DGCG 3/05

TECHNICAL ARCHITECTURE
– A FIRST REPORT

The Way Ahead

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On behalf of: IEE Power Systems and Equipment Professional Network

Sponsored by: DTI/Ofgem - Distributed Generation Coordination Group

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Technical Architecture Report

The Distributed Generation Co-ordination Group (DGCG), a DTI/Ofgem co-chaired industry group, commissioned IEE Power Systems and Equipment Professional Network to produce a report on the future of our electricity networks. Scenarios addressing the Government's Energy White Paper's renewables targets, as well as the need to re-wire Britain and connect more distributed generation, are discussed.

The following report is a thorough look at future scenarios. It covers a great deal of ground. Perhaps inevitably, at times the report asks more questions than it answers.

It is acknowledged that we are in a time of transition. We do not propose to produce a response to this report. We see this as a piece of work which can engage all stakeholders in the future challenges: Government, Regulator, industry and consumers. The responsibility to deliver is a shared one.

The report will not sit idle. The DGCG successor body, the Electricity Networks Strategy Group, are committed to using the report as a key reference as they develop workstreams to meet the future challenges our networks present.

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Revision History

Revision	Date	Comment
Draft 1.0	08/12/2004	Initial draft
Issue 1.0	24/12/2004	Issued to DGCG 26/01/05
Issue 1.1	08/03/2005	Collective comments from readership incorporated + updated Appendix 4 and addition Appendix 10
Issue 1.2	10/05/2005	Reference list expanded + minor updates to Appendix structure
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Foreword

Britain's electricity networks are extensive, mature and a key part of the infrastructure that supports today's society. These networks are moving from a period of stability to a time of great transition. This change is being driven by their need for age-related renewal on a large scale, and by the strong leads being shown by government to harness cleaner and renewable sources of electricity generation.

This sea change is a time of opportunity for businesses, the power sector, and for consumers. Considerable investment will be needed and this has been heralded in the price controls recently announced by Ofgem for the distribution network companies. Indeed, Ofgem have described the challenge as 'rewiring Britain'.

The Technical Architecture project was conceived from a need to build on much of the good work that has already been achieved in many separate activities so providing "joined up thinking" between them and extending the work done to date. Duplication or "reinventing the wheel" was to be avoided while innovative solutions were to be encouraged; thus a non-prescriptive framework for technical implementation would be developed that should recognise and encourage activities within the liberalised business environment.

In order to deliver innovative solutions it is necessary that many associated, yet diverse, activities are in place to facilitate successful implementation. It is the aim of this project to provide the best possible chance of success for innovative solutions that will enable the efficient and cost-effective development of the British distribution networks. This development must take into account the important considerations of health & safety and environmental impact.

The project work reported here has been very challenging in both its scope and its resourcing. To deliver meaningful results when confronted with such a wide remit is difficult at the best of times but to do so while the industry has been responding to a regulatory price review and progressing large-scale company re-organisations, it is testimony to the team that such good work has been achieved.

Without the dedicated and professional team of volunteers this project would have been impossible to deliver. I extend my thanks to everyone who contributed to this project, whether as a core team member or as a participant in one of the many successful public seminars held.

In a climate where there is a tendency to simplify activities into manageable silos, this project was both bold and imaginative and it is to the DGCG's credit that such a wide-ranging and visionary project was instigated.

Finally I would like to record my thanks to the many companies who have supported this effort in both time and resource, my own included. This report does not, of course, necessarily reflect the policies of individual companies.

I look forward to responding to the future challenges set out in this report.

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<u>The Technical Architecture Project Team</u>

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John Scott (IEE PN Exec, TSG & Ofgem)	Regulation and Business Environment
Phillip Cartwright (IEE PN Exec & Areva)	Future Scenarios
Mike Kay (TSG & UU)	Standards
Mike Lees (IEE PN Exec & EATL)	Asset Management Strategies and Skills
Frank Duffy (IEE & ENA)	Current Infrastructure
Dragana Popovic (ENA)	Automation Review
Alan Laird (IEE & SP)	Interface with TSG WS 5 activities
Prof. Nick Jenkins (TSG & Univ. of Manchester)	Future Loads and Generation
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David van Kesteren (IEE PN ExecYEDL/NEDL)	Stakeholders and Future Scenarios
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Bruce McLelland (IEE PN Exec & IEE)	Event Organiser and Team support

Executive Summary

Introduction

Since de-regulation the Electricity Supply Industry has undergone a metamorphic change both technically and commercially. The industry has become much more streamlined and, at the same time, more fragmented in its different approaches to solving the common challenges of an ever more demanding customer base, an ageing infrastructure and a rising preponderance of different forms of distributed generation.

The challenge going forward is to provide greater flexibility to allow distribution power networks of the future to deliver the demands that will be placed on them by future generations. To achieve this, the normal ambition of best practice and cost efficiency must be blended with technical innovation and sustainable strategies to allow the liberalised market to flourish and deliver the real promise of a lower carbon economy in an affordable, safe and environmentally acceptable manner.

This report sets out the steps that will be necessary to ensure the most appropriate use is made of our legacy infrastructure, the opportunities that innovative technological, commercial, regulatory and environmental solutions can offer and a framework that will allow these solutions to be delivered in a liberalised context. The report proposes the processes needed and offers recommendations to achieve this goal.

Project Remit

The remit of the project was intentionally very broad. The project was to analyse the current status of distribution networks, review possible future scenarios and to propose projects that would close any gaps identified. As a consequence of these broad aims and objectives, this project report focuses upon the tasks required to determine the potential requirements of future distribution networks. The outputs from each task will effectively enable key stakeholders to consistently plan the cost effective distribution networks of the future, incorporating innovative new technologies.

Project Process

In order to ensure an inclusive approach, members of the team were sought from every facet of the industry. The core team was organised with many of the key stakeholders represented[1]to ensure a coherent approach and one that could be supported by each of them.

Brainstorming workshops and open events provided a broad swathe of stakeholder and public opinion of the issues that face the industry, firstly with respect to the adoption of Distributed Generation and secondly the wider aspects of an ageing infrastructure and greater drive for energy efficiency and a low carbon economy.

The team asked the obvious question: **how strong is the need for an ongoing Technical Architecture project?** The views from the both the team and participants at the open events were clear, evidence was cited repeatedly to illustrate the lack of joined-up engineering thinking in many aspects of the industry. The project was not only needed but the vast majority of the participants at the second event wished to see details of the proposed future scenarios sooner rather than later.

The team adopted a thematic approach to the project to avoid the 'silo' mentality that had been identified in the workshops, and which currently affects the cross functionality that needs to be addressed (namely Government policy, regulatory frameworks, commercial structures, technical factors, etc.).

Each team member took responsibility for a thematic area to identify the key aspects and build a requirement specification to enable a contractor to deliver the component of work. Team peer review identified areas of common linkage between themes and ensured that coherent project proposals were developed.

The project team worked closely with other relevant bodies (such as DTI, Ofgem, ENA, Research Institutes, Manufacturers, Generator Representatives, Consultants, etc) to ensure joined up thinking was achieved across the many different industry sectors.

The proposed projects will result in the definition of a clearer technical architecture that maximise distribution network flexibility, reduced risk and increase the likelihood of successful delivery of innovation and thus meet the network challenges to 2020 and beyond.

This initial report is the output of the process thus far.

[1] A list of the team members, their role in the project and their affiliation is included in the TA Frequently Asked Questions fact sheet and is attached as Appendix 1

Key Recommendations

1. To ensure a co-ordinated approach, it is proposed that **a single entity is given responsibility** to be the focal point for developing future technical architectures. This entity would operate transparently and be responsible for identifying technical barriers, proposing holistic solutions and options for future distribution networks and their interfaces with generation and transmission networks. The remit of this group should be broad.

2. Subject to the agreement of the DGCG (or its successor body), it is envisaged that the new Distribution Committee might undertake this focal point role.

3. A number of projects have been identified, specified and requirements specifications written. These are attached as Appendices to this report and are summarised as follows:

    - **Automation for active networks**
    - **Future Network Scenarios**
    - **Stakeholder Liaison**
    - **Tools and Methodologies**
    - **Skills and Asset Management**
    - **Technical Standards**
    - **Regulation and Business Context**
    - **Procurement and Commercial**
    - **Global Scanning**
    - **Migration Options**

    These projects are closely inter-linked and many are mutually dependent to deliver the desired results in each of the thematic areas. It is therefore likely that these projects will need to be treated as a holistic package if the desired results are to be obtained.

4. **Project Outline Plan -**The projects identified within this report must be undertaken recognizing the inter-dependencies between them. This will require a degree of co-ordination. With the agreement of the DGCG (or its successor) the next step in the project will be to develop the project plan to take account of the revised organisation post DGCG.

5. **Project Resources -** Sufficiently skilled and knowledge individuals will need to be allocated to deliver the projects stated. This has been problematic from time to time in cross-sector projects and the issue is drawn to the attention of the DGCG and its successor as a potential risk to progress. Further, it is recommended that project programme management services continue to be contracted.

6. **Trading issues -** In due course, work will be needed to integrate the trading aspects of distributed generation that exports to the network, also the issues

of islanding and storage. These are not sufficiently well identified (or urgent in project terms) to propose specific projects at present.

Further clarification can be found in the Conclusions and Recommendations section of this report.

Benefits

There are a number of key benefits that have been identified resulting from the projects proposed:

- By providing a focal point for technical architecture of distribution networks of the future and by concurrently considering technical, regulatory, commercial and environmental issues it can be confidently expected that potential conflicts and barriers will be identified and resolved in an efficient and timely manner.
- The more structured approach proposed will facilitate joined up thinking which will reduce the potential for wasted effort and increase the likelihood of success, especially with more sophisticated technical solutions, such as automation, that require a high degree of coordination.
- The ability to adopt different forms of technology that depend on a ‘holistic’ view of the networks such as distributed generation, energy storage, demand side management and smart metering (among many others) will be considerably more manageable bringing more rapid delivery of results and the desired benefits for customers and other parties.
- Each stakeholder will have a clear understanding of the technical and commercial risks involved in the design, development, implementation and maintenance of technology adoption.

Important Observations

A number of important observations drawn from the body of the report, identified in the appendices or raised at public events are brought to the reader's attention:

1. The issue of **joined up thinking** has been confirmed from a number of different sources as an issue that could derail much of the good work that has been completed to date. This has led, in part, to re-enforce the recommendation to have **a focal point or single entity** to facilitate those interfaces.

> **Technical Architecture Aims**
>
> The goal of the TA project is to identify and propose network development strategies that will facilitate the efficient planning, connection and operation of:
>
> - current and future generation technologies;
> - static and responsive demand;
> - storage devices; and
> - network auxiliary plant and equipment,
>
> to ensure a cost effective and technically sound approach to delivery of Government low carbon energy generation policies.

2. The inability of anyone to forecast the future, especially out to 2050, with any accuracy or conviction identified the need for a pragmatic approach to which future possible scenarios where likely or appropriate. The proposed approach was developed to allow flexibility but not predicate the opportunity to 'tune' the solutions as events and changes occur. Therefore the parallel **'rolling project update'** is a method to achieve this. Two project streams are conceived, one to implement the first projects identified here in an 18 to 24 month time frame, while the second (and in parallel) evaluates the next 18 to 24 month projects beyond the first. In this way an adaptable road map to changing circumstances will still have continuity but also have the flexibility to change factored in.

