AN INTEGRATED PLANNING, DESIGN AND ANALYSIS ENVIRONMENT FOR NEW DISTRIBUTED GENERATION CONNECTIONS

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ABSTRACT

With the recent and sustained increase in distributed generation, there is a corresponding, and sometimes geometric, increase in requests for network planning to accommodate new distributed generation schemes. At the same time, many network operators are suffering a dearth of experienced network planning engineers through retirement and natural wastage.

This paper considers the workload involved with planning new HV and MV distributed generator connections to public networks and presents the use of a combined enterprise-wide planning, design and analysis toolset based on advanced IT systems and components.

The paper refers to a practical example of a combined planning/design/analysis system and provides comment on the business benefits that have been identified in use at a distribution network operator.

INTRODUCTION

This paper describes key drivers on the 21st Century Distribution Network Operator (DNO), with particular reference to the experience of DNO utilities in Great Britain, where deregulation commenced in 1990 and has continued to evolve leading to increasing and changing pressures on the utility business.

This paper outlines how these drivers are now leading to developments in integrated engineering tools designed to both improve the productivity of skilled engineers and assist newly qualified engineering staff.

NETWORK PLANNING AND DESIGN

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 know as microgeneration) will increase over the next several years.

THE IMPACT OF RENEWABLES ON NETWORK BUSINESSES AND THEIR CUSTOMERS

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[1]. It is also noted that in the recent price control review OFGEM stated[2]: *"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"*.

The impact of delays was also addressed by OFGEM[3]: "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."

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 the author's experience that one single prospective site can be the subject of numerous, different, connection enquiries leading to necessary duplication of effort by network planning and design engineers.

MICROGENERATION

The author has noted that domestic customers can now obtain 'simple' renewable generation devices from commercial/retail companies, including 1kW wind turbines and 1kWe micro-CHP gas boilers. In both of these cases, the impact of one of these machines on an LV network is considered insignificant and usually too small to make any detrimental impact on the supply quality and power quality experienced by other consumers in the area. However, if the take-up of these devices increases over the future, there may be a case for detailed examination of LV network characteristics in a similar way to the analysis more usually carried out when connecting larger generators to MV and HV networks.

While not included in this paper, the author is confident that the solution outlined in this paper would also be suitable to provide the analysis required at LV.

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.

OPERATING STAND-ALONE NETWORK ANALYSIS – PRACTICE AND ISSUES

With a stand-alone network analysis package, the network planning engineering staff are typically involved in a significant effort in both 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.

The technical analysis of new embedded generation connections may also involve the use of more than one analysis tool. For example, some analysis packages are focussed on fault level and load flow calculations; any requirement for the calculation of reliability indices, including Customer Minutes Lost (CML) and Customer Interruptions (CI), may involve an alternative analysis tool with further training, user support requirements.

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 mentioned above.

OPERATING EMBEDDED NETWORK ANALYSIS – PRACTICE AND BENEFITS

The benefits available from performing network analysis embedded in an enterprise-wide Geographic Network Analysis implementation include:

1. User benefits:
   a. Quick and simple creation of complex network models – through the use of 'compatible units', which can be available to represent multiple network elements.
   b. Generate and maintain 'per unit length' asset data, including, for example, cable length, trench length, and relevant excavation conditions.
   c. Access to further advanced applications – e.g. protection coordination, can be made available via the same user interface.
   d. 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.
   e. 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.
   f. 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).
2. Wider, business benefits:
   a. 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.
   b. 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.

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

The author recommends 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.

The figures below give practical examples of a GIS (GE Energy's Smallworld Design Manager[4] in this example) with an embedded network analysis engine.

