

## White Paper

# Smart Grid – From System Trials to ‘Business as Usual’

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*Future Networks and Policy at Scottish & Southern Energy Power Distribution are researching new systems and building foundations for Smart Grid Networks.*

*This paper tells of a journey based on a vision to introduce more formal modelling methods using an IT practice to allow the company to deliver business-driven end-to-end solutions that meet business needs.*

## A Vision

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Our journey begins with an *understanding* and a *vision*. The *understanding* – that as well as harnessing tried and tested technologies, smart grid solutions introduce significant new complexity and necessitate business change. The *vision* – that more formal modelling methods are essential to address these new challenges and achieve an effective business implementation.

Smart Grid projects require a different approach to cope with complexity. These projects typically involve a range of stakeholders from across different business departments; multiple hardware and software components; and multiple third party partners and suppliers. In addition, there are often critical delivery dates to be met which requires parallel development.

All of this demands a way of defining a common view of the project that can be shared by multiple parties at the same time. This allows them to gain an accurate and holistic understanding of the requirements and integration points and to communicate and share their ideas effectively.

The Future Networks project team recognised the potential benefits of introducing modelling techniques to capture an understanding of the project scope and clearly communicate business requirements as well as proposed technical solutions.

*“Our challenge is to create a common viewpoint for research projects. Using formal methods allows us to create tradable information in the form of graphical models so that people can gain a common understanding of what the project is trying to achieve. It is smart working for a smart grid future”*

**– Ian Freeman, Systems Architect, Scottish & Southern Energy Power Distribution (SSEPD)**

This paper documents the development of the practice. This starts with the use of the initial approach on Low Carbon Network Funded (LCNF) projects to the full development of the process for the Northern Isles New Energy Solution (NINES) and Orkney Active Network Management.

## The Smart Storage Heating Trial

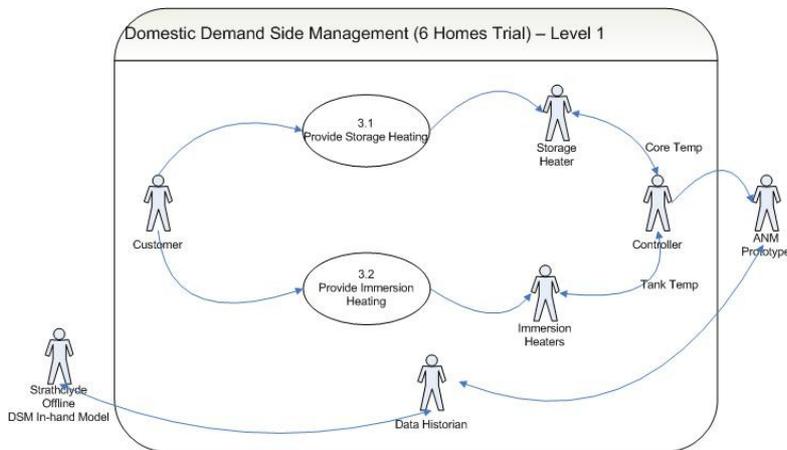
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The trial commenced in August 2010. This is a research project to install new controllable heating and hot water tanks in six homes on the Shetland Islands. These are controlled and monitored to collect and analyse usage data.

This project is a precursor to a larger scale domestic demand side management solution. These devices help balance the network by storing energy which can be provided by local new renewable generators. This technology extended to a larger number of homes can offer a means of allowing more renewables on the Shetland network.



The Future Networks project team needed to define the scope of the project and to capture the business requirements. To achieve this they created a use case model. Use case models are part of the Unified Modelling Language (UML) – a technique now very commonly used on software development projects to capture and communicate functional requirements in a business-oriented and modular fashion. The team believed that this technique could be of equal value when applied to power systems projects.



The team identified the roles of key stakeholders who needed to interact with the six homes trial. These are shown on the use case diagram as stick people (and known as ‘actors’).

They then identified the business goals, expressing these in business terminology from the point of view of each actor. On the use case diagram these are shown as ovals connected to the relevant actor with a communication line.