> **Drivers for Technical Architecture**
>
> The principal drivers to be accommodated through this evolution are:
> 1. Distributed Energy Resources
> 2. Asset renewal
> 3. Liberalised market frameworks
> 4. Lower carbon energy systems
> 5. Efficient, cost effective solutions

3. By analysing the many different aspects of how the electricity industry is operating today and possible future scenarios, it is possible that a significant number of issues could emerge, which may not have immediate relevance but nevertheless **should be captured for future** usage. This could include the convergence of real-time and planning tool issues raised in the Tools and Methodologies Appendices.

4. As greater emphasis on **automated systems** is advanced the management of data and its associated configuration, validation, version control and other aspects will become an important factor along with the new skills to manage and maintain the data infrastructure in a power context.

5. **The availability of innovative network technology per se is not the primary issue to be addressed, the widespread adoption of it on the networks is however challenging both from an engineering and business perspective.** In order for new and emerging technologies to be adopted suitable commercial, regulatory, safety and environmental factors will have to be addressed to ensure the cost effective utilisation of the new developments.

6. In order to deliver the future networks beyond 2010 it is clear that access to suitably skilled personnel will be required. **The forecast demographics do not indicate we will have sufficient traditional and new skills to meet this requirement.** The added complexity of more active networks and increased intelligence will require particular attention to the skills sets and competencies of design, operational and maintenance staff. This will also have implications for outsourcing and support arrangements.

7. In the global context, **Technical Architecture is complementing work that is being progressed elsewhere,** most especially in the United States of America and Europe. Global companies and universities are engaged in many similar activities overseas and there is extensive collaboration in place to ensure the UK can take advantage of these developments.

Technical Architecture 'Ground Rules'

- Network development must be ADAPTIVE, recognizing a considerable bandwidth of UNCERTAINTY.
- Uncertainty will be ongoing, future-proofing has to be part of design
- Development must consider TECHNICAL issues jointly with SAFETY, ENVIRONMENTAL, COMMERCIAL & REGULATORY factors.
- Development should consider distribution and transmission factors, ensuring cross coupling of ideas and developments, and avoiding artificial divisions.
- Development should accommodate rapid prototyping and demonstration of new technology.
- Technology and products should benefit from international best practice and open sourcing.
- New technology, once proven, should be rolled-out rapidly to maximise benefits.
- Designs should seek simplicity; escalating or uncontrolled complexity is a potential risk.
- ENABLING TECHNOLOGIES can be identified for generic development: for example
  - voltage control, including SVC, - fault level control, - flow control devices, - islanding capability, - ancillary services capability, - storage, - demand side management, - DMS, EMS & RTU, - power electronics, - communications
- Migration paths should recognise the potential for eventual islanding capability.

The Issues

Background

In January 2004 a paper entitled "Technical Architecture – A framework for tomorrow's networks" was presented to the Distributed Generation Coordinating Group (DGCG)[2]. The paper was based on analysis from an earlier seminar in November 2003[3] where the largest identified barrier to Distributed Generation (DG) being adopted in large scale was the "lack of joined up thinking" in the industry.

The DGCG asked the Technical Steering Group (TSG) to investigate the options for addressing the issues raised in the Technical Architecture (TA) paper. As the TSG was heavily committed with short to medium term deliverables, the piece of work required was to taker a longer term view, it was decided to ask the IEE Power Systems & Equipment Professional Network (PN) to lead the project and form a team to investigate and conclude the best course of action.

The remit given to the team was simple yet broad:

- To review the possible future states, or visions, for distribution networks to 2020 and beyond
- To identify the gap between those future states and the present situation
- Make proposals for work packages that would close the gap.

A project team and leadership was identified in March 2004 and commenced by scoping what was effectively a "plan for a plan". The team was drawn from across the Industry: academics, manufacturers, consultants, Distribution Network Operators (DNO), and generators including representatives of micro-generation and CHP.

Brainstorming sessions allowed a distillation of the issues to be identified. As the original TA paper and November seminar identified a lack of coordination and joined up thinking as a key barrier, the team adopted a cross functional approach to avoid unduly narrow analysis within specific 'silos'. The team also arranged events and a dedicated website to ensure the widest possible engagement with the Industry to garner stakeholder views and concerns.

[2] Attached as Appendix 2
[3] IEE event "Greener Generation – Delivering the Technology" held on the 4th November 2003 at the IMechE, One Birdcage Walk, London.

Current status

It is impossible to build a plan without a beginning, middle and an end. This project has only one certainty to which its plan can be anchored and that is the current infrastructures in use today among the fourteen distribution network licensees. The networks include a diverse product, solution, operation and maintenance base which brings an added dimension to the complexity.

Before privatisation the Electricity Council, comprising the Central Electricity Generating Board (CEGB) and Area Boards, provided the direction for the technical architecture and standards to be adopted on the networks. Interfaces between the various connection points, generation, transmission and distribution were clearly defined by a single authority.

Since privatisation the challenge for the liberalised market has been to agree interfaces, standards and operation and maintenance strategies in a much more dynamic and less regimented manner. Many have taken different paths for local reasons and drivers. Combine this with the ever increasing pressure to increase efficiency and productivity with fewer people; the ageing network infrastructure, the globalisation of products, the investment profile in research and development over the period, the growing distributed generation issue at various voltage levels and the issues this raises, etc.

It has become abundantly clear that unless a common framework for future network design is adopted, the chance of being able to integrate in a cost efficient, safe and reliable way, many of the enabling technologies to allow future flexibility could be severely limited and, at worst, be excluded from the UK. This will not only damage our competitiveness as a country but will reduce our ability to take advantage of innovative solutions in the future.

The issues we face in the UK are not unique but are at the leading edge in many of the regulatory, trading and environmental aspects that result in a different challenge to those overseas. The project therefore was concerned not to duplicate work or “re-invent the wheel” that had already been completed elsewhere but, instead, could be evaluated and where appropriate deployed in our solution portfolio and built on. To ensure this was monitored the team engaged continuously with the relevant European, Asian and US activities.

The work being implemented by the various DGCG TSG Work Streams (WS) and particularly WS 5 (this group were tasked with delivering the short to medium term solutions for the distribution network up to 2010) would have a major impact on the TA project in terms of the equipment and solutions that would be deployed in the next five years. This equipment may have a life expectancy of 40 years or more that may be only just be installed by 2010. It was imperative that the two teams had a close working relationship to avoid costly disjoints in the strategy going forward.

A common task was identified to understand the as-built infrastructure, particularly with respect to the light current solutions. The WS 5 work would identify what was already in place and specifically look to see what solutions could be adopted for

Active Network Management before 2010. While the TA project would build on this task and consider the wider issues of new technology and requirements the possible/most likely future scenarios would demand of Active Network Management. E.g. energy storage, demand side management (DSM), smart metering, etc.

A review to understand the different stakeholders involved today and their particular drivers, constraints and strategies was identified as another piece of important work. These groups would hold the key to ensuring any recommendations made were adopted as a commercial reality.

As well as understanding the asset base, the project also identified the need to understand the skill base required for the future scenarios as this would have to be implemented in parallel to ensure sufficient numbers of skilled staff to design, implement and maintain the new network technologies were available at the appropriate time[4].

[4] This was also outlined at the DTI/ENA workshop held on 7th December 2004 at the DTI offices at Victoria.

The Future Vision

It would be unrealistic to second-guess the possible demands and the possible solutions that may be available as far ahead as 2050. The large investment and slow life-cycle nature of power networks combined with the uncertain external constraints placed upon it indicate that an innovative approach to forecasting and to developing options for framework designs is required.

The technical direction of the industry could be compared to a super tanker and the very large turning circle that is required by such a vessel. To allow the power networks to be flexible in the future it will be necessary to introduce a degree of agility in the design process such that the "direction" may be influenced at early and formative stages such that huge cost or risk to the stakeholders can be avoided.

Technical Architecture is about the move from:

A Centralised Plant Model	to	**An Active Networks Model**
▪ typically centrally planned		▪ typically liberalised market
▪ large scale generation to utilise Economies of Scale		▪ smaller-scale generation
▪ long transmission lines		▪ generation at all voltage levels, transmission and distribution
▪ passive Distribution networks		▪ on-site generation
▪ little or no distributed generation		▪ grid-friendly demand (DSM)
		▪ active/intelligent distribution networks

Characteristics of the Transition Process

▪ no Blue Prints	▪ co-operative working across sector
▪ no sure winners	▪ gov't & regulators facilitate, not direct
▪ many incremental changes	▪ public/private partnerships
▪ some breakthrough changes	▪ organic and adaptive processes

In looking at the possible future scenarios, of which there are many, it would seem obvious to look for the common or "generic" solutions that will be required to deliver any of them and to schedule these as the first steps in the evolution of a plan. These projects could be identified and implemented over, say, a two-year period.

In parallel it would be astute to evaluate and propose other projects which define the future two years of work beyond that outlined above, thus allowing a form of rolling process to take account of changing circumstances and new technologies. This strategic approach to integrated design principles reduces risk to all parties while moving the whole of the UK power industry in a common direction. Benefits exist to the whole supply chain if these principles are encapsulated in the various industry codes, standards and operating principles.

The role played by the non-technical aspects, regulatory, health & safety, environmental, commercial, etc cannot be over stated. These elements will in most cases dictate the success or failure of any given “innovative technical solution” to either be adopted or commercially viable. The mechanism for providing a flexible resolution to these issues must be adopted. The projects should identify not only the technical barriers to adoption but also any non-technical barriers such that early decisions can be made as to the most appropriate resolution, either changing the non-technical environment policy or rules or identifying the cost to achieve the same result with existing frameworks in place. In this way a transparency will be established to allow informed decisions to be made. E.g. Regulatory cycles influence the planning horizons of many Distribution Network Operators (DNO) from what used to be 40 years plus to, in some instances, 5 or less years.

Technologies that have hitherto not been widely used or implemented will play a part in the future, such as Demand Side Management (DSM), Energy Storage, Wave, Tidal and Solar generation. There will be further developments in new technology to deliver the promise of Fuel Cells, super-conducting materials and nano-technology in many forms. If these technologies are to be economically harnessed a technical architecture will have to balance the competing needs of each of these technologies and provide common interfaces to ensure volume can provide the scale of economy desired.

In order to meet the 60% reduction in carbon emissions by 2050[5] the need to control losses and improve energy efficiency will need to be factored into the power network architecture along with innovative uses of technologies such as ResponsiveLoad[6] that could become part of the white goods market.

The future migration plan begins now. Every piece of new equipment placed on the power network will become either a problem or part of a solution to the future architectural issues. It is therefore essential that the projects outlined in the recommendations be implemented without unnecessary delay to avoid expensive mistakes being compounded. A guide to the process to be adopted for migration is the subject of one of the proposed projects.

The ability to bring innovation to the electricity market in terms of real-time trading to deal with such issues, as islanding and support services will again require power networks to be developed in a coherent manner.

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[5] As outlined in the DTI white paper “Our Energy Future – creating a low carbon economy” [1]
[6] ResponsiveLoad is a technology to help stabilise electricity distribution grids [2]

Conclusions and Recommendations

The Technical Architecture project has focused on identifying the needs of customers of the future and providing an electricity distribution infrastructure with sufficient flexibility to deliver the future requirements in an economic, safe, reliable and environmentally friendly manner.

The role of each of the participants in the supply chain is changing; many of the DNOs are now reliant on academia and manufacturers for their expertise in design and innovation. In the latest distribution price review innovation has been given a "kick start" by the Regulator in the form of the Innovation Funding Incentive (IFI) and Registered Power Zones (RPZ). It can be anticipated that more collaborative activity will be evident on these networks than has been the case for many years. It is imperative that these and other initiatives are working to coherent goals rather than producing further fragmentation of the already disparate network designs. This is especially true of the light current solutions that will form the backbone of any automated networks of the future.

