

## AN INTEGRATED MV DISTRIBUTED GENERATION CONNECTION PLANNING TOOL

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### ABSTRACT

*Network planning and design for new distributed generation (DG) connections typically involves considerably more attention than that required for new demand connections. In particular, generation connections involve consideration of voltage rise, voltage flicker and harmonics, together with fault level limits on existing plant.*

*The objective of this project was to develop a DG connection planning system for use by network planning staff, comprising NETMAP, EDF Energy's Smallworld GIS application, with Smallworld Design Manager(\*) and an embedded network analysis engine (DigSilent PowerFactory).*

*In conjunction with EDF Energy, GE Energy (GE) and Realworld investigated the current planning processes and built a proof of concept solution that significantly reduced the time and effort required to build the network analysis model required by the planning team.*

*The project demonstrated that there is the potential to significantly reduce the engineering time taken to create the network analysis models that are needed to support the DG connection request process. The potential business benefits include:*

- 1. Improved customer service*
- 2. Increased process efficiency*
- 3. The opportunity to introduce a consistent, accurate process across the EDF Energy regions*
- 4. Identification of other connection requests that are in the same area and are still in the planning stage*
- 5. Provision of audit/tracking functionality and supporting evidence to provide quality assurance and replicate decisions made*
- 6. Models are easily regenerated later*
- 7. The ability to more easily manage enquiries at multiple offices/locations*
- 8. The opportunity to more easily identify deep reinforcement requirements arising from multiple connection enquiries and other planned schemes which could also be managed through this system*
- 9. The opportunity to extend the tool to meet OFGEM's recently imposed Standard Licence Condition, SLC 4F, with obligations to meet target connection design/planning response rates and to audit and report on achievements each year.*

### UK REGULATORY SITUATION

Typical custom and practice in network planning design involves a number of separate disciplines, including draftsmen and other drawing office staff, surveyors, asset managers, network designers, commercial engineers, and network analysts. Their joint and separate involvement leads to the time elapsed between an initial enquiry and final design/costing sometime taking a number of months.

This timeline has led to increasing pressures on network operators, particularly those involved with government and regulator-led initiatives aimed at increasing the amount of renewable generation: in general, renewable generation projects are connected to the EHV, HV and MV distribution network and it is expected that LV connected renewable generation (also known as microgeneration) will increase over the next several years.

As an indication of the effort involved in providing an accurate quotation for the connection of embedded generation to a network, National Grid, UK operate a regional, fixed price fee for a construction application for a new connection ranging from £6000 to £10,000<sup>1</sup>. It is also noted that in the recent price control review OFGEM stated: "in electricity, special arrangements had to be put in place during the current control to allow the transmission companies to invest in response to increased connections from renewable generators"<sup>2</sup>. The impact of delays was also addressed by OFGEM: "A subsequent delay in the connection of new generation to the transmission and distribution networks could result in an increase in the costs of constraining new or existing generation plant off the system. This would not be in the interests of consumers who would ultimately pay these costs."<sup>3</sup>

### CUSTOMER EXPECTATIONS

Typically, in these cases, the customer is a renewable generation developer who is keen to identify a suitable site for his scheme and obtain, as quickly as possible, the costs associated with making a suitable connection to the existing distribution network.

It is often the case that one single prospective site can be the subject of numerous, different, connection enquiries leading to unnecessary duplication of effort by network planning and design engineers.

### REGULATORY AND TECHNICAL REQUIREMENTS

Typically, there are both technical and commercial regulatory requirements for utilities when planning and designing new network connections. These include:

- To ensure that any new connection does not affect the supplies to existing network customers in terms

of voltage, voltage flicker, fault level, harmonics, and circuit overloading.

- At the same time, utilities are often required to ensure that any new connection is the lowest cost, technically feasible option. In some circumstances a regulatory review can be requested by the new customer with the risk of financial compensation payments from utility to customer where the connection is later considered over-engineered and therefore too expensive.

**ISSUES FACING EDF ENERGY NETWORKS BRANCH**

EDF Energy is one of the UK’s largest energy companies. It provides power to a quarter of the UK’s population via its electricity distribution networks in London, the South East and the East of England. It supplies gas and electricity to over 5 million customers and generates about 5GW of energy from its coal and gas power stations, as well as combined heat and power plants and wind farms. The company is also a key player in national infrastructure projects including management of private electricity networks serving four London airports and the Channel Tunnel Rail Link, the country’s first major new railway in 100 years. EDF Energy employs nearly 13,000 people at locations across the UK and is a core part of EDF Group, one of Europe’s largest power companies. EDF Energy’s Networks Branch is responsible for the three electricity distribution licence networks.