A description was written for each use case explaining the scenario and interaction between the actors and the six homes. The resulting use case model was found to offer an excellent way for the team to share the nature and scope of the project with senior management, other internal departments and external partners.

## The NaS Battery Pilot Project

The Future Networks project team now realised the potential benefits of this model-driven approach and were determined to extend and develop these techniques on a larger pilot project. In November 2010 the NaS Battery project was chosen.

This project introduced a battery storage management system at Lerwick Power Station on the Shetland Islands. Initially shift supervisors would use local control software to manually schedule the battery’s charge status, and then monitor battery operation in the existing SCADA control system at the Power Station.



Use case models were used to great effect during the initial stages of this project, and a solutions architecture diagram was constructed.

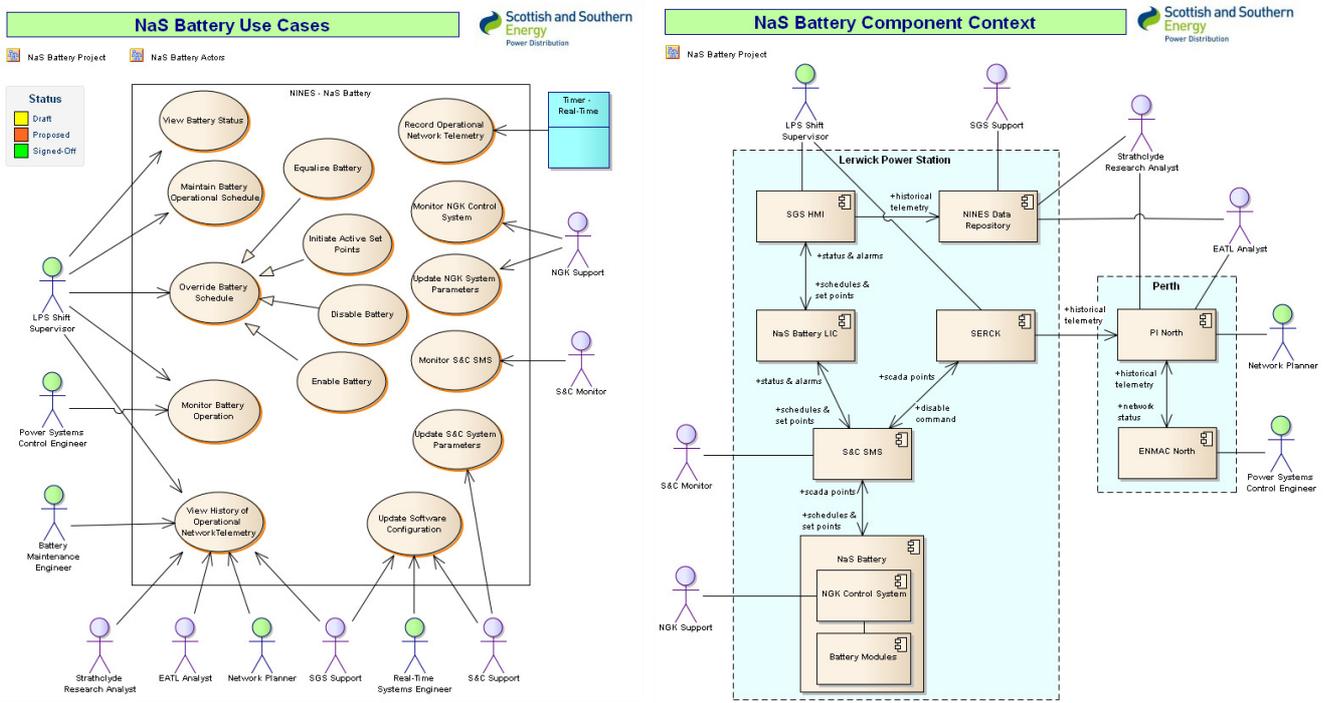
In July 2011 Hippo Software joined the team to mentor team members in the wider use of industry standards including the Unified Modelling Language (UML) and Business Process Modelling Notation (BPMN). A Hippo Software consultant worked alongside SSE to extend the use of graphical modelling and to practically demonstrate the potential business benefits.