Since the demise of the nationalised industry, the implicit technical architecture activity for the UK distribution networks no longer exits. National technical design cannot be left to chance in a time of change and rising investment. There is a clear need for a degree of coordination of design both in heavy current and light current activities to allow the liberalised market to flourish and for investment to be undertaken efficiently.

Indigenous manufacture of power components is fast giving way to global product supply. The ability of the UK to influence future product, solution and service design and the embedded functionality is dependent on a strong indication that the volumes outlined materialise and that the return on investment is warranted. A technical architecture plan that is implemented would provide a level of credibility that has been missing for some time.

The culture shift in thinking that needs to take place in the industry from one of continual contraction to one of innovation, and indeed excitement, as we move into one of the largest renewal and change periods in the industry's history will require careful attention to both training and recruitment. The Technical Architecture Project will provide a clear indication of the skills needed and the quantities likely to be required for both new and old infrastructures. Working closely with the various stakeholders a measure of co-ordination and common purpose will be restored to the recruitment requirements of the industry.

In order to make best use of resources it is important that we remove barriers to innovative solutions and build on work that has already been completed, or is being completed. The coordination of these activities combined with an understanding of the impact throughout the technology supply chain of various decisions is seen as a major requirement to the success of innovative solutions. A single entity should be the focal point for this process and have the necessary authority to deliver the vision and therefore is a priority. A proposal for the role this group might provide is combined with a description of the proposed tasks (projects) that will need to be implemented to address the aims of the TA project.

1. To ensure a co-ordinated approach, it is proposed that **a single entity is given responsibility** to be the focal point for developing future technical architectures. This entity would operate transparently and be responsible for identifying technical barriers, proposing holistic solutions and options for future distribution networks and their interfaces with generation and transmission networks. The remit of this group should be broad.

2. The remit of this group should be broad enough to address the full range of interfaces to the industry at a macro and micro level. The group must be able to:

    - Develop a coherent framework for the safe, cost effective and environmentally sensitive adoption of new technology into existing infrastructures to meet the demands of Government policy, regulation and customer expectation
    - Advise the appropriate bodies on the impact of Government policy in relation to the technical architecture framework
    - Advise the appropriate bodies on the impact of regulatory provision with respect to technical architecture framework
    - Advise the appropriate bodies on the impact of statutory and voluntary code modifications to the technical architecture framework
    - Liaise with the many different stakeholders to ensure "joined up thinking" is adopted (A list of some of the external stakeholders is supplied in Appendix 6)
    - Deliver best practice guidance on the most appropriate technical architecture solutions to adopt for given scenarios

Subject to the agreement of the DGCG (and its successor body), it is envisaged that the new Distribution Committee could be effective in this focal point role.

3. A number of projects have been identified, specified and requirements specifications written. These are attached as Appendices to this report and are summarised as follows:

    - **Automation for active networks** – to understand what infrastructure and operational processes exist today amongst each of the DNOs and how these can be adapted and migrated towards delivering the automated requirements of the future. This project will complement the work undertaken by TSG Work Stream 5 on Active Network Management. Communications will play a vital part in the delivery of network automation and will therefore be a major part of the project evaluation. (Appendix 3)

- **Future Network Scenarios** – There are three basic tasks within this project that are closely linked; the evaluation of future generation and loads; the evaluation of distribution networks to support the former and the identification and participation of the major stakeholders. Much work has already been completed internationally on the possible future scenarios for power networks. It is not the intention to duplicate such work; therefore a literature survey is proposed to investigate the most credible range of scenarios applicable to the British distribution networks. Modular approaches will be proposed to provide solutions to a wide variety of network challenges. Workshops will be held to develop the ideas further with interested stakeholders. (Appendix 4)
- **Stakeholder Liaison** – Identification of the key stakeholders both today and in the future should achieve the necessary "buy-in" through the inclusion of these groups in the planning process. This is seen as both an enabler (if included) or as a barrier (if excluded) from the process. (Appendix 5)
- **Tools and Methodologies** – this task aims to analyse current tools and methodologies to identify shortcomings, to propose new requirements and to specify new approaches in order to improve the analysis of economic, environmental and power requirements. The tools will be aiding new methodologies to be implemented to cover planning, operation, data management and processes. There is a requirement to consider the combination of real-time and planning tools combined with data management issues. (Appendix 6)
- **Technical Standards** – A key aspect of the ability to integrate and interface in an economical, safe and environmentally friendly manner depends on the adoption of appropriate technical standards to deliver the required outcomes. This project will play a key role in understanding the standards in place today and how these standards may need to be modified or replaced for future scenarios to be adopted in the manner identified. Many different aspects of the industry are addressed in this project (from Building Regulations to impact of Transportation, Energy Policy and many others. (Appendix 7)
- **Regulation and Business Context** – This task will analyse the extent to which regulation and the commercial framework may influence the development of different scenarios. This is seen as a significant enabler but also a possible barrier. This task will also investigate how 'professional engagement' can play a greater part in increasing both efficiency and business foresight. (A discussion paper on this subject is included in Appendix 8 and a web survey is being prepared and may be taken forward by the IEE)
- **Procurement and Commercial** – The ability to adopt new and innovative solutions is highly dependent on procurement processes and commercial priorities. It is the remit of this project to propose new thinking in this area to establish flexible strategies and new business cases to assist the adoption of the proposed future scenarios.
- **Global Scanning** – This project needs to feed into each of the other projects to ensure the latest thinking on the subject from a global perspective is maintained. This will have two main goals – one to

eliminate duplication and secondly to ensure solutions specified are based on global products and solutions, thus providing access to scale economies. (Appendix 9)

- **Skills and Asset Management** – this project focuses on the requirement to develop new skill-sets within the industry, such that sufficient resources are available to deliver the envisaged scenarios. It is likely that current and new technologies will co-exist over an extended period. It will be essential to retain existing knowledge whilst acquiring new skill sets in order that a loss of 'corporate knowledge' does not impede the implementation of new and innovative solutions in the future. The lack of an indigenous skills base could prove to be a major barrier to implementing future scenarios. (Appendix 10)
- **Migration Options** – This task will need to be developed as the proposed scenarios are selected. In essence this project will provide a technical, commercial, regulatory, Health & Safety, planning and implementation road map(s) to ensure barriers to adoption are reduced and the success rate of implementation is increased.

These projects are closely inter-linked and many are mutually dependent to deliver the desired results in each of the thematic areas. It is therefore likely that these projects will need to be treated as a holistic package if the desired results are to be obtained.

4. **Project Outline Plan -**The projects identified within this report must be undertaken recognizing the inter-dependencies between them. This will require a degree of co-ordination. With the agreement of the DGCG (or its successor) the next step in the project will be to develop the project plan to take account of the revised organisation post DGCG.

5. **Project Resources -** Sufficiently skilled and knowledge individuals will need to be allocated to deliver the projects stated. This has been problematic from time to time in cross-sector projects and the issue is drawn to the attention of the DGCG and its successor as a potential risk to progress. Further, it is recommended that project programme management services continue to be contracted.

6. **Trading issues -** In due course, work will be needed to integrate the trading aspects of distributed generation that exports to the network, also the issues of islanding and storage. These are not sufficiently well identified (or urgent in project terms) to propose specific projects at present.

Further work will be needed to integrate the trading aspects of distributed generation that exports (e.g. large populations of microCHP, etc.), the issues of islanding and storage.

Evaluation of the best available forecast data of the types of generation that will appear on the distribution networks of the future (until 2020) indicate that a portfolio of generation types will evolve over time (see fig 1). Technical Architecture for the networks of the future will require to accommodate this evolution along with other trading, demand side, energy storage and power quality evolution. The possibility of Micro-grids, islanding and re-synchronisation will probably form a part of any future architecture and will be analysed as part of the Future Scenario project.

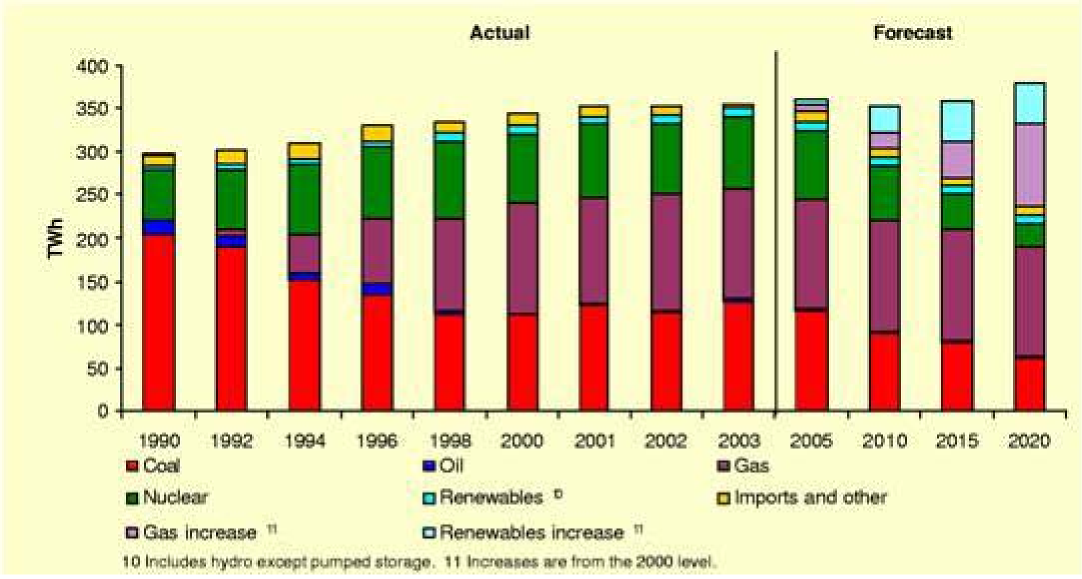

Figure 1: Electricity generation by fuel type – UK

(source: DTI projections as used in JESS report5 – November 2004)

It is important to recognize that innovation will inevitably lead to some projects that will fail. This is a typical outcome of research and development and should be seen in context, as the "major breakthrough" innovation projects that are really successful will only be unveiled by these learning experiences.

Throughout history successful deployment of innovation has only occurred when all internal and external factors associated with the "innovation"[7] are favourable and available. It is with this in mind, the projects proposed here are hoping to facilitate and provide the best possible environment for success. The holistic approach should provide confidence to the entire supply chain community both technically and commercially.