With a stand-alone network analysis package, the network planning engineering staff are typically involved in a significant effort in both manually creating or updating the model of the existing network assets from the proposed point of connection both ‘upstream’ to a convenient energy source and ‘downstream’ to include other adjacent customer installations. This effort can often involve the interpretation of network asset diagrams to identify circuit lengths and conductor sizes together with plant ratings and existing network peak demands and operating conditions (switch positions).

The increase in applications for renewable generation connections can often lead to an overlap between proposed projects so that it is also necessary to consider the order in which applications have been received and any technical interaction between these projects. This normally requires a multiplication of studies to provide details of reinforcement required for each different possible outcome. The complexity of these studies may be further compounded where different planning/design engineers attend to separate connection requests, possibly at different office locations.

Generally, the final steps in a new connection assessment will involve the calculation of the material and labour costs of both installing new assets and replacing/upgrading existing assets. The asset cost data associated with this activity is generally part of the utilities asset management system and remote from the network analysis tools.

**OBJECTIVES OF THE PROJECT**

The objectives of the project were to review the existing options for interfacing a network analysis tool/engine (in this case DigSilent PowerFactory) with the GIS application NRM/NETMAP and for the selected option, the development and implementation of the interface with the embedded analysis engine. In addition:

1. The evaluation of existing Design Layout Tools (DLTs) – to identify the need for and creation of additional DLTs.
2. The evaluation of Loading Data and other associated data requirements.
3. Prepare a Report of the projects findings.

**PROJECT SUMMARY**

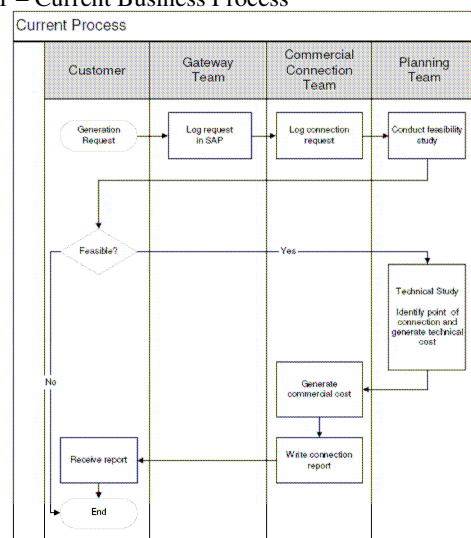
The project was broken down into a number of phases;

1. An evaluation of the existing business processes whereby EDF Energy handle Embedded Generation requests.
2. An evaluation of the interface options.
3. Development of an initial prototype.
4. Review of the initial prototype and further improvements.
5. Development and review of the final proof of concept.
6. Building of a demonstration model.
7. Creation of a final report.

**CURRENT BUSINESS PROCESS**

The connection process differs in some respects in each of EDF Energy’s three licensed areas; these differences are mostly due to earlier investments in analysis tools and other support systems, prior to amalgamation under EDF Energy. Fig 1 shows the main elements of the current high-level business process to support 11 kV generation connections requests.

Fig 1 – Current Business Process



1. The process is initiated by a customer request for a generation request which is logged and EDF Energy then contacts the customer to find out the technical details of the connection request and to confirm their willingness to proceed with a funded generation connection study.
2. If the customer agrees to proceed then a technical study is initiated to identify the best connection point option, a technical cost and an engineering summary of the impact of the connection and related network engineering required to support the request. It was this part of the process that the project focused on.
3. A commercial cost for the connection is then generated and returned to the customer.

There are four main elements to the technical study, namely:

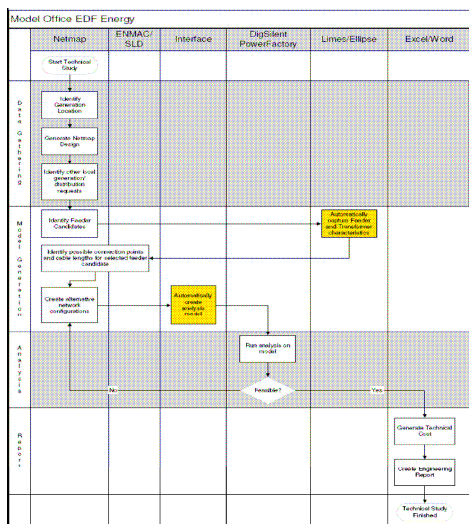
1. Data gathering – identify all of the network information required to create an analysis model. This includes identifying the feeders, which the generator can connect to and is a manual process involving a number of different data sources.
2. Model generation – manually creating the model in the analysis tool. It is these two activities that take the most significant amount of time and which the project aimed to address.
3. Run the analysis ensuring that the voltage levels do not change by more than 2-3%, and that the fault levels of the equipment are not exceeded.
4. Generate the technical costs.

