A PRACTICAL APPROACH TO ACCOMMODATING LOW CARBON CONSUMERS IN EXISTING DISTRIBUTION NETWORKS

Stewart REID
SSE – GB
stewart.a.reid@sse.com

Brian SHEWAN
SSE – GB
brian.shewan@sse.com

Mark STANNARD
SSE – GB
mark.stannard@sse.com

Peter GRINDROD
University of Reading – GB
p.grindrod@reading.ac.uk

John SCOTT
KEMA – GB
John.Scott@kema.com

Dave HAWKINS
GE Energy – GB
dave.hawkins@ge.com

ABSTRACT

To date, the majority of the UK's medium and low voltage networks have been designed and operated to meet easily predictable demands. The introduction of new low carbon technologies at domestic and commercial/industrial customer sites is expected to impact MV and LV network peak demands and utilisation factors with the risk of involving urgent reinforcement programmes.

Existing industry practices, if applied to a low carbon future, will result in overspending on, and delays to, load related reinforcement with likely consequential deterioration in customers' Quality of Supply and likely restrictions on the take-up of low carbon technologies.

The paper describes project plans to develop a Model, Monitor and Manage methodology in order to demonstrate an alternative to traditional network management and reinforcement. The paper summarises key targets and anticipated learning points. The paper will also include a reference to earlier lessons learnt from other international programmes involving low carbon technologies.

INTRODUCTION

The low carbon future will require fundamental changes to commercial and industry structure across the entire value chain. At the same time, domestic consumers will be encouraged to migrate from carbon-intense activities (e.g. petrol-engine vehicles) to low carbon alternatives (e.g. battery-electric vehicles). Preparation of DNO functionality for this requires a bold project to address all the corporate and industry impact, including the evaluation of a Distribution System Operator (DSO) role, and the opportunity for new entrants, including Energy Service Companies (ESCos).

A location comprising a varied customer base and network topography is essential to the solution, so that the outputs present a scalable solution to the rest of GB.

Bracknell has diverse demographics; there are a variety of housing types; and the combination of domestic and commercial demands on the system are representative of a great many built up areas in the UK. There are no special features in its network topology, and crucially, from a learning perspective, there are no major 'eco' initiatives in the town at present, enabling carbon reductions achieved by the Project to be accurately attributed to the project.

The solutions centre on creating an intelligent distribution network that:

- creates a modelling solution to determine the nature and locality of low carbon technologies on the network;
- enables new techniques to be evaluated in a systematic manner; and
- facilitates active community engagement and knowledge-sharing with multiple stakeholders

Customer and community engagement is essential to the success of the Project and the Project team has already established a manageable range of Public and Private sector collaborators.

Figure 1, below, gives an example of the anticipated change in network loading for a typical domestic customer. The Load Duration Curve for a domestic home with non-electric space and water heating was created using historic industry data while the modified Load Duration Curve for a home with e-vehicle charging was created using an assumed battery charging regime.

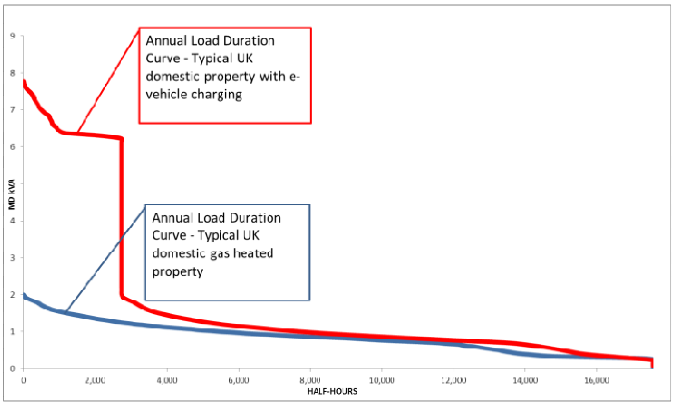

Figure 1 – Anticipated change in domestic load

The increase in the peak demand at a single home reflects that anticipated in other recent papers ([1]). While most LV networks can easily accommodate a single 'low carbon' customer with e-vehicle and other new electric technologies, it is anticipated that a take-up of over 20-30% in many LV networks serving domestic customers would cause significant over-loading leading to urgent network reinforcement works at great expense.

Through the active promotion of PV installation and the innovative use of storage devices to replicate a future concentration of new technologies (EVs, GSHPs, PVs), the Project will be able to illustrate the impact of these new loads on the network that may not otherwise materialise for some years. Promoting low carbon solutions will also demonstrate the potential appetite for customer acceptance of these products. The Project will also utilise this approach with an emphasis on alleviating fuel poverty.

Project Approach

The Thames Valley Vision (TVV) Project will develop and rigorously validate new least cost solutions, including making extended use of existing business systems. The project will:

- Determine the optimum amount of monitoring required
- Develop the modelling and planning tools necessary to allow active network planning and management
- Revise old and create the new standards for the application of smart technologies and commercial arrangements
- Optimise load-related investment and significantly improve asset utilisation factors
- Engage with a wide range of customer groups in Bracknell to identify benefits for both customers and DNOs.