[7] A report on UK Innovation Systems for New and Renewable Energy Technologies for the DTI written by ICCEPT and E4tech Consulting details the issues of innovation. [3]

References

[1] DTI white paper “Our Energy Future – creating a low carbon economy”
http://www.dti.gov.uk/energy/whitepaper/ourenergyfuture.pdf

[2] ResponsiveLoad Ltd has developed technology to assist with stabilisation of electricity grids.
www.davidhirst.com/responld/rlhome.html

[3] A report on UK Innovation Systems for New and Renewable Energy Technologies for the DTI written by ICCEPT and E4tech Consulting
http://www.dti.gov.uk/energy/renewables/policy/renewables_innovation_review.shtml

[4] DTI Innovation Review 2004
http://www.energyprojects.co.uk/dti_review2004.htm

[5] DGCG TSG Workstream 1 Scenarios
http://www.distributed-generation.gov.uk/documents/27_10_2003_ws1-p06-d01v1-2.pdf

[6] DGCG web site
http://www.distributed-generation.gov.uk

[7] DTI Technology Programme
http://www.dti.gov.uk/technologyprogramme

[8] DTI Innovation report
http://www.dti.gov.uk/innovationreport

[9] Tyndall Centre – Connecting new and renewable energy sources to the UK electricity system
http://www.tyndall.ac.uk/research/theme2/project_overviews/it1_30.shtml

[10] Science and Technology – Fourth Report
http://www.publications.parliament.uk/pa/ld200304/ldselect/ldsctech/126/12602.htm

[11] Distributed European Energy Partnership (EU – DEEP)
Integration of Renewable Energy Sources and Distributed Energy Resources – (IRED) http://www.ired-cluster.org/
http://www.conference-on-integration.com

[12] The Office of Gas and Electricity Markets
http://www.ofgem.gov.uk

[13] The Institute of Electrical Engineers
http://www.iee.org/

Glossary

Acronyms

BETTA	British Electricity Trading and Transmission Arrangements
BHA	British Hydropower Association
BWEA	British Wind Energy Association
CCGT	Combined cycle gas turbine
CCL	Climate Change Levy
CEGB	Central Electricity Generating Board
CHP	Combined heat and power
CO_2	Carbon dioxide
MicroCHP	Domestic combined heat and power
Defra	Department for the Environment, Food and Rural Affairs
DER	Distributed Energy Resources
DG	Distributed Generation (equivalent to Embedded Generation)
DGCG	Distributed Generation Co-ordinating Group
DNO	Distribution network operators
DTI	Department of Trade and Industry
DSM	Demand Side Management
ECI	Environmental Change Institute
EPA	Environmental Protection Agency
EPR	Energy Power Resources
EPSRC	Engineering and Physical Sciences Research Council
ESRC	Economic and Social Research Council
ETS	Emissions Trading Scheme
GW	GigaWatt (1,000,000,000 Watts)—see below
GWh	GigaWatt hour
IGCC	Integrated gasification combined cycle
JESS	Joint Energy Security of Supply Working Group
kW	KiloWatt (1,000 Watts)—see below
kWh	KiloWatt hour
LGA	Local Government Authority
LPG	Liquid petroleum gas

MW	MegaWatt (1,000,000 Watts) – see below
Mwe	MegaWatt equivalent
MWh	MegaWatt hour
NaREC	New and Renewable Energy Centre Ltd
NERC	Natural Environment Research Council
NETA	New Electricity Trading Arrangements
NGC	National Grid Company
NGT	National Grid Transco
NPPG	New Planning Policy Guidelines
Ofgem	Office of Gas and Electricity Markets
OWEL	Offshore Wave Energy Ltd
OXERA	Oxford Economic Research Associates
PIU	Performance and innovation unit
POST	Parliamentary Office of Science and Technology
PV	Photovoltaic
R&D	Research and Development
RCUK	Research Councils UK
RD&D	Research, Development and Demonstration
RDA	Regional Development Agency
RO	Renewables Obligation
ROC	Renewables Obligation Certificate
RPA	Renewable Power Association
TSO	Transmission system operators
TSG	Technical Steering Group reporting to the DGCG
TW	TeraWatt (1,000,000,000,000 Watts)—see below
TWh	TeraWatt hour
UPS	Uninterrupted power supply

Appendix 1 – FAQ for Technical Architecture

Author: Duncan Botting Technical Architecture Project Leader

The Technical Architecture Project has been charged with scoping the problem posed in a paper to the DGCG on the 8th January 2004 regarding the importance of achieving "joined up thinking" in the Industry when considering future network developments.

Why has the Technical Architecture project been initiated ?

Since liberalisation the Electrical Supply Industry has developed and evolved by driving down costs, by the improvement in both productivity and efficiency of managing assets and developing a trading environment to create competition in generation.

The network companies now find themselves approaching a watershed; the combination of ageing assets and the drive for more sustainable generation is leading to the need to make important choices. To some extent the choices are limited by the as-built infrastructure and the regulatory environment that exists. None the less, choices remain for the future commercial and technical direction of the networks. Choices such as traditional versus innovative, services versus supply and consolidation versus diversification will need to be addressed along with decisions about the technical configuration of the infrastructure to deliver these developments.

Currently the interactions between commercial, regulatory, environmental, health and safety and sustainability dictate the technical strategies for many network companies . In some the loss of skill sets, the loss of "corporate memory" and resource constraints has led to a very depleted ability to evaluate the more innovative solutions offered by manufacturers. There has been a reluctance to explore other routes due to the risk of encountering either higher costs or regulatory confrontation.

What is the problem Technical Architecture is trying to solve?

The Technical Architecture project has been charged with the task of identifying options and best practices for future technical solutions in order to deliver the reality for a journey between where we are today and where we aim to be in the future. It will take cognisance of the as-built world and the environment that bounds the decisions that will deliver change. It also aims to ensure "joined-up-thinking" and a coordination of the information and knowledge that many disparate R&D, and working groups nationally and globally produce. This should reduce the burden of "re-inventing the wheel" and reduce risk while gaining valuable insight into technologies used in other disciplines that may yield solutions to problems in the Industry. This is no simple task and requires diplomacy, commercial astuteness, technical comprehension and environmental awareness. To deliver any one of the proposed scenarios will require the willingness of each of the stakeholders in the Industry to re-establish a 'joined-up-thinking' process which has largely been lost by the fragmentation of the Industry since privatisation. The need to articulate the benefits and risks for each stakeholder is of paramount importance as goodwill can easily give way under the pressures of commercial realities. If the Government's policy as set out in the Energy White Paper "our energy future – creating a low carbon economy" is to be implemented as a coherent strategy across the Industry at a cost that can be tolerated by customers there will be a need to be a coordinated framework to deliver this based on a liberalised, competitive market place.

How will the work be approached ?

The Technical Architecture Project in its first phase will identify the tasks that need to be investigated, developed, designed and tested to deliver the aims of the project. The complexity of this is the reason for a two stage approach. The first stage aims to build a "Plan-for-a-Plan" while the second stage aims to deliver the identified plan.

The following is a simplified example of the types of tasks that will be needed. Many in the industry are of the view that there will be a need to make distribution networks of the future 'active' rather than the 'passive' networks we have today. To achieve active network management (ANM) starting from our current position what sort of considerations will be needed?

- To deliver Active Network Management on a network in a cost effective manner
- To meet the multiple needs of the operating companies to manage their assets, deliver meaningful statistics to the regulator for trips and forced outages, reduce the need for scheduled maintenance but ensure safety, balance the power quality and energy storage requirements with the need to implement Demand Side Management (DSM) and various other related issues.

To achieve these results, what technical architecture will allow the delivery of these requirements given the starting point of the infrastructure we have today?

- How long will this take?
- Do Products and Solutions exist today or do they need to be developed by Manufacturers?
- Is the technical solution possible or viable given the regulatory framework?
- How will we migrate from today's infrastructure to tomorrows without compromising the Network integrity both technically and from a safety perspective?
- Will the new technical solution be more cost effective or less?
- How will security from cyber terrorism be built into the solution frameworks?
- How will the supply chain evaluate best practice with the technical framework?
- What standards exist to meet this demand? Will new standards be required?
- How will distributed generation react and the Network survive fault ride through with Active Network Management in place?
- Will new infrastructure be needed to support the new technical architecture?
- What modifications to guidelines, best practice and Distribution Codes are required to accommodate ANM?
- What will be the impact on planning consents?

These are just some of the issues raised by addressing future Technical Architecture. A further dimension of such a task will be the interrelationship of various entities such as DNOs, TNOs, Government, Regulator, Local Government, Regional Development Agencies, Academics, Professional Institutions, Standards Bodies, Consultants, Manufacturers, Local Residents, etc.

What are the benefits of developing a Technical Architecture?

By setting out a framework of options for the future in a structured, yet flexible manner we can have confidence that this ‘Big Picture’ or holistic approach will reduce the risk of expensive failures or inherent flaws in policy, design or construction of the networks of the future. This will be the enabler for achieving best value for money for all customers and network performance that meets the needs of tomorrows flexible network configurations, including the national aspirations for a lower carbon economy and greater energy efficiency.

There will be a need for a body to be a focus for addressing these issues and be a catalyst for change, working with all sides in the Industry to reduce risk and deliver the flexible framework “UK plc” requires to prosper in the 21st Century.

“Market Forces” alone will be an inefficient process for creating a new technical architecture given the complex nature of the inter-relationships of the stakeholders involved and the challenges of moving from the current infrastructure to a myriad of possible future solutions. .

The Technical Architecture project is about providing a non-prescriptive framework to allow constructive, free market principles to deliver the “breadth and depth” of solutions for each player in the process, minimising the risk of increasing complexity and without compromising our national objectives for the future.

<u>How will this be achieved?</u>

The initial phase report will make recommendations as to how best the process could be managed and what needs to be done to achieve the aims of the Technical Architecture Project. It will not identify the solutions to the possible scenarios but will advise the most appropriate manner of completing these tasks.

The report will be divided into six sections.

1. Project Remit

The first section will cover the general remit of the project, the project aims and the delivery process for the work being carried out in the first phase. It will identify the need for coordination of the tasks identified in order to reduce risks and improve stakeholder returns.

2. Current Status

The second section will cover the “Where are we now” status. It will identify the work already completed in other areas towards this goal and will also identify the tasks that will need to be completed in the future to provide the starting point for future work to build on.

3. Scenarios Identified

The third section will include the various future scenarios that have been identified by the project to deliver the possible extremes of various solutions and how these may be accomplished.

4. Work Plans

The fourth section will identify the work that will need to be done to take us from where we currently are towards the future scenarios. This work will detail issues such the likelihood of design constraints due to as built environments, new equipment requirements, migration strategies, etc. These issues, and others, will be identified and proposals made for they could be managed in the future.

5. Risk Assessment

The fifth section will identify possible barriers and enablers to this process to achieve successful implementation of the project aims.

6. Implementation

The sixth section will conclude the actions required to achieve the recommendations delivered in the report. It will also recommend the responsibilities for the body given the task of implementing the recommendations of this report.

How are we organised to deliver the initial report?

The project has been divided into 'theme' groups in an attempt to breakdown the barriers of typical functional 'silos'. Functional 'silos' tend not to address the wider issues of the functions or environment that bound them. E.g. A technical solution may be designed to be the best technical solution for the job but the reality of the commercial environment would preclude its use. It is intended that the 'themed' groups will go beyond these silo walls to deliver economically, environmentally and technically attractive solutions.

The team and their 'theme' responsibilities are given below:

Name	Area of Responsibility
Duncan Botting (IEE PN Exec, TSG & ABB)	Project Leadership, Light current issues and migration planning
John Scott (IEE PN Exec, TSG & Ofgem)	Regulation and Business Environment
Phillip Cartwright (IEE PN Exec & Areva)	Future Scenarios
Mike Kay (TSG & UU)	Standards
Mike Lees (IEE PN Exec & EATL)	Asset Management Strategies and Skills
Frank Duffy (IEE & ENA)	Current Infrastructure
Alan Laird (IEE & SP)	Interface with TSG WS 5 activities
Prof. Nick Jenkins (TSG & UMIST)	Future Loads and Generation
Prof. Jim McDonald (Univ. Strathclyde)	Tools & Methodologies
Prof. Goran Strbac (DGCSE & Univ Strath.)	Interface with National and Global activities
David van Kesteren (IEE PN ExecYEDL/NEDL)	Stakeholders and Future Scenarios
Stephen Andrews (TSG & ILEX)	Interface with Generation (CHP)
Dave Sowden (TSG & MicroGen)	Interface with Micro Generation

The team have the responsibility to deliver a "Plan-for-a-Plan" that will enable the DGCG to evaluate, instigate and sponsor a relevant course of action. A timescale of the end of 2004 has been identified for delivery of the report although a slight extension into Q1 of 2005 is being sort due to the resource constraints early on in the project delivery.

How are we engaging the rest of the Industry in this process?