SSE recognised that they needed more than just a drawing tool to facilitate the creation, storage and dissemination of their models. They reviewed the market, drew experience from other industry sectors and identified Enterprise Architect from Sparx Systems as the best solution. Enterprise Architect supports UML and BPMN and is widely used in the software development industry. The challenge was to apply these techniques to a power systems engineering discipline and prove that these models could be of equal value to the power distribution industry.

*“It was important to find a tool which is easy to use, cost-effective and also meets our wider business and systems architecture objectives”*

– **Henrik Magnusson, Solutions Architect, SSEPD**

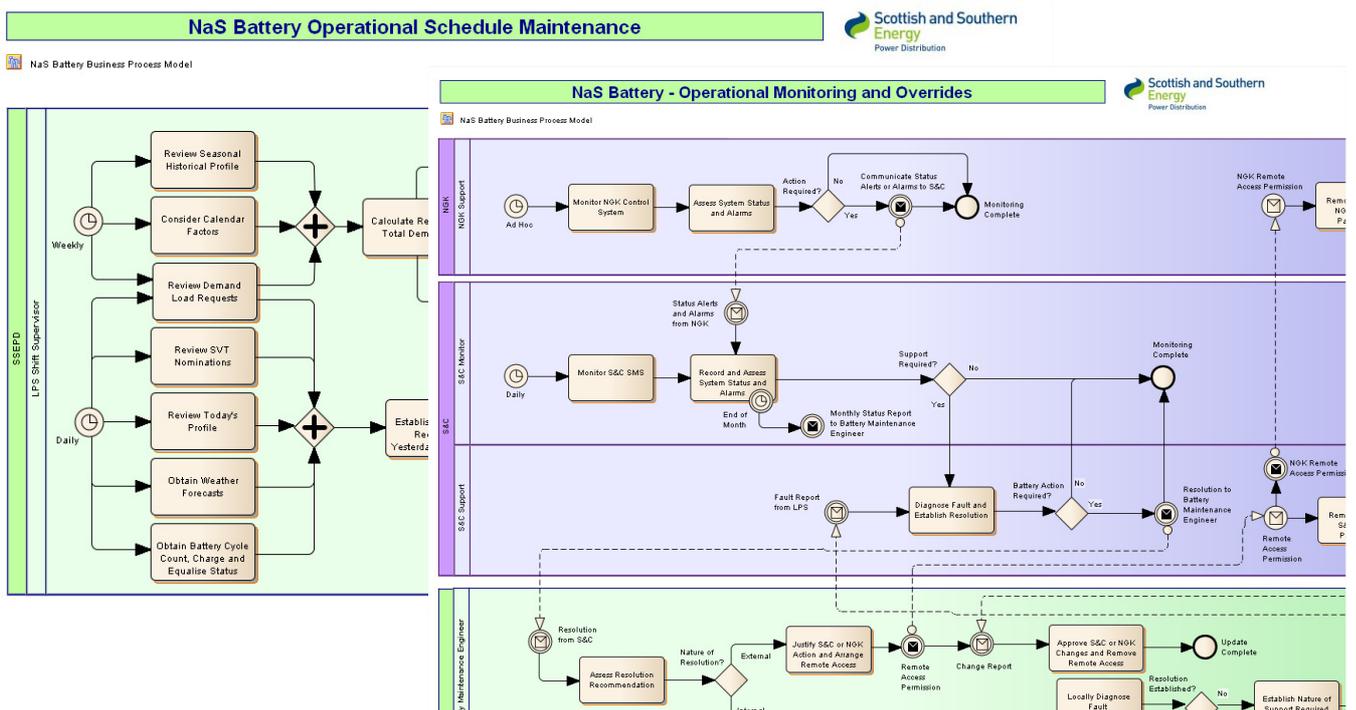
The NaS Battery project team developed and refined their use case model and produced a component context diagram to communicate the hardware and software elements of the system and how stakeholders would interact with different parts of the system. Internal SSE stakeholders are colour-coded in corporate green and blue while external third party partners are colour-coded purple to differentiate. With any project involving so many different parties (internal and external) it is extremely important to use models to understand the roles and responsibilities of each and how they can interact effectively.



