

SUPERGEN FUTURENET AND FLEXNET

Cliff Walton
FlexNet UK
cliff.walton@ppaenergy.co.uk

Tim Green
FlexNet UK
t.green@imperial.ac.uk

Tony Woods
FlexNet UK
tony.woods@ppaenergy.co.uk

ABSTRACT

The paper outlines the work and conclusions of the four year Supergen FutureNet consortium of eight UK universities and many industrial sponsors that concluded in summer 2007. It then sets out the research program and objectives of the follow-on four year £7m FlexNet consortium and its implications for Smart Grids.

INTRODUCTION

Proper planning and operation of the electricity network is vital for integrating sustainable energy technologies with the dependable services society desires. The Supergen FutureNet consortium was established in 2003 to research the future form of the electricity network. The challenge that faced the consortium was very significant: it encompassed the search for engineering solutions to the technical problems of a high reliance on renewable energy resources, the development of economic ideas that support renewable energy, analysis of the social acceptability of engineering solutions and the exploration of scenarios for the far future of the electrical energy system. The interdependences of the challenges and the interdisciplinary nature of the work call for flexibility, imagination and careful co-ordination of effort from the many contributors.

After the four-year first-phase, the consortium has been renewed as **FlexNet**. The key challenge identified is how a network can be evolved that is flexible enough to cope with changes in the scale, technology and geographic location of generation which can not be foreseen in detail whilst being based on assets with service lifetimes of several decades. The flexibility may cover major increases in bulk renewables to support electric vehicles and low carbon buildings.

FutureNet

FutureNet is a consortium of universities researching Future Network Technologies able to support a sustainable energy policy for the UK.

A sustainable low carbon pattern of energy use requires:

- renewable sources of energy
- efficient means of harvesting that energy
- efficient and secure means of transmission and distribution

- efficient end use and
- a regulatory and market framework that encourages the sought-after behaviour of businesses and people.

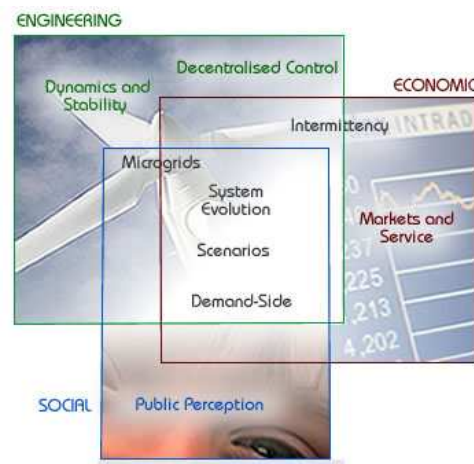
FutureNet concentrates on one specific aspect: an electrical power network that supports and encourages renewable energy sources while providing the standards of service that customers expect.

Our challenge has been two fold:

- to devise and construct an electrical system able to cope with the future and to do so at a cost that does not jeopardise the overall objectives and
- to devise a form of regulation and market that encourages customers, wholesalers, generators and system operators to behave in a way that promotes sustainable energy use

Interdisciplinary Research

The programme has brought together researchers from a wide variety of backgrounds, institutions and disciplines and the interaction between those that may not otherwise have engaged has produced some surprising insights.



FutureNet Achievements

Scenarios - four scenarios for the GB power system in 2020 and six for 2050 have been constructed and the key technologies required for the future identified

Dynamics and Stability of Renewable Energy Sources - models of large wind turbines have been developed and used to investigate the difference in behaviour from conventional generation

Intermittency Issues - investigations carried out include wind energy resource modelling, short term wind speed prediction, the role of energy storage, and transmission system impacts

Decentralised Control – an approach has been developed for multi-agent based emergency control and for coordinated voltage control making the best use of available resources in a decentralised power system

Demand-Side Participation – areas progressed include domestic consumers and load control and time-of-use tariffs, a technique to quantify the benefits of demand-side participation for industrial consumers, a model of domestic electricity consumption, and incorporating demand-side control in a software package

Microgrids - two experimental test facilities have been developed: one has been used to demonstrate how de- and re-synchronisation can be achieved, the other to explore dynamic stability. Means of fault detection and protection suited to microgrids have been proposed

Public Perceptions - ideas have been developed and empirical research conducted along several key strands: public participation and the concept of 'energy citizenship', public awareness, understanding and acceptance, such as the case-study of hydrogen for storage of renewable electricity on Unst, Shetland Islands

System Evolution – a computational general equilibrium model of the UK economy has been built, and is being integrated with a detailed electricity sector model

Market Design and Service Valuation - models were used to assess market designs for transmission contracts. Other work includes short-term markets and intermittent generation and an investment planning model combining wind output volatility, transmission constraints, and investment decisions

FutureNet concentrated on electrical power networks able to support and encourage renewable energy sources while providing the standards of service that customers expect. Specifically the aim was to devise and construct electrical systems able to cope with the future and to do so at an acceptable cost, and to devise forms of regulation and

market that encourages customers, wholesalers, generators and system operators to behave in a way that promotes sustainable energy use

The work of **FutureNet** is now complete and details of the many achievements and extensive range of publications and resources are available via the group's website at www.futurenet.org.uk and in the books that have been published as part of the programme

FlexNet



FlexNet continues the research agenda initiated by **FutureNet** focusing on developing and showcasing flexible networks for a further four years commencing in October 2007.