As the initial project has been entrusted to the IEE Power Systems & Equipment Professional Network as lead organisation the project team have been able to harness the extensive network of professional engineers as well as respected institutions and companies working in the Industry to contribute to the delivery of the project. There has already been a very successful IEE seminar to launch the Technical Architecture project at UMIST in June 2004. This was a capacity event with over 100 people attending. A second event is planned to build on the success of the first in November 2004. This will take the form of an update and engagement process. Presentations in the morning are structured to provoke interaction in facilitated afternoon break-out sessions to deliver critical/constructive feedback as well as identifying missing 'links' on the three 'themed' sessions from the morning Cultural, Business and Technical scenarios.

By engaging in seminars and direct contact with stakeholders the project hopes to garner the views of the widest possible audience to enable informed future proposals to be made and tested against the backdrop of real stakeholder issues.

Appendix 2 – Paper presented to DGCG on the 28th January 2004

Paper DGCG 1/04

Distributed Generation Co-ordinating Group
28th January 2004

Technical Architecture – a framework for tomorrow's networks

Paper by Frank Duffy (Energy Networks Association) & John Scott (Ofgem)

The authors bring forward this paper as individuals and they do not necessarily represent the policy of their respective organisations. They were both speakers at the IEE event referenced in the paper that first identified the issues being discussed.

The Issue in Summary:

- To respond to increasing densities of distributed generation, it is likely that networks will need to become increasingly active and intelligent.
- This will be achieved more effectively and cost efficiently if consideration is given to the development of a **technical architecture** for tomorrow's distribution networks.
- Technical Architecture provides a high level framework to ensure that compatibility and efficiency is achieved in the design, procurement, construction, and operation of these networks.
- The Technical Architecture of today's distribution networks is established by a series of standards, codes and guidance documents.
- An understanding of best practice options for future Technical Architecture will directly benefit connecting customers by providing consistency and co-ordination, and will enable manufacturers to respond through their product portfolios, and encourage equipment to be made non-proprietary.
- How might this best be achieved in a liberalised industry structure that rightly has no central planning? This paper proposes a way forward.

Background

1. In November last year a one day seminar was organised by the IEE, supported by DTI and Ofgem, to identify the key elements of the end to end supply chain for technology to support the move to 'greener generation'. This addressed research and manufacturing as well as network design and operation. The delegates' views from the break out groups are summarised in Attachment 1.

2. Analysis of this feedback shows a number of familiar issues, the majority of which have already been identified by DGCG and are being addressed through the Technical Steering Group (TSG) and elsewhere. There is a notable exception that is brought here to the attention of the DGCG.

3. The issue that received the highest number of votes in the informal poll at the end of the day, and was identified as a major risk to progress, was "Lack of joined up thinking". Or, in the terminology adopted in this paper, the absence of a shared view of good practice for the Technical Architecture of future distribution networks.

What is Technical Architecture?

4. Technical Architecture establishes fundamental design concepts and standards that allow multi-component systems to be designed, procured, constructed and operated with compatibility at the many interfaces. For example, if the networks of tomorrow require a greater degree of intelligence, how is this best accommodated? When is it best centralised, with radial signalling to remote elements, and when is it best dispersed within the network with interlinking communications? How are these designs best integrated with existing protection and auto-switching systems? Are there international standards for communication protocols that could be recommended, so ensuring open access and minimising the risk of technology 'lock in'?

5. A more detailed list of elements that might comprise a Technical Architecture is set out in Attachment 2. The main headings are Procurement, Design, Testing, Safety, Skills & Support, Performance Indicators, and Operations & Management.

Who benefits?

6. Answers to the issues posed above are important to a number of stakeholders:

- **The DNOs**: to provide good practice guidance to network designers, ensuring both effective solutions in the short term, and confidence that investment is consistent with a robust long term development strategy. Furthermore, the DNOs can utilise this information to inform their procurement decisions, particularly where new technology is concerned, to ensure efficient utilization of current and future products.
- **The Connecting Generators**: to minimize design one-offs and have recognisable connection configurations and communications methodologies.
- **The Manufacturers**: to develop their product range to meet the requirements of DNOs and connecting generators, wherever possible being encouraged to offer open systems. It helps all parties if manufacturers can inform their view of the British market, while allocating their resources against an international context.
- **The Regulator**: to obtain reassurance, on behalf of all electricity consumers, that network investment is being made efficiently, that stranded assets are avoided, and that quality of supply and safety are safeguarded. If the sector develops and publishes its thinking on Technical Architecture, this is likely to accelerate the evolution between companies of optimal technical/business positions.
- **The Government**: to promote distributed generation and encourage progress towards declared carbon reduction targets

- **The R&D community**: to focus the direction for innovation which, by its nature, is a long lead-time activity that can benefit greatly from clarity and consistency.

Why is this work needed?

7. Broadly speaking, present distribution networks have a well established and recognisable design. This results from their history under a centralised, nationalised, industry in which the Electricity Council provided technical focus and developed a common suite of standards and guidance documents. Many of these now form part of the distribution and grid codes, and changes to these documents are currently being brought under improved governance processes[8].

8. In recent years the development of distribution networks has been very largely incremental, following established practices and standards. An exception has been DG connections where new standards have been developed, for example in response to the advent of domestic scale generation[9]. The challenge ahead of establishing more active distribution systems, is a fundamental change of concept that requires attention to the core of network design on a scale not addressed for many years.

9. The work required to establish guidance for distribution network Technical Architecture needs specialist knowledge that has become scarce in the sector as companies have become leaner under the pressures for greater cost effectiveness. The approach proposed in this paper will not only enable the pooling of knowledge to the benefit of all parties, but will also be a catalyst for innovation and fresh thinking in the network philosophies adopted by the DNOs.

10. Looking to the long term, where a significant proportion of GB's generation may be connected to distribution networks, there is an important issue of stability of networks for national security of supply. For sound technical reasons, this cannot be achieved through piecemeal development (as has been demonstrated by the dynamic stability problems in NE America last August, and operational difficulties in Denmark).

11. In the more immediate future, an absence of a best practice framework is likely to result in sub-optimal design decisions and hinder efficient procurement. This is not to the advantage of connecting generators or to customers at large. It is likely to result in bespoke designs to which manufacturers have difficulty responding and under which connecting parties are at a disadvantage. It also leads to unfocussed R&D and the absence of collaborative research which is often cost-effective and lower risk. All these factors contribute potentially to unnecessary costs that are likely to be high and would ultimately be borne by customers.

Proposal

12. The DGCG is invited to consider and agree the following:

    a. **That TSG should be asked to scope the development of a framework to provide guidance to the sector on best practices for the Technical Architecture for more active distribution networks. This exercise should take into account the work currently being undertaken in Workstreams 3**

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[8] Governance of Electrical Standards www.ofgem.gov.uk/
[9] Engineering Recommendation G83/1 www.ea-eng.org.uk/ENA-Docs/

& 5, co-ordination with DTI's technology route mapping, and international views of future networks.

b. **The TSG should evaluate the results of this scoping exercise, keeping the DGCG advised of progress, and identify detailed work elements and their relative priorities for integration with current work programmes.**

c. **The TSG should seek to involve a cross-section of the sector, and consider the scope for enhancing and extending existing industry documentation. It must ensure that the outcomes are facilitating and not constraining on the actions of the network companies and other interested parties.**

13. It is envisaged that this work will be structured into clearly deliverable and project managed packages, to be advised to DGCG through the TSG's project planning process. It is likely that consultancy support will be necessary and the budgeting and procurement of this will be addressed by TSG in conjunction with DTI.

14. Any proposals brought forward to modify or extend existing industry documentation would be developed in full recognition of the relevant governance arrangements.

<u>Acknowledgement:</u>

This paper has been prepared using the valuable contribution of the break out group reports from the participants of the IEE Greener Generation seminar, and particular thanks are due to Mr Duncan Botting for the initial thinking set out in Attachment 2.

The speakers at the IEE seminar were:

Dr Ian Gibson, Science & Technology Select Committee
John Loughhead, Alstom
Frank Duffy, Energy Networks Association
John Scott, Ofgem
Prof Nick Jenkins, UMIST
Charles Overstall, VATech
Bob Taylor, EME

Attachment 1

IEE Seminar: Greener Generation – Delivering the Technology.
Held at IMechE on 4 November 2003

EVENT OUTPUT

<u>Break Out Group 1 – INDUSTRY AND PARTNERS theme</u>

GENERAL OBSERVATIONS
- Problem Solvable – If economic systems are put in place for generators to make a profit. This would inspire incentives. (2 votes)
- A drive is needed to encourage 16/17 year olds into the industry – or face an uncertain future. (4 votes)
- Stop subsidising the coal industry – and start funding the renewable incentives. (4 votes)
- A comprehensive detailed route-map needs to be designed and owned (by the government) to reach our renewable targets. (2 votes)

STRENGTHS
- Ability to rise the challenge
- Opportunity if there is a valid reward (4 votes)
- System operators are experienced, competent, flexible (2 votes)
- UK continues to have a strong base of consulting engineers
- Robust Network (2 votes)

WEAKNESSES
- No incentive to move from the status quo (6 votes)
- Marine and tidal energy is not a main player globally
- Wind energy is dependant on wind
- Spinning reserve is expensive (2 votes)
- Banking community is only backing wind at the moment – because of uncertainty (3 votes)
- Network design does not support a change in culture e.g. Micro CHP
- Desegregation is a weakness (1 vote)
- Regulatory framework inhibits Generation and Distribution incentives. (2 votes)

OPPORTUNITIES
- We have a wind resource
- Government targets drive opportunities (and cost) (2 votes)
- Renewable targets provide opportunities for the university sector (4 votes)
- Renewable targets could open the way for a drive in recruitment
- Micro CHP is an opportunity for the customer (2 votes)
- New generation technologies – assuming the cost can be justified/met

THREATS
- Time is marching on – are we running out? (5 votes)
- Security of supply – have we addressed this issue enough bearing in mind the time scales (1 vote)
- China's potential CO_2 output could dwarf our CO_2 drive into insignificance
- Unknown global technical authority (1 vote)
- Fragmentation of the sector is inhibiting progression (3 votes)
- Lack of joined up thinking (9 votes)
- Cultural weaknesses (1 vote)

Break Out Group 2 - POLICY AND REGULATION theme

STRENGTHS
- ROCs
- White Paper Energy Policy (1 vote)
- White Paper follow though (3 votes)
- Core industry expertise (1 vote)
- Technology is available (but it needs to be UK proved) (3 votes)
- Strong public environmental awareness (4 votes)
- Well endowed with renewable resource (3 votes)
- Growing professional interaction across the energy sector (ENA and IEE) (3 votes)

WEAKNESSES
- Lack of clarity on nuclear policy (1 Vote)
- Resource constraints – skilled and experienced people (4 Votes)
- Current regulatory framework (2 vote)
- Lack of co-ordination – Government initiative/ Government funding (3 votes)
- Lack of critical mass in research (1 vote)
- Security of ROCs (2 Votes)
- Compatibility of market and environmental objectives (1 vote)
- Lack of manufacturing and installation capacity (1 Vote)
- Lack of national champions; where is the lead going to come from? (3 votes)

OPPORTUNITIES
- Bring ROCs review forward
- Refine ROCs
- Develop markets to recognise characteristics of new generation technologies (1 vote)
- Opportunity to develop manufacturing and services (UK development integration) (1 vote)
- Taking the lead in the developing the renewables industry (4 votes)
- Exporting our skills and market knowledge
- Taking the lead in managing Ireland's renewables
- Lighter touch regulation
- Greater public/private co-operation (2 votes)
- Re-branding power engineering courses (2 votes)