The elements comprise:

- Project Management Work Package (WP) managing each subsequent WP;
- A technology and commercial solutions deployment layer – comprising: Network Monitoring; Network Controls; Energy Storage and Generation Use; End Point Monitoring; Demand Response & Control; Large Enterprise Demand Response

Once these solutions have been delivered and commissioned they will contribute to the Integrated Operations Environment where all data collection and control scenarios will be operated and evaluated.

The Modelling WP will take the necessary data inputs and provide the necessary advice for future planning and operational tools. All project materials and learning points will be captured and disseminated by the Learning and Dissemination WP.

THE 3M APPROACH

The Project will develop a Model, Monitor and Manage methodology to provide a corporate and electricity industry alternative to traditional network reinforcement, to determine the most efficient and effective ways to reliably meet the needs of customers over the coming years and longer time horizon to 2050.

The Project will also promote low carbon technologies to determine the most effective solutions and engage with the local community and other industry parties, to contribute to the Project and provide valuable learning channels and facilities.

M-1: Model

Building on successful applications in the retail sector, which have resulted in increased services and reduced costs, the mathematical demand modelling will be provided by the University of Reading, Department of Mathematics. In conjunction with this project SSE is supporting the establishment of a Centre for Smart World Analytics at the University to form a centre of excellence for this topic, thereby providing a significant vehicle for learning and dissemination.

The creation of a dynamic Tracking and Inferencing Model will enable short, medium and long term demand forecasts to be derived – essential for managing the more dynamic characteristics of customers in the future and overcoming the severe limitations of today's capital planning based on average peak demands. The Project will also develop unbalanced (three phases) LV state estimation and evaluate its benefit in this context.

This modelling work will enable network operators and planners to forecast network constraints at LV nodal level. The analytics techniques will dynamically track and characterise large areas of the network through intelligent use of limited data samples combined with wide area modelling.

The development of shorter time horizon forecasting models will allow more targeted use of the emerging network solutions including the deployment and management of localised energy storage, demand response initiatives and innovative customer propositions.

A LV and MV modelling environment will be developed using existing GIS and readily-available network analysis technologies. This modelling environment is intended to provide advanced support for distribution network planning and design without incurring a large increase in utility planning engineer workload.

M-2: Monitor

To identify the detailed localised network characteristics that may arise in a low carbon future, the Project will establish a Bracknell Grid Monitored Network comprising about 350 LV sub-stations with sensors to capture the electrical characteristics of the HV/LV network and consumer behaviour. The output from these sensors will be integrated into the existing SCADA/DMS system already installed at SSE.

Advanced/smart metering in three highly metered 'focus zones', will provide the modelling data required to extend the derived value over the full geographical grouping by means of a customer typology characterisation and extrapolation techniques.

While the number of sensors installed will be greater than anticipated in actual smart grid deployments, the Project team aim to robustly evaluate the approach to determine the appropriate level of cost-effective monitoring.

The retro-fitting of sensors to existing LV cables and on the LV side of MV/LV transformers normally requires the interruption of supplies to customers. In support of the TVV programme, SSE has already commenced a 'LCNF Tier 1 project' which will prototype methods of installing monitoring equipment without interrupting customer supplies while delivering a robust solution, integrated with the existing SCADA/DMS system already deployed at HV and MV.

Full integration of the monitoring solution outlined above will enable SSE to benchmark all modelling techniques developed and demonstrated under M-1 and is intended to assist with identification of those MV/LV sites where monitoring would not be required.

M-3: Manage

Deployment of advanced monitoring and modelling solutions will, for the first time, enable these networks to be managed closely: enabling improved asset utilisation to be demonstrated, delaying or avoiding traditional reinforcement, and facilitating new techniques such as real time ratings, active network management, and intelligent switchgear. Energy Storage will be deployed at LV substation, street cabinet, and household locations and its performance assessed using this network observability. It will also enable stress testing to simulate customer demand/export real loading conditions.