*“The formal methods and models helped turn our ideas into a systems design and operational practice. It enabled us to show what we wanted and how we expected to operate the system. Being able to visualise this early in the project created the opportunity to share views with business operators, ensuring common goals and a clear view of what was required for delivery”*

– Gary Milne, Project Manager, SSEPD

The team then started to think about how the business would own and operate this technology. They created business process diagrams using BPMN to show the responsibilities of the various parties involved and highlight key decision points within each business process.



The challenge was to produce models that could explain to the engineers on the ground at Lerwick Power Station how they would operate and maintain the NaS Battery alongside their already full-time and demanding job of running the engine sets in the Power Station.

The BPMN diagrams were initially created on whiteboards at a workshop in Perth, entered into Enterprise Architect and then taken to Lerwick for a walkthrough with the management team at the Lerwick Power Station. During the walkthrough each step in the process was discussed and helpful detail added to the models. Also a better understanding of how this new technology would fit within existing best practices at the Power Station was gained and this was again reflected in the models.

These walkthroughs provided an excellent medium for communication of ideas and real business practice – enabling the NaS Battery team to better understand the reality of the operations at the Power Station and the Power Station engineers to appreciate the opportunity to potentially increase renewable energy on Shetland by use of a battery energy storage technology.

*“For projects that impact our business, business process models like these provide one of the best techniques I have come across for communicating how we need to develop the operation. We found these very similar to flowchart diagrams that we have used previously in engineering process diagrams”*

– **Darren Hitchin, Operations Manager, Lerwick Power Station**

## **An Emerging Plan**

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As a consequence of the success with the NaS Battery project, the Future Networks team was reassured that their vision was correct. This gave them the confidence to apply these same modelling techniques to the rest of the Northern Isles New Energy Solutions (NINES) programme. The challenge was to meet the timescales. The programme was already underway and working to extremely tight deadlines.

The team understood the potential benefits of this modelling approach and in December 2011 they organised a management briefing session. Hippo Software delivered an Enterprise Architect management overview and the Future Networks project team shared the models developed for the NaS Battery pilot project with senior management on the NINES programme as well as partner companies. At the conclusion of this session, the consensus of opinion was that this graphical modelling approach was to be a key deliverable for all Future Network programmes and projects.

*“A major feature of our smart grid development work is taking practical solutions from other industries and applying them to our own. These types of models are new to our industry, but well-proven elsewhere – it’s a perfect example of how effective that approach can be. These types of graphical models should be a feature of all our R&D projects.”*