THREATS
- Security of ROCs (1 vote)
- Failure of market to encourage new entrants (1 vote)
- Time (2 votes)
- Declining value of ROCs
- Planning issues (4 votes)
- T&D infrastructure not available in time to support the new generation sources (2 votes)
- Loss of momentum; necessary change fails to happen (4 votes)
- Insufficient power systems graduates (2 votes)
- Island mentality (1 vote)

Attachment 2

Initial Thoughts
Elements that might comprise a Technical Architecture:

Procurement

- **Framework procurement process for new technologies and intelligent systems**
- **Framework specifications for new products to ensure consistency with overall Technical Architecture**
- **Framework specifications for communications media and protocols to ensure consistency with overall Technical Architecture**
- **Technical evaluation templates to normalise and assist in the weighting of various tender submissions regarding the Technical Architecture**
- **Provide options for managing Intellectual Property Rights (IPR)**

Design Considerations

- **Best practice options for centralised versus distributed control, command and intelligence**
- **Road Map / migration path from various current control, protection and automation configurations to the desired best practice Technical Architecture**
- **Limitations / Benefits table of product mapping (functionality, inter-operability etc)**
- **Modelling of networks to identify options for re-enforcement versus re-configuration**
- **Data requirements specification, minimum/enhanced options**
- **Integration assistance**
- **Security requirements to ensure National Security is not compromised by unilateral implementations (rogue web services etc)**
- **Software application templates to provide operational security**
- **Configuration Management processes to ensure tight control of released firmware, software and hardware combinations**
- **Development of new topology, stability and protection applications to deal with increased 'intelligence', 'islanding', 'transients', 'synchronisation', 'reverse flow configurations' etc in networks with high DG penetrations**
- **Power Quality – consideration of various components on the power quality e.g. auto-reclosers etc**
- **Ability to 'plug and play' when new hardware is added to a network**
- **Ability to interface active and intelligent systems and equipment externally**
- **Provision of model business case to enable effective demonstration of benefits and payback**

Testing Considerations

- **The inability to test these intelligent and active systems on 'live' networks requires careful planning of test scenarios and test specifications**
- **Development of good practices to minimise the risk of commissioning errors**
- **Difficulty for in-house staff to be aware of end-to-end testing issues (interaction between multiple vendor applications etc)**

Safety Considerations

- **The further automation of various control functions within the Technical Architecture inevitably brings different issues that require careful consideration of current working practices and the development of suitable method statements, risk assessments etc**

Skills & Support Considerations

- **Any change to the Technical Architecture will require the correct training of staff to ensure full understanding of the consequences of actions on the new Technical Architecture**
- **Development of efficient support mechanisms (Distributed or Centralised updates etc)**
- **Multi vendor maintenance considerations**
- **Skill requirements to design, commission and support active networks**
- **Outsourcing best practices for more advanced technologies**
- **Ability to manage change and adapt to it successfully**
- **Software management of dispersed devices; eg remote diagnostics and upgrading**

Performance Indicators

- **Mesurands to track improvements/degredations of active networks**
- **Trends to identify / trigger review**
- **Consideration of national fault and defect reporting systems implications**
- **Data Requirement specification to 'build' the various indicators**

Network Operations & Management

- **Transient and Dynamic stability of active distribution networks**
- **Synchronisation and automatic switching of islanded networks**
- **Waveform quality and harmonics with high distributed generation penetrations**
- **Security of dispersed and intelligent systems to hostile intrusion**

Appendix 3 – Automation

Technologies and Infrastructures for the Future Networks Monitoring, Protection and Control

(Sensing, Intelligence and Control)

Author: Dragana Popovic

Electricity distribution systems (DS) are undergoing rapid changes and a significant complexity increase due to increasing market regulation, integration of distributed generation and power electronics technologies, limited transmission and distribution capacity, adoption of efficient and advanced computation, communications and control technologies, and the requirements of a digital society.

The leading challenge for distribution network operators is to balance consumer needs with the cost of upgrading their systems, while also addressing regulatory and economic pressures to reduce operating costs. The existing power delivery infrastructure is not being expanded or enhanced enough to facilitate communication between consumers and markets, accommodate emerging technologies (distributed generation (DG), storage) and needs of a customer of today. The power delivery system of the future will need to keep pace with emerging technologies and all stakeholders' demands. To cope with the implied increased level of complexity and multi-functionality, distribution system will need to become an actively managed system primarily through the extensive data management and use of network automation and communications with consumers.

The key enabling technologies that would add to the capabilities of a DS in the future are distribution automation (automation, sensors/monitors and comms systems), DG and energy storage, power electronics, and DSM. Key element is information ie the right amount of data to the right device/system/computer within the right amount of time. New communication technologies are powerful enablers to make monitoring and control system solutions more effective, with a broader scope of application. Existing monitoring, control and protection systems used in distribution systems are driven by established practices that have been proven in the utility market. While control systems are expanded and modified over time, the newer information and communication technologies are only introduced into the system when such an investment can be economically justified and/or the older communication solutions have become so obsolete to use and maintain. As a result, communication designs and hardware infrastructures that are in operation today are of various vintages and possess different levels of technical maturity while the existing standards are often incomplete, overlapping and/or conflicting. The network-wide consequences include

- limited ability to integrate products and implementations

- lack of a standard communication architecture and data management procedures
- no industry architecture for integrating and upgrading on large scale
- systems engineering practices are often not followed

Automating distribution networks offers the opportunity to fully utilize installed capacity, reduce operating margins and length of customer interruptions. Introduction of a new generation of digital relays and other Intelligent Electronic Devices (IEDs) enables new monitoring applications (via IEDs and distributed SCADA, substation state estimation, sensors, wireless and optical communications), better coordination of protection and control , distribution automation control, integrated measurement and protection solutions, and cost-effective network diagnostics and maintenance (through self–monitoring, self-diagnosis, communication of self-assessment results and ongoing integration of information and data management). Furthermore, an increased application of advanced technologies and infrastructures can enable the development of distribution management systems (DMS, similar to EMS) and distribution control centres (DCC). DMS/DCC will be used to complete the active management and operation of distribution systems during normal and emergency conditions.

Future networks functionalities

- Integration of new technologies (DG, storage, PE devices, elastic loads)
- Communications with consumers
- Adaptability and flexibility (wrt capacity, power flow, fault management, voltage support, control, customer services)

Technologies and infrastructures

- Sensors/monitors
- Intelligent electronic devices (IEDs) / automation
- Data management / information model
- Communications model
- Coordinated fully integrated design

Key focus areas:

1. Data acquisition and management

Availability and significance of data is well recognized and emphasised in all recent studies on effective network management and operation. Data can for example be used to provide insight on modifications needed to relay coordination and design practices for achieving a full system protection integration, facilitate optimal decision making and control needed for volt/var, fault and island management as well as to more accurately assess system risk in the future.

Data acquisition function provides real time and other data (historical, computed, informational) from the network to systems & applications. Mechanisms for data retrieval and the issuing of control commands include direct power equipment controllers, local IEDs, field systems for monitoring/control (non-centralized), and centralized control centre based SCADA systems.

The key challenge facing utilities in the future is determining a standard data management architecture that can extract all the desired information, and deliver this information to the users who have applications to analyze the information. The challenge is at least twofold:

- to utilize a range of new data sources/acquisition systems to include intelligent electronic reclosers, voltage regulators, remote-controlled switches, integrated substation control, monitoring, measurement and automation systems, smart relays, capacitor controllers, electronic recloser control
- to develop new procedures and techniques that permit the data from field devices and systems to be efficiently collected, checked for integrity, sorted and summarized, and used in system planning and operation.

2. Distribution Automation (DA)

Use of advanced monitoring and communication technology allows utilities to implement flexible control and management of distribution networks, which can be used to reconfigure the system after disturbances, enhance efficiency, reliability, quality of service, more effective utilization and life-extension of the existing network infrastructure. In principle, distribution automation can perform a range of functions such as

- Data gathering and checking
- Distribution system modelling and analysis
- Alarm processing
- Contingency analysis
- Coordinated volt/var optimization and control
- Fault location, isolation and service restoration
- Feeder reconfiguration

through

- interfaces with different databases and systems,
- near real-time simulations of operating conditions,
- near real-time optimization
- actual real-time control

As has been mentioned above, one major problem in the current distribution networks is providing a suitable framework for managing the large quantity of available information. The most common one-vendor solutions prevent the integration of equipment from multiple sources. On the other hand, systems based on client-server and Web technology are sometimes inflexible and often centralize much of the system monitoring functionality, which can lead to a requirement for high network bandwidth. However, if a utility information and communications architecture is in place or the primary use of the IEDs is expanded, very different requirements would be placed on IEDs and overall network capabilities achieved. Consequently, new IEDs will become more easily deployed and managed as strategic resources leading to a much higher level of their functionality and overall network sophistication.

Need for

- improved monitoring and diagnostics
- automated fault assessment/outage management
- network-wide IEDs integration
- DMS development
- EMS and DMS coordination

At the substation level

- new sensors
- new local /distributed monitoring and control functions
- functional integration and testing

3. Communications

Some DA applications (such as many SA functions) can be implemented using only local information. However, most applications that can improve performance of the overall distribution system through centralized optimization require comms and information exchanges to monitor conditions at different locations in the system.

State-of-the-art needs

- Identify a need for more advanced functionality (esp in RTUs in order to obtain more refined data close to the process)
- Identify what technology and level of interaction could be used, from both manufacturer and utility perspective
- Identify barriers (constraints and concerns) for the future (economic, technical and regulatory)
- *State estimation* – as an alternative for remote measurement and communications – reduces the requirements for/specification of the communication circuits.
- *Guidelines for the future information flow and comms infrastructure* (comms architecture and information model development, advanced communication infrastructures for feeder automation, advanced communication infrastructures for network automation)

Two immediate/current UK needs (Roberts 2004)

- High speed comms esp in rural areas
- Reliable and secure (and cheap) comms across the DNs

4. New devices and related control concepts

Opportunities exist to study the increasing amounts of available data and identify new phenomena that can lead to the development of new devices and operating practices.

Examples:

- new sensors and measurement systems

- networked sensors and monitoring systems
- advanced power electronics – based devices
- new power device concepts
- new configuration of controllers

5. Related work in other areas

As new devices and more information become available, opportunities exist to evaluate new control or protection systems.

As data integration and information sharing among users become feasible, it becomes necessary to improve overall system performance.

Need for a broad and unbiased view to identify new control and protection paradigms.

Examples:

- system-wide relaying coordination with control strategies
- new concepts in relay implementation
- advanced tools and methodologies for testing, evaluation and setting coordination
- integration of substation and feeder automation into EMS and DMS
- customer focused energy delivery / customer system integration
- new control concepts / advanced distribution controls

Scope for this work package in 2005/6

1. In-depth analysis of the existing monitoring, protection and control capabilities (eg frameworks, functions and applications) across all DNOs.
2. Assessment of the current monitoring, protection and control infrastructure developments and implementations to include identification of infrastructures and their functional and operational limitations.
3. Evaluation of the current infrastructures with respect to any architectural significance to include identification of common features, gaps and missing pieces
4. Identification/Definition of the future capabilities, functional requirements, concepts and principles for data, technology and infrastructure driven developments (focus on improved comms and control, data/information networks ….) needed for achieving a target system-level technical architecture

Appendix 4 – Future Energy Deployment and Design

Technical Architecture Project

Theme: Future Distribution Networks

7th March 2005

Authors: N. Jenkins, P. Cartwright

Background

The Theme will address the requirements for the UK distribution system to 2050. In particular it will consider the role and requirements of the distribution network as a transport system for electrical energy. Figure 1 illustrates the distribution system as a transportation network linking inputs to loads. The distribution network can also be thought of as fulfilling a number of other roles (such as a facilitator of competition) but these are considered to be of secondary importance, and will not be considered initially.