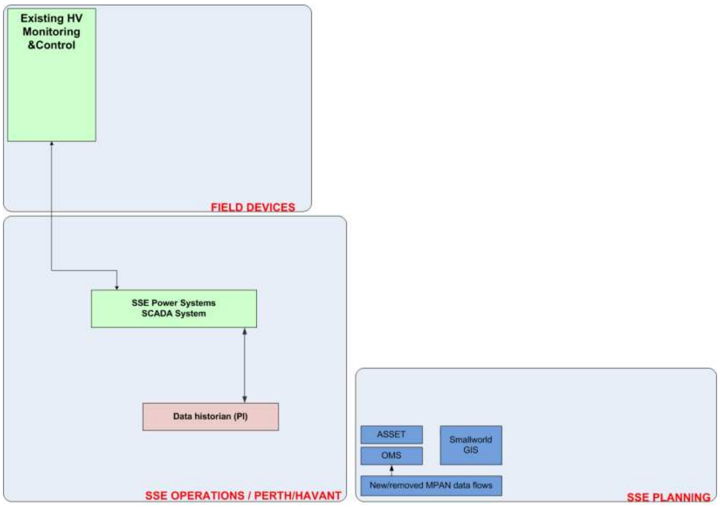

Figure 2 Existing DNO Technology Architecture

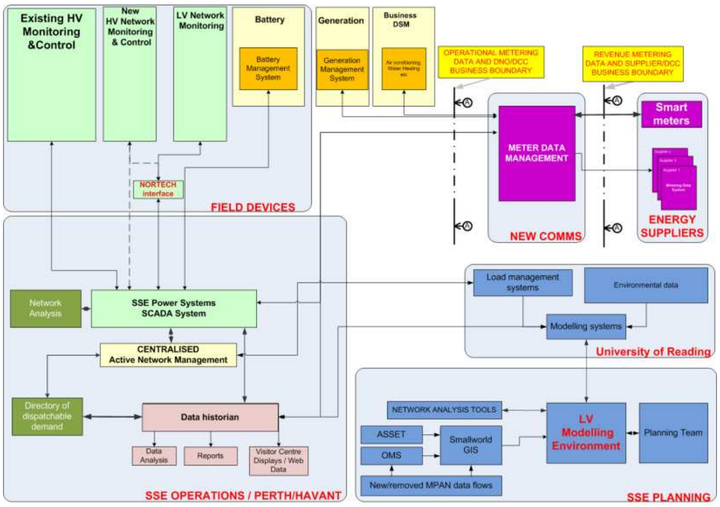

Figure 3 Proposed Solution Architecture

The extension of Distribution Network Operator responsibilities to provide System Operation (DSO) functions in a similar way to the Transmission System Operator, TSO, activities will be a key outcome of this project.

While Figure 3, above, does not demonstrate how DSO functionality will be delivered, it is important to point out that the proposed system architecture meets the following requirements:

- The architecture recognises all existing GB business separation issues. This is particularly important where the network operator does not own the meter and may not own the meter data management and head-end system.
- Network and academic modelling systems are separate from the existing and planned operational systems. This reflects the likely difference in data processing requirements and the need to achieve operational DSO

functionality in near real-time, i.e. sub 5 minute or faster.

- Responsibility for load dispatch is divided between system operator and energy trading systems. The division of responsibility occurs at 'Gate Closure', which is T-1 hour in GB under NETA. Pre-gate closure dispatch will be effected by suppliers via the meter data management / DCC (Data Communications Company) system which post gate-closure dispatch will be from Distribution System Operator via DCC. Balancing and Settlement of each DSO dispatch instruction will require additional trading arrangements and options are intended to be reviewed during this project.
- While energy trading dispatch will be directed at groups of customers/loads which are aggregated under tariff classes, DSO dispatch will need to provide a multicast solution directed at customers/loads associated with a specific section of the distribution network, i.e. that part of the network which is forecast to experience a constraint condition.
- The DNO/DSO data historian will support the aggregation of new monitoring data plus all forecast data provided by the planning/modelling activities. A single high-performance data repository is expected to be essential.

Involving Customers

Through the I&C Consumer Consortium, the development of a 'retrofit' Smart Building, and control of customer Building Management Systems and stand-by generation facilities, the Project will seek to optimise net community carbon benefits as opposed to site-only energy efficiency improvements.

SME and domestic demand side response applications will be promoted through the development and application of commercial incentives and customer focussed products. The Project will also address high PV penetration by balancing generation and demand utilising heat storage capability in the customer property.

Engaging domestic customers

The Project will promote existing Government Low Carbon incentives to the local community. This will provide evidence of the challenges of customer acceptance, resulting network constraints, and a means of alleviating fuel poverty. The project will also facilitate a public sector based Energy Service Company (ESCo) with the potential to facilitate direct incentives for low carbon solutions in the planning arrangements at the new build/refurbishment stage. The Council has agreed to facilitate the installation of Electric Vehicle (EV) charging posts.

Working with communities

The engagement with customers and communities is vital to the success of this Project, to underpin effective demand response and participation. To address the challenge of raising community engagement and actively promoting UK industry learning and dissemination, SEPD will establish a Community Low Carbon Energy Centre and a flagship Low Carbon Smart Networks Centre. This will communicate the concepts of low-carbon solutions and smart grids in a highly interactive visual way and provide a 'live window' on to the TVV project.

Project Deliverables

The key project deliverables include:

1. A set of 3M multi-dimensional network planning, design and operating policies, illustrating how a modelling, monitoring and management approach can be integrated into the existing DNO operating regime. These new policies may also lead to proposed changes to the Distribution Code of Practice and other associated regulatory codes.

2. DPCR6 Readiness. The GB DNOs are required to submit business plans for 2015-2020 and this project is intended to inform those business plans with respect to both load-related and non-load-related capex in addition to operating costs where new practices are introduced.

3. Education via learning and dissemination to all stakeholders and other interested parties; these include other DNOs, government departments and regulators, industrial, commercial and domestic customers, DNO staff, manufacturers, energy suppliers and other industry participants.

REFERENCES

1

STANOJEVIĆ, SILVA, PUDJIANTO, STRBAC, LANG, MACLEMAN Application Of Storage And Demand Side Management To Optimise Existing Network Capacity. CIRED 2009.