuring the success of the project and its effect on the surrounding network. Currently, due to the infancy of active network technologies, it is too early to measure the impact of deployment for many projects, although it is expected that in future editions of the register the significance of this section may grow. As with the Summary of Technology/Activity column, the statements within this section are kept as close as possible to official statements on the impact of the project.

For further information on the projects within the register, a point of contact or relevant website is provided, and when applicable, a link to either a report or website providing more information is given.

Projects and programmes within the register were identified through guidance and discussion with key individuals involved in the field of active network research. For each entry, the main information resources were technical papers, project reports and contact with individuals involved.

The Classification of Technical Focus and Activity Type sections are key elements in the register, as the information collected through these sections provides the basis for useful analysis considering the maturity and spread of active network projects and technologies.

Table 1: *Entry from Active Networks Deployment Register*

Project ID	Project Title	Lead Organisation	Partner Organisations	Funding Source	Activity Type	Activity Status	Start and completion dates	Country	Classification of technical focus	Summary of Technology/ Activity	Deployment Summary	Impact of Technology/ Activity	Contact details	Report Link (URL)
004	Facilitate Increased Generator Connections to the Orkney Distribution Network	Scottish Hydro Electric Power Distribution Ltd	University of Strathclyde	DTI Technology Programme: New and Renewable Energy. Contract number: K/EL/00311	Research & Development	Completed	2003 - 2004	UK	Power Flow Management	Initial specification of active power flow management scheme. Scheme works through the identification of control zones and available capacity for export from the Orkney distribution network. Power flows are managed using operating margins and generator output regulation and tripping.	To date an online closed-loop trial has successfully been completed and full implementation is progressing during 2007/08.	Results in capacity for around 3x firm generation to connect.	David.MacLeman@scottish-southern.co.uk	http://www.ensg.org.uk/assets/kel00311r0000.pdf

Analysis of the Active Networks Deployment Register

The analysis of the activity type and areas of technical focus throughout the register offers a general overview of the state of active network development. The full analysis of the Active Networks Deployment Register is available in the project report which accompanies the register [3]. This information can be used to determine what active network technologies are close to maturity and deployment on distribution networks, and may be used to increase the penetration of DG in the future.

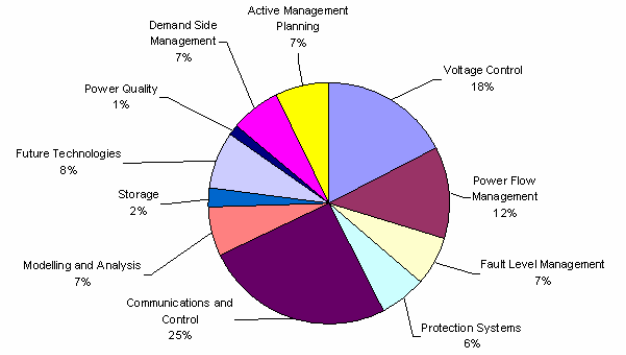

Figure 1: *Register content by classification of technical focus*

The spread of technical focus within the register is shown in Figure 1. This shows that 25% of the register entries are in the areas of communications & control, which is unsurprising due to the passive characteristics of distribution networks, suggesting lack of advanced communications infrastructure is one of the main barriers towards active operation of distribution networks. The next two largest areas of work are voltage control and power flow management, likely as these are the two main technical barriers which arise with the connection of DG.

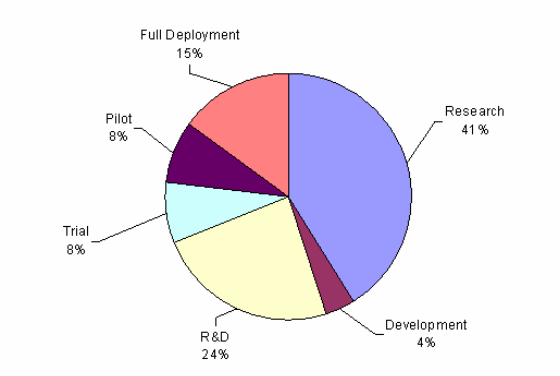

Figure 2: *Register content by activity type*

Figure 2 shows the proportion of project maturity within the register, taken from the activity type for each project. Currently the majority of projects are at the research and/or development phases of maturity, with trials, pilots and full deployment only accounting for 31% of entries, suggesting that the majority of projects are not at the stage where they are likely to be demonstrated on the network in the near future.

To realise the true value of this data, it is necessary to consider each area of technical focus, and consider the spread of activity within the technical area. This analysis is available for each area of technical focus, additionally taking the activity status (completed or ongoing) into consideration. This provides the user with additional insight into the maturity of active network technologies, as the stage of maturity for each technical area is observed.

Key results from the register

The key results from the analysis of the register contents are as follows:

- 69% of active network activities are currently at the research & development phase
- Activities currently at the R&D phase are unlikely to reach full deployment and have significant impact on energy targets before 2010
- Since the first edition, many existing projects have progressed from simply research to R&D phase of maturity, an encouraging sign that emphasis is focusing toward the eventual demonstration of technologies and solutions.
- Technical solutions in the areas of voltage control and power flow management are the most mature; this is expected as these are often the largest technical barriers faced in the connection and operation of DG.
- The majority of current deployed solutions are bespoke systems; to achieve widespread deployment of ANM, there is a need to develop solutions that have wide applicability.
- Novel communications and control schemes are seen as key to enabling active distribution networks, however, the majority of projects concerning this are at the R&D stages. There is uncertainty regarding the ability of existing SCADA solutions to support ANM, if new communications and control schemes are required to support ANM then this must be recognised and emphasis set toward the deployment of such schemes to trial and pilot demonstration.

IMPACT OF ACTIVE NETWORK TECHNOLOGIES ON FUTURE NETWORKS: FURTHER WORK

Current research at the University of Strathclyde is investigating the changes occurring to the operational characteristics of distribution networks which underpin current design standards in the UK. The deployment of ANM systems will change these operational characteristics, in turn affect network planning and design. The magnitude of this change is greatly dependant on the extent to which network parameters are actively controlled and the scale of deployment.

If the deployment of ANM solutions continues the current trend, as bespoke solutions designed to overcome a barrier to DG connection on a distinct section of network, the impact is likely to be less.
Large-scale deployment of ANM systems in the UK, monitoring and controlling distribution networks, would increase the accessibility of distribution networks for new generator connections, giving network planners greater control over issues such as situating sites for DG connections, and the need to incorporate and connect control systems to network expansion

Assuming the growth and successful demonstration of ANM solutions, it will be necessary to include the impact of such solutions into account when performing long-term planning of network expansion and reinforcement. ANM technologies have the potential to defer network reinforcement, and may be applicable to such situations, though this will also include the need to incorporate control systems to the planning process.

These are the fundamental changes that will take place, but the work aims to further identify detailed aspects of current design standards which may prove disadvantageous to the deployment and operation of active distribution networks.

CONCLUSION

The findings from the register confirm that there are still few ANM technologies deployed in the UK to date. Of current projects, the majority are at the R&D phase, projects which hold promise for facilitating the connection of DG should be identified and fast-tracked toward deployment.

Due to the fast-moving characteristics of active network technologies, the register will continue to be updated biennially in order to keep its contents accurate and informative.

REFERENCES

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[4] European Commission, "*Strategic Research Agenda for Europe's Electricity Networks of the Future*", European Technology Platform SmartGrids, 2007