The Theme will consider the inputs to the distribution system from both the transmission network and from distributed generation. It will include consideration of the future energy mix in terms of centralised generation or distributed generation - and in particular how the performance of the generation impacts on the required functions of the distribution system, if indeed a distribution network is required for a potential future scenario. Of equal importance is the possible development of loads both in terms of power/energy requirements and the type of loads that will need to be supplied. This will include consideration of the quality of supply required.

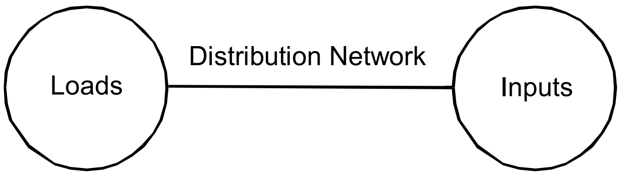
The Theme will also address possible developments within the distribution network. This will be sub-divided into:
Distribution system development (system design and architectures)
Distribution plant and technologies (including new materials, new control systems and new sensors required to capture data for the future control, systems)

In order to manage the Theme, it will be split into 2 Sub-Themes (ST).

ST1-Generation and Loads. This ST will consider the options for generation of electrical energy and their impact on the distribution system. It will also address the development of demand and loads on the UK power system.

ST2-Networks and Plant. This ST will consider the options for networks and their likely uptake. It will also address the likely development of distribution plant, new materials and new control systems.

ST1 can be thought of as defining the functional drivers of the future distribution system. ST2 is concerned with technology development and possible future technical options to deliver these functions.



Loads: Magnitude and Type (including quality of supply)

Inputs: Central generation and DG

Figure 1 Distribution network linking inputs to loads

ST1-Generation and Loads

The Sub-Theme will use a scenario approach to establish the boundaries of the functional requirements for the distribution system out to 2050. It is proposed that this work would start with scenarios of UK society in 2050, which will define the requirements for electrical loads and hence the need for generation and transmission. The approach will also consider the potential of a future role for energy storage, controllable loads and distributed control systems. These general scenarios will then be refined to investigate the implications for the distribution network and several potential likely technical scenarios for 2050 will be identified. In addition the barriers which will prevent these scenarios being implemented will be identified.

A typical example of these types of scenarios is shown in Figure 2. The importance of undertaking this work is that the functional requirements of the distribution system are driven by external factors and these need to be understood as can best be achieved at this long timescale. It is only by considering the overall possible requirements that might be placed on the electrical distribution system that the likely boundaries of the required technical capabilities can be explored without resorting to arbitrary assumptions

Clearly any scenario approach that is adopted must be consistent with that used in other Themes

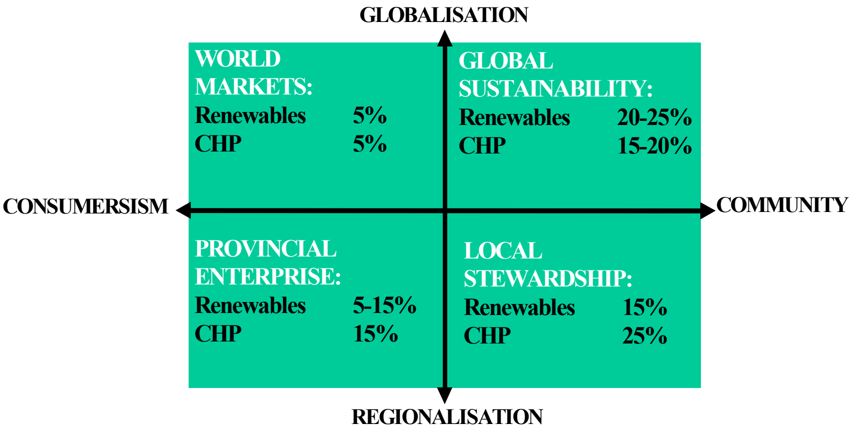


Figure 2 Typical scenarios (J Watson, SPRU). In this case the scenarios were developed to examine the possible impact of Renewables and CHP on the E&W power system.

There has been a very large volume of previous work generating scenarios of the UK energy system. It is proposed to review this work systematically and consider if it provides the insights necessary for the Technical Architecture project. Sources include:

Foresight: Energy for tomorrow, powering the future 2001.
Tyndall and Oxera studies of renewables and CHP
Supergen: Future Networks, High level scenarios out to 2050
Foresight: Intelligent infrastructure project
European Vision 2020 Project: Vision Of Future Energy Networks

It is only if existing scenarios and subsequent analysis is inadequate that new work will be commissioned.

Tasks for ST1

The proposed Tasks are listed with an outline timescale in terms of lapsed months:

Task No	Months	Task Description
1	1-4	Review Scenarios for Generation and Energy Supply in the UK (out to 2050)
2	1-4	Review Scenarios for Demand, Loads and Energy Storage in the UK (out to 2050)
3	Milestone 1	Review existing scenarios and consider

		if new work is required, if yes proceed.
4	5-6	Agree new high level society scenarios
5	6-8	Translate high level society scenarios into consequences for the distribution system (i.e. in terms of inputs and loads)
6	8-9	Through workshops confirm implications for the distribution system (i.e. in terms of inputs and loads)
7	9-10	Create boundaries of the functions required from the distribution system.

Notes:
1. There is likely to be considerable overlap between Task 1 and Task 2, as both will be based on Scenarios of UK society. Hence a single contractor should be appointed for this work.
2. Task 4 will only be undertaken if existing Scenarios are not adequate.
3. Task 6 is crucial in order to confirm implications for the distribution system and to ensure "buy-in" from stakeholders
4. Task 7 will generate the boundaries to which a new Technical Architecture of the Distribution system will need to extend.

Deliverables of ST1

The deliverables follow from the work programme. Milestone 1 will involve the delivery of a report reviewing the existing scenarios and in particular their relevance of this work for the Technical Architecture project. Are they useful for thinking about the distribution system to 2050? Then, if further work is commissioned the subsequent Milestones will be:

- Agreement on new high level scenarios
- Initial translation of high level scenarios into consequences for the distribution system, i.e. into input and load scenarios
- Confirmation of consequences for the distribution system through workshops
- Mapping of functions required from the distribution system

ST2-Networks and Plant

It is conventional to divide the technology of distribution systems into those related to networks and those concerned with the development of new plant. Of course, this division is in some senses artificial as new network concepts inevitably require new plant and conversely new technology developments allow new system concepts to be realised. However, this division is proposed as a useful way of dividing the work.

The Sub-Theme will start by reviewing previous work in both areas and attempting to form an understanding of its relevance for the UK and the requirements developed by ST1. The ST2 review will deal with a very wide range of work ranging from simple changes to existing distribution networks (e.g. changing neutral earthing practice) to much more radical ideas (e.g.

variable frequency operation). Hence a key element of the work will be to place possible technology developments into their appropriate time scale. The ST will also have the difficult task of recognising the scale of investment in existing assets while still being open to new concepts.

A review will also be provided which will take into account the various characteristics and services that enabling T&D technology can offer to the system under various scenarios identified in ST1 and will include a review on how success or failure of the enabling technology is measured . This will include not only primary plant but also the assessment of the value of communication and control infrastructure. In particular, the development of the new and emerging standards and recommendations (such as IEC61850) will be reviewed with respect to the benefits they provide to integrate devices and applications into the distribution network. The 'joined up thinking' they bring with respect to the development and real time control of power networks will be considered.

There has been very considerable work undertaken in both distribution networks and plant although some research on new materials and new equipment may be commercially confidential and not available to the project. Concepts that will be investigated include:

Networks

Comparison of UK and other national distribution practices
Alternative architectures for distribution networks serving different load densities and types
Emerging concepts such as active management of distribution networks
Research concepts including MicroGrids and self-organising networks
Speculative concepts including the role of gas and hydrogen as energy vectors.

Plant and materials

Review of new developments in distribution plant for conventional network architectures
Status report on plant technologies that have yet to gain widespread market acceptance (e.g. superconductors, power electronics etc)
Status reports on network protection and automation, including DMS systems.
Review of new materials with potential for major developments of distribution plant.

Again, there has been a very large volume of previous work, particularly that undertaken by EPRI in the US and various research projects (e.g. on MicroGrids in the US and EU). The potential of new materials and new plant has also been investigated by a number of organisations. A fruitful line of enquiry is likely to be a review of those devices that have been developed to the prototype stage but have yet to gain market acceptance.

Tasks for ST2

The proposed Tasks are listed with an outline timescale in terms of lapsed months. The challenge with the initial work of ST2 will be to deliver a coherent overview of a very broad area without spending excessive time or resource. Hence ST2 is only defined for an initial 6 month period to be followed by a Review:

Task No	Months	Task Description
8	1-4	Review previous work on network architectures and place in UK context for development out to 2050
9	1-4	Review existing and anticipated developments in distribution plant and materials
10	Milestone 1	Report and workshop to summarise Tasks 1 & 2.
11	5-6	Review work of ST1 for relevance to outputs of ST2.

Deliverables of ST2

The deliverables follow from the work programme. The initial 4-month studies will each result in a report that will be discussed at the Workshop. Then the results from the Workshop will be used to relate the outputs of ST2 with those generated by ST1.

Appendix 5 – Key Stakeholders & Barriers to Success

Technical Architecture – Key Stakeholders & Barriers to Success

Author: David van Kesteren

Background

The electricity distribution infrastructure of Great Britain has developed over the past century from many stand-alone networks into large radial and interconnected networks, linked nationally by the GB transmission system. The distribution systems have generally been designed to have power flows from the transmission system, down to end-customers connected to the distribution networks.
It is recognised that the way electricity is generated and used continues to evolve and that the existing distribution systems also need to evolve. The future development of the distribution systems and the way in which they connect to end-users is the focus of this project.

The Technical Architecture project is aiming to determine the possible requirements of the distribution systems in 2050 and then to identify ways of moving from the current architecture to those future possible position(s). There are already papers in the public domain discussing aspects of the work to be undertaken by this project. Where credible work already exists in a particular area there is no plan to duplicate effort.

Way Forward

To deliver the overall objective, the project has been broken down into a number of individual work packages. It is recognised that these work packages cannot be undertaken independently of reach other. Where subject areas overlap, coordination is required to ensure proposed outputs are complementary.

This work package will identify the stakeholders that are key to the delivery of the overall project. It will also identify the barriers to success so that plans can be made to minimise the barriers as necessary.
This work package will have close links with those identifying what the future will possibly look like in 2050. *Which work package will deliver the initial road map??*

Tasks

Initial Identification of barriers to change

Any proposed scenario for the future technical architecture of the distribution network is unlikely to be achievable without overcoming some existing or future barriers to success. It is recognised that not all barriers to success may be fully identifiable prior to detailed analysis of the proposed scenarios.

However, there is merit in collating those existing and potential barriers that are easily identifiable now.

This task will identify, at a high level, the existing and easily identifiable future barriers to the successful development of the technical architecture of the 2050s.

This task will probably involve a literature survey of published papers that consider the development of distribution systems and end-user connections / technologies, to collate identified barriers to change.

At this stage, it will not be necessary to identify how the barriers will be broken down.