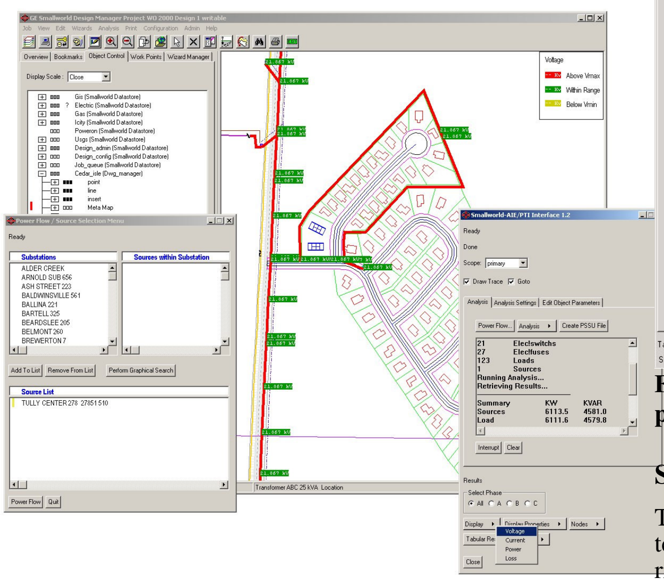

Figure 1 GIS User Interface to Network Analysis Tools

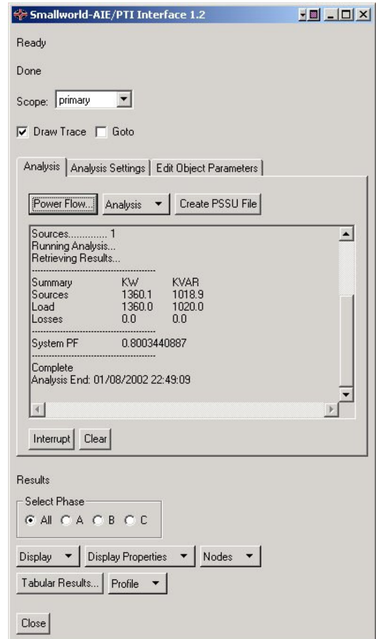

Figure 2 Full access to analysis modes is provided via an interface window

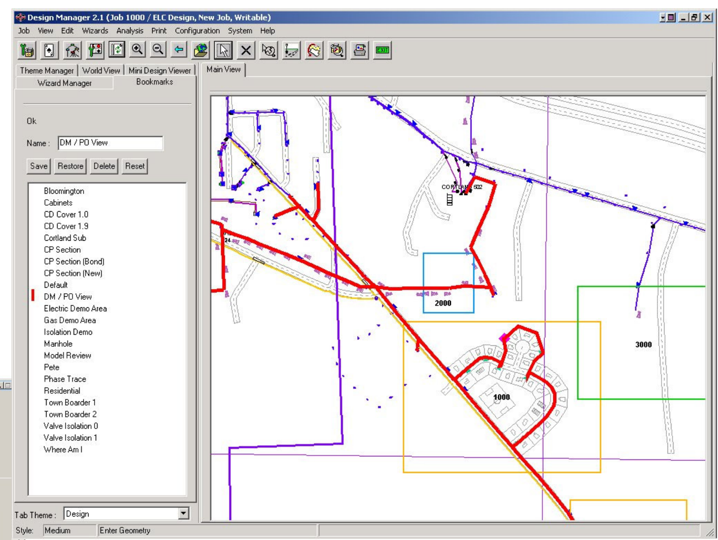

Figure 3 GIS User interface showing overlapping projects and scope of analysis

SUMMARY

This paper is intended to encourage the use of GIS technologies where they are capable of providing a feature-rich environment for skilled engineering staff. The benefits described in this paper are based on practical experience of a recently planned installation at a major European utility. The author recommends a similar approach to other utilities where the benefits may be different in detail but will remain significant and in excess of the costs of implementation.

REFERENCES

[1] Transmission Price controls and BETTA statutory licence consultation, OFGEM, February 2005
[2] Transmission Price Control Review, Initial Consultation, OFGEM, July 2005
[3] OFGEM letter on Transmission Investment for renewable generation, October 2005
[4] Trademarks of General Electric Company