– **Stewart Reid, Future Networks and Policy Manager, SSEPD**

## **The NINES Programme**

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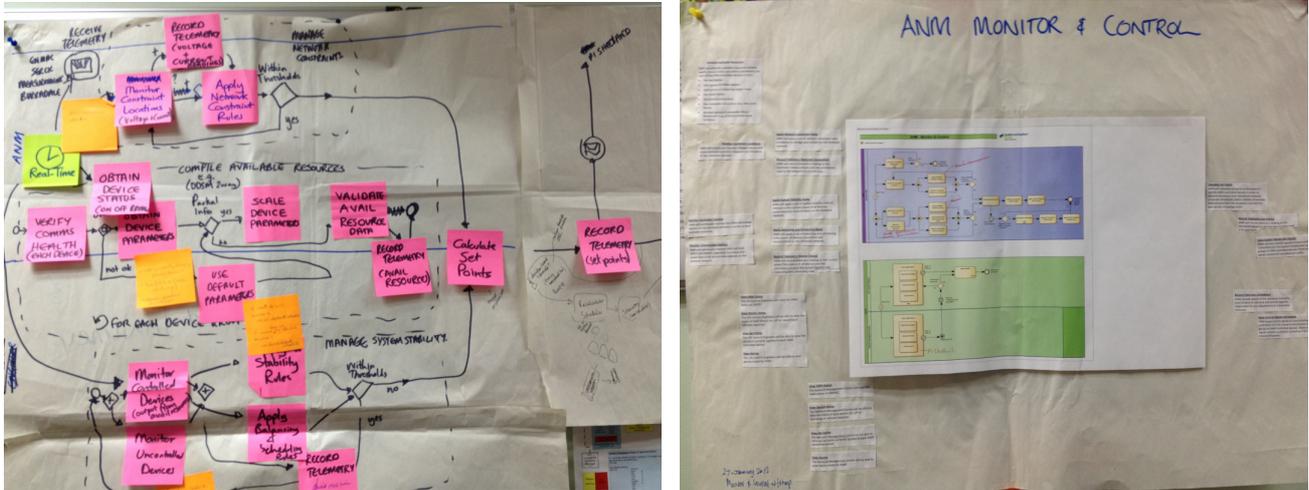
The NINES programme is aimed at informing the design of the replacement of Shetland’s 50 year old power station. This comprises three projects – stage two of the NaS Battery project, the Domestic Demand Side Management (DDSM) project and the Shetland Active Network Management (ANM) project. The success of the modelling for the NaS Battery pilot paved the way to applying UML and BPMN modelling techniques to the other larger and more complex projects within NINES.

At this stage Hippo Software helped SSE to set up and structure a central Enterprise Architect repository to store models for all SSEPD programmes and projects. Guidelines were documented to encourage consistency and quality across all projects in terms of the project structure and navigation as well as the set of project models.

The Future Networks project team recognised the opportunity for reuse and established central catalogues of business roles and components to allow these model elements to be reused across all SSEPD programmes and projects. The team established the role of Enterprise Architect Design Authority to monitor and maintain these catalogues. As new roles or components are added to individual projects they are reviewed by the Enterprise Architect Design Authority and promoted into the central catalogues.

A highly interactive approach was taken for the NINES projects. Initially a use case workshop was held with senior managers and key personnel to define the objectives and construct use case diagrams to scope the DDSM and Shetland ANM projects.

Top level business processes were identified. For each business process, a discovery workshop took place using flip chart paper, post-it notes and marker pens to provide a creative and dynamic environment. This workshop involved key personnel from SSE as well as partner companies and resulted in BPMN diagrams that could be more formally modelled by business analysts within Enterprise Architect.