FlexNet builds on the achievements of **FutureNet** and lays out the major steps - technical, economic, market design, public acceptance and others - that will lead to flexible networks, including starting to showcase these so that they can be taken up by the commercial sector, government and regulators for practical implementation.

The **FlexNet** work-streams include

- » Future Energy Mix
- » Shape & Size of the Network
- » Power System Electronics
- » Smart, Flexible Controls
- » Customers, Citizens and Loads
- » Markets and Investments
- » Future LV Networks
- » Validation and Showcase
- » Deliberative Engagement

FutureNet provided inputs to the UK government's Energy Review, the UKERC assessment of Intermittency, evidence to select committees of parliament and submissions to consultations by the UK regulator Ofgem and **FlexNet** will continue this service.

At the heart of **FlexNet** is a research programme to underpin a major change in the design and operating philosophy of networks. The analysis and verification studies that are underpinning this will be published in

leading academic journals and showcased to a wide range of industry and other stakeholders.

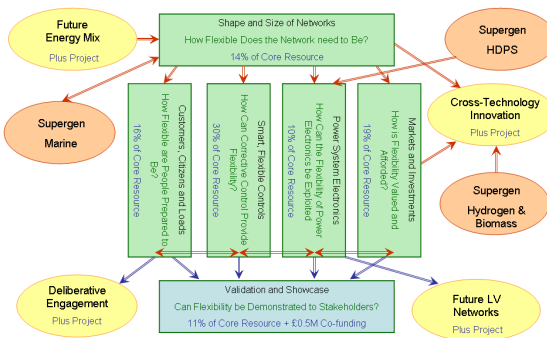
FlexNet Beginnings

The consortium’s new group of research staff are just beginning their work at a time when the electricity network is at a crucial stage in its history. Many of the assets fall due for replacement soon after decades of use and their replacements must last perhaps forty years. The future patterns of generation and use of electricity are so uncertain that the replacements must be very flexible and adaptable. Most of that flexibility must come from new approaches to network control but there will also be a role for new equipment. Among the crucial questions to be addressed are:

- what control is needed?
- how will the investment in the new network be initiated?
- how will investment in future flexibility be initiated in time?
- how will people react to proposed changes in the technology, location and service quality?

An important focus of the **FlexNet** programme is to devise approaches which will improve the ability of networks to be flexible in the face of a wide number and range of uncertain future scenarios.

The diagram below shows the structure of the **FlexNet** programme:-



The FlexNet Team

FlexNet consists of a consortium of nine universities as shown below. In addition there are a number of industrial sponsors (also shown below) who are providing both material support and direct input and guidance



The Future and FlexNet teams have

- published many hundreds of papers and journal articles,
- produced books and book chapters
- presented at a large number of events around the world and jointly arranged conferences and seminars such as “Thinking Networks” and “International Interconnections” to name but two.

Further information and access to published papers, presentations and videocasts are available via the consortium websites

www.Futurenet.org.uk
www.flexnet.org.uk

Skills

The achievement of many of the changes in networks necessary to support a low carbon infrastructure will be significantly dependent on the availability of highly-skilled and experienced individuals. **FutureNet** and **FlexNet** are making a significant contribution to the pool of such individuals by

- the large number of PhD students whose research is being supported by the programmes
- the support provided to both senior and more junior academics to improve their understanding within their particular specialisms.

Links to SmartGrids

The name **FlexNet** provides linkage to the first **FutureNet** programme whilst recognising the distinctive aspects of the work now to be done, and '**Thinking Networks**' strapline emphasises the consortium's intention to both 'think about networks', and to develop networks that can 'think' for themselves.

The work undertaken by the **FlexNet** and **FutureNet** programmes will contribute to the development of **SmartGrids** in many ways.

In particular

- technically, by devising practical innovations approaches and systems that will aid the establishment and future operation and control of electrical transmission and distribution systems
- by outlining market structures and methods of operation, together with appropriate regulatory frameworks that will incentivise efficient investment and ongoing management of networks and other related aspects
- by deepening the understanding of how people respond to the need for infrastructure investment brought about by policies to encourage a low carbon approach

Acknowledgments

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