**PROPOSED SOLUTION**

The proposed solution was designed to remove the majority of the manual data gathering and model generation elements and it was based on the assumption that the network model in NETMAP had sufficient connectivity and static data to support the detailed analysis.

The elements of the revised process are shown in Fig 2.

Fig 2 – Revised Business Process



The key changes are in the Data Gathering and Model Generation activities which have been automated.

Data Gathering – the first step of the revised process is to identify within the GIS environment the proposed embedded generator location and automatically identify suitable connection points to the existing network. At this point, the user can then enter the technical details of the generator, ask the GIS system to identify any other planned network changes in the area that may overlap or impact on the new request. The user may include elements of these designs in the new design if required.

1. Data Transfer to the Analysis engine - the user can then automatically transfer the proposed network details to the analysis tool. Once a satisfactory technical solution has been identified, a (partial) technical cost can be generated from NETMAP.

These two revised steps are the key step change in the business process saving a considerable amount of engineering effort which, depending upon the complexity of the model may run into days.

**BENEFITS OF THE PROPOSED SOLUTION**

From summary, i.e. specific benefits:

The Proof of Concept solution has demonstrated that there is the potential to significantly reduce the engineering time taken to create the network analysis models that are needed to support the DG connection request process. The potential business benefits include:

1. Improved customer service
2. Increased process efficiency
3. The opportunity to introduce a consistent, accurate process across the EDF Energy regions
4. Identification of other connection requests that are in the same area and are still in the planning stage
5. Provision of audit/tracking functionality and supporting evidence to provide quality assurance and replicate decisions made
6. Models are easily regenerated later
7. The ability to more easily manage enquiries at multiple offices/locations
8. The opportunity to more easily identify deep reinforcement requirements arising from multiple connection enquiries and other planned schemes which could also be managed through this system
9. The opportunity to extend the tool to meet OFGEM's recently imposed Standard Licence Condition, SLC 4F, with obligations to meet target connection design/planning response rates and to audit and report on achievements each year.

Further generic benefits may also be available:

**User benefits:**

1. *Quick and simple creation of complex network models – through the use of ‘compatible units’, which can be available to represent multiple network elements.*
2. *Generate and maintain ‘per unit length’ asset data, including, for example, cable length, trench length, and relevant excavation conditions.*
3. *Access to further advanced applications – e.g. protection coordination, can be made available via the same user interface.*
4. *Modelling of ‘current’, ‘current + 1 year’, ‘current + 2 year,’ etc. network models can be made available, again via ‘version management.’ Where speculative connection applications involving projects planned to take effect in one or two years time are reviewed, these can be modelled against the planned future network configuration to take account of major network projects, e.g. new supergrid sites, etc.*
5. *Geo-environment issues can be more easily included in connection applications. For example, the GIS can model and highlight public rights of way and land ownership to assist with new route selection.*
6. *Near automatic creation of project cost analysis can be provided. Where new assets are added, the GIS data model can include price/cost data to enable this facility. The cost information can also include labour, e.g. cable jointing costs and environmentally sensitive labour/materials data such as cable trenching costs to reflect soil types, uses and finished surfaces. The asset and activity cost data can be maintained in the GIS or automatically through interface with the utilities asset and work management system(s).*

4. *Reduce user-training requirements. A simple user interface can be provided to new users, with a more advanced user interface available for specialists.*
5. *Finally, provide enhanced stakeholder confidence through quicker speed of response to application enquiries, availability and auditability of planning results, and regulatory compliance.*

It is noted that this approach will help utilities meet the expected rapid increase in network expansion and provide a repeatable means of reviewing existing network status, e.g. analysis of network reliability (CI, CML analysis) and protection coordination. The approach will also assist utilities with increasing the productivity of skilled and new engineering staff.

**REFERENCES**

- <sup>1</sup> *Transmission Price controls and BETTA statutory licence consultation, OFGEM, February 2005*
  - <sup>2</sup> *Transmission Price Control Review, Initial Consultation, OFGEM, July 2005*
  - <sup>3</sup> *Letter on Transmission Investment for renewable generation, OFGEM, October 2005*
- \* Trademarks of General Electric Company

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**Wider, business benefits:**

1. *Shared workspace – all planning/design projects can be viewed by all users. This encourages team working and can help identify where two or more separate projects may either create conflicting or reinforcing issues.*
2. *Management of multiple connection enquiries/applications can be made easier. In particular, the use of GIS ‘version management’ technologies can help with multiple projects where duplication of asset data is required.*
3. *Enterprise-wide database of historic and present connection applications can provide a valuable source of information about future, third party access requirements. For example, developers may show continued interest in particular brownfield sites which will be more evident via a macroscopic GIS overview: these potential developments can then be included in the utility’s long term network development plans.*