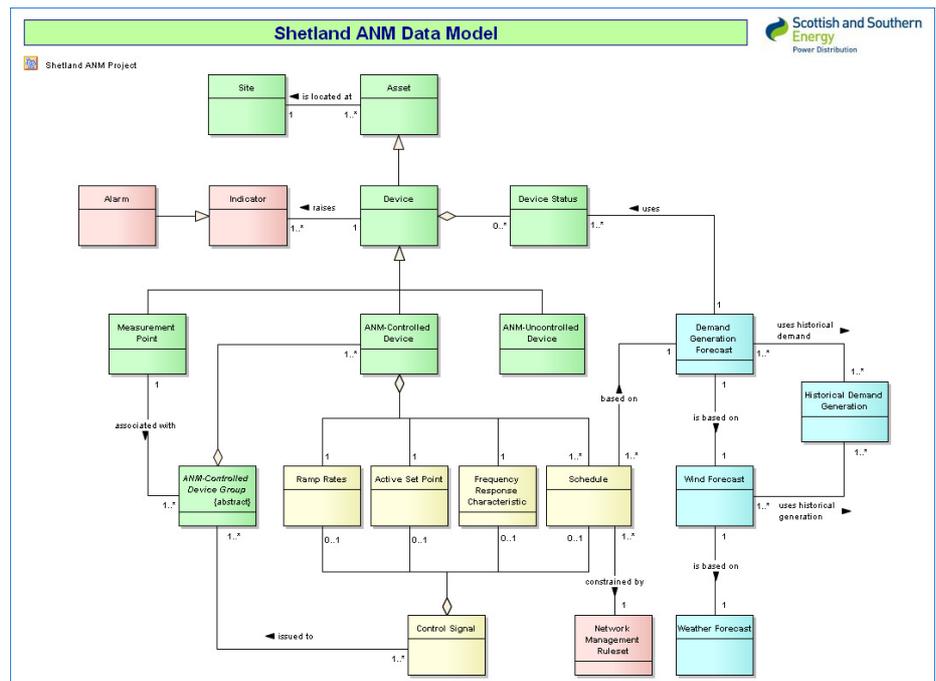


Models were printed and used as the basis of a follow-on business-oriented workshop. Business stakeholders were invited to attend the second workshop where a walkthrough of the use case model and business process diagrams gave them the opportunity to review and validate the models, debate responsibilities and identify missing or inaccurate steps in the business process.

The cycle was agile and intense with a new business process for DDSM, and then Shetland ANM examined and delivered every week for a period of about 8 weeks. This culminated in a visit to Shetland to obtain invaluable feedback and refinements from the engineers based at Lerwick Power Station.

Models in Enterprise Architect (use case, component, business process and requirements) were updated to reflect feedback from the business and a formal requirements document was generated directly from Enterprise Architect using SSE developed Rich Text Format templates.

In addition to understanding the functionality and business processes, it became apparent that the flow of data between the various control systems was critical to the operational business. In order to understand the nature and lifecycle of the data, simple UML class diagrams were produced showing the types of data entities, their key attributes and their relationships. This was supported by a cross-reference between these data classes and the logical hardware and software components.



## The Orkney RPZ ANM Project

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The Orkney Registered Power Zone (RPZ) Active Network Management (ANM) system is existing technology deployed on Orkney to monitor real-time network measurements of current, and where necessary, constrain generation on the island to maintain secure network operation. The scheme allows new renewable generation to be connected to the Orkney network.

The decision was taken to use UML and BPMN models for knowledge capture. This provides clear and succinct documentation that allows SSEPD to clearly understand the existing technical solution in order to migrate the project from research into 'business as usual'. These models are allowing the management team to consider their options for extending and enhancing the existing technology on Orkney.

*"The same techniques that were applied to the NINES programme have helped us to accurately document and clearly communicate the existing technologies in use on Orkney. This is important as it will inform strategic decisions about the future direction of the Orkney programme"*

– David MacLeman, Research and Development Manager, SSEPD

## A Reality

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The advantage of a modelling approach is that it provides a better understanding of what Smart Grid solutions need to do and how they will be used in practice by the business. They expose issues and areas of concern early and allow management to address and resolve these ahead of implementation. Furthermore these modelling techniques encourage and support team working, allowing SSEPD to work collaboratively alongside its partners and suppliers.

Future Networks teams at SSEPD no longer communicate in one dimensional text, but in multi-dimensional models of systems. These models work in a number of planes – they are visual which enables the 'big picture' to be easily and quickly assimilated; they are interrelated which means that it is easy to connect from one idea to another through views which provide just the right level of information; and they support an end to end definition of the system starting with a business scenario and ending with a finished systems design and business process implementation.

With these techniques and a repeatable and rigorous analysis and design process, SSEPD is now much better placed to understand business needs and assess the impact of business change. These formal modelling techniques have proven extremely valuable for formulating and scoping new projects, defining solutions for implementation and capturing, documenting and communicating existing business knowledge.

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*Ian has nearly 30 years experience in systems development and design, both in real-time and application systems development. Use of formal methods has been a key element in many of the development projects that he has undertaken. In the last few years he has been the Systems Architect for SSE's Smart Grid Research and Development programme.*

### Gillian Adens

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*Gillian was one of the first people in the UK to specialise in object technology and is considered an expert in UML, BPMN and Enterprise Architect. She is a consultant with considerable project management experience and assists customers with the adoption of processes, tools and technologies.*

Glossary:

ANM – Active Network Management

BPMN – Business Process Model Notation

DDSM – Domestic Demand Side Management

UML - Unified Modelling Language

LCNF – Low Carbon Network Funding

NINES – Northern Isles New Energy System

SCADA – Supervisory Control And Data Acquisition