*The following areas should be considered, but is not considered to be exhaustive:

Technical limitations
Cultural issues
Regulation
Statute
Customer reaction
Cost
Resources

Identification of Key Stakeholders

Prior to the development of the possible technical solutions and architecture for the distribution networks of the 2050s, it will be essential to identify who the key stakeholders are likely to be and to obtain their support for the project. It should be recognised that the key stakeholders will probably come from those areas where potential barriers to change are identified as well as those areas where implementation will be required. The group of key stakeholders should represent the overall electricity sector (including end-users, manufacturers, etc.) in an un-biased manner, but must include those people with the necessary understanding and influence to enable any necessary changes within the sector to take place.
This identified group of people will provide a balanced representation of views,

This task will, based on the existing industry structure and the identified potential barriers to success, draw up a list of the stakeholder business sectors / organisations / groups and the barriers to success that are identified as existing within that sector. Individual key stakeholders within the sectors will then be identified, based on their knowledge, understanding and ability to enable any necessary change within their sector.

Appendix 1 contains an initial view on the possible list of stakeholder groups. This list is provided for information, but is not considered to be definitive.

Detailed identification of the barriers to change

After developing the possible solutions for the future and proposing a roadmap showing the possible steps for the development of the distribution network, it would be prudent to undertake a review of the proposals to identify what barriers exist. It is probable that the road map will already have barriers marked on it.

This task will examine the proposed roadmap and identify any additional barriers to development of the network that are not already identified on the roadmap.

*Where barriers are identified, then solutions to avoid or remove the barriers will be required.

The identified key stakeholders will also be reviewed to ensure that the list remains comprehensive and up-to-date.

Deliverables

Agreeing Scope of task

Prior to commencing work on the tasks, the contractor will provide, for approval, a written assessment of how they will tackle the tasks and how they will present the deliverables. Any proposed changes to the specification will be agreed before commencement of the work.

Initial Identification of barriers to change and key stakeholders

Tasks 3.1 and 3.2 will be combined to deliver a report showing the identified existing and potential barriers to success. Against each barrier, is required a list of those groups of key stakeholders who would most likely be important in removing the barrier to success.

Key stakeholder groups should be identified by sector. It is recognised that some groups of stakeholders may not be identified as being key to the removal of any barriers.

For each stakeholder group, a list should be provided of contact details for prominent individuals capable of engaging in the Technical Architecture debate and with the necessary influence to drive the overall project to a successful conclusion. For each person identified, a précis of no more than 50 words should be included, showing their relevant experience to the successful delivery of the project.

Identification of Barriers to Change

This deliverable will only be achievable when a roadmap for the Technical Architecture has been created. It will consist of two parts:

- A table that reviews the identified barriers to change on the roadmap, and the key stakeholders who could influence the severity of the barrier.
- Identification of additional barriers to success and key stakeholders, based on the roadmap.

Stakeholder Groups

The following list is only indicative of the potential stakeholder groups for the Technical Architecture project. The list of organisations and people attending the IEE TA events may also provide some ideas about potential stakeholders

- Skills training providers
- Network designers
  - DNOs
  - TNOs
  - Generators
  - Private networks (large industrial / commercial)
  - 3rd party designers – consultants
  - LV designers – wiring regs
- Network operators
  - DNOs
  - TNOs
  - Generators
  - Private network operators
- Energy Suppliers
  - Vertically integrated
  - Brokers
- End users
  - LV Domestic
  - LV Commercial
  - LV Industrial
  - HV Industrial
  - HV Commercial
- Equipment manufacturers – by region
  - UK
  - Europe
  - World
- Equipment manufacturers – by type
  - Generators
  - Load devices
  - Switchgear
  - Transformers
  - Protection
  - Control and instrumentation
  - Telecommunications
  - Cables
  - Overhead lines
- R&D Organisations
  - Manufacturers

- Universities
- Private Research houses
- Trade bodies
- Government departments
- MoD (DRA?)

Standards bodies

- BSI
- ENA
- CIGRE
- IEC
- CENELEC

Governing Bodies

- Ofgem
- DTI
- HSE

Appendix 6 – Tools and Methodologies

Technical Architecture Project:
Tools and Methodologies

December 2005

Prof. Jim McDonald, Dr. Graham Ault & Colin Foote

Centre for Distributed Generation and Sustainable Electrical Energy, University of Strathclyde

Main arguments presented in paper

A short summary of the main arguments presented in this paper is listed:

- Analytical tools are the mainstay of developing real understanding of power systems from planning to operations timescales
- Many analytical tools for power systems exist from commercially available status to research and development stage
- It is thought likely that the existing tools do not address all the issues in analysing power systems with different architectures and under different commercial and regulatory frameworks
- An overall framework and methodology for the analytical tools of the future is required to clearly show how they will be used and what value they bring in planning and operating future power systems
- Many unused or underused tools and techniques can be identified that can bring value to understanding power systems of the future
- A guide to the use of existing analytical tools can be developed to show how value can be extracted from these tools
- The identified new tools can be prioritised to identify those with the potential to yield real value in the analysis of future networks
- Research, development and commercialisation plans are required to the new analytical tools with identified high value potential
- Standards and specifications for new analytical tools can be generated to provide signals to the software development market
- Data collection, integration, management and exploitation is viewed as a key facet of any analytical tools and methodologies strategy

Objectives for Tools and Methodologies Work Stream

The initial brief provided for this work stream by the Technical Architecture project steering group is as follows:

'To ensure deployment of innovative products and solutions in an economically efficient manner there will need to be tools to evaluate various technical scenarios as well as methods for implementation at the lowest risk. Identifying these tools and methodologies will also have to be complimented with performance indicators to identify the merits of various different scenarios to allow management to assess the benefits or deficiencies of particular implementations'.

During the course of the project specification phase the remit for this work stream has been the topic of substantial discussion and a more precise statement of the scope of this area might be:

Identification and specification of analytical tools and an overarching methodology to facilitate the transition of power systems from their present configurations towards future architectures foreseen by this project. This includes the key elements of data inputs, analytical techniques and output metrics and covers analysis in the planning phase through to analysis conducted in the operational phase.

The key elements stated in this objectives statement are developed throughout this paper.

The primary aim of this paper is to scope out a set of tasks to be taken forward by contractors to the project to investigate and develop specifications for key analytical tools to underpin the evolution of network technical architectures appropriate to various scenarios that might arise in future years.

The audience for this paper is primarily the successor industry wide work group to the Distributed Generation Coordinating Group (DGCG) and its Technical Steering Group (TSG).

Background to Analytical Tools and Methodologies Development

The challenges for analytical tools and methodologies will stem from the visions of future networks developed elsewhere in the Technical Architecture project. However, for now it is assumed that future networks will contain more distributed generation, more communications, more automation, more power electronic devices and possibly more energy storage devices and demand side management activity. In addition, active management of generation sources might be more prevalent and expectations of quality of service will probably have risen further. Regulation will be conducted from enhanced information and data sets and will place challenging targets for technical and financial performance on network operators. All of this will take place in a socio-political climate that is likely to demand ever-higher standards of supply, safety and environmental protection.

Power system analysts already have many tools available for use in understanding the power network and recommending actions required from shorter operational timescales to longer planning timescales. It is expected that network operating company analysts will be one group in the set of primary users of new analytical tools and methods. Other groups are likely to be generation developers, regulatory analysts, consultants and academics each of who will have specific objectives in mind in analysing power distribution systems of the future.

Shortcomings in currently available tools and methodologies can be identified from a brief discussion with any power system planner or operational engineer. Some of the high level challenges for analytical tools are discussed below:

- ***Rate of Technological Change***: The pace of change in technologies already being connected to power networks and in various stages of research and development present a serious challenge for the existing generation of analytical tools and methods. Existing tools and methods are optimised for large-scale transmission systems and distribution systems with little or no power generation. The proliferation of energy storage, distributed generation, solid-state equipment (converters, switches and transformers to name a few) and greater demand-side participation are not addressed well in today's software applications. To enable power system analysts and planners to evaluate these technologies and recommend effective and efficient developments to power systems requires a rethink of the analysis tools that provide the foundation to executive decision-making.

- ***Growing Need for Detailed Analysis***: One of the primary challenges facing distribution companies is the modelling, simulation and analysis of network performance and behaviour in a new technical, economic and regulatory environment. New technologies, such as distributed generation and power electronics, require the development and validation of new models. And with different incentives for stakeholders in the network and new ways of operating, new types of analysis will have to be performed. In line with changes in the industry and regulation, distribution companies must also conduct more comprehensive economic and financial evaluation. This includes the proper consideration of externalities like environmental factors. Thus, the analysis that must be conducted by distribution companies is both more extensive and more complex.

  This poses a problem because conventional analysis methods are too expensive, in terms of time, skills and other resources required. High-level planning decisions are sometimes made without sufficient technical analysis. For example, lower voltage assets are treated as numerous enough and cheap enough to be replaced based on statistical analysis. New connections are sometimes agreed without detailed analysis of the implications. Generally, there is a different approach to major and minor projects due to the high expense of investigation. It is assumed that the system can accommodate small changes but limits are eventually reached. If the burden imposed by technical analysis was smaller then decision-makers could be better informed about the implications of particular courses of action. The context for greater levels of analysis is one of declining or at least static personnel numbers with a reduced technical/analytical skill set.

In the past, distribution networks have had spare capacity for a number of reasons including standardisation of equipment. The additional capacity and security provided cover for the uncertainties of demand predictions. The acceptance of generous margins also made it possible to apply rules of thumb and use prepared tables and charts in design. However, the excess capacity built into the networks of the past has been taken up by load growth, and reduced expenditure in recent years means the excess capacity has not been replaced. Pressures on DNOs now mean that networks must be designed more precisely with less, potentially useless, spare capacity. This requires new rigour in the analysis of requirements and design of solutions.

- ***Difficulties in Formulating Strategies and Making Decisions:*** With all the changes in technology, regulation and the commercial environment, one of the primary challenges faced by distribution companies is the formulation of strategies. With so many new issues to contend with, within an ever-changing incentive structure, managers and engineers need new methods to support decision-making. Preparing internal business cases and developing expenditure plans for presentation to the regulator are central tasks in the life of a DNO and both require the exploitation of existing and new tools and methods.

Conventional approaches to electricity distribution network planning are often deficient in their accommodation of multiple objectives or multiple criteria. The multitude of optimisation algorithms that have been proposed in the past are typically based on a three-pronged approach addressing load forecasting, substation site and size, and feeder route and capacity. These algorithms rely on a limited expression of requirements. Typically, they minimise costs – calculated as a function of substation and feeder type and capacity – with predicted customer demand profiles as the goal to be satisfied; statutory and company design standards might be included as constraints. An optimisation algorithm focusing on a limited number of factors might be used to produce the first version of a plan then constraints imposed to take account of externalities like environmental issues. Optimisation methods may also be used to define design standards, which are then applied in a wide variety of circumstances.

Planning and design would be improved by explicitly including more factors amongst the objectives considered in the first place. Attempts have been made to extend optimisation algorithms to take account of additional issues, reliability being one example, but it can be difficult to translate continually changing regulatory, environmental and financial drivers into tangible engineering objectives. In electricity distribution, there are many stakeholders with different and ill-defined objectives so the emphasis must be on finding an acceptable solution rather than an optimum. For this reason, conventional optimisation algorithms are inappropriate. Greater network complexity will necessitate the explicit consideration of even more issues, reducing further the value of limited optimisation algorithms.

In general, in the conventional approach to distribution network planning and design, there is a lack of support at the higher decision making level. There have been some recent advances in the integration of computer-based tools but integration and interpretation of results is still mainly a manual task. Integration of power system analysis tools with enterprise wide information and analysis systems is also under-developed on the whole.

- ***Managing Power Systems Knowledge:*** As with other engineering enterprises, DNOs rely on the knowledge of their staff for effective and efficient operation. Information systems, including databases and documentation, should be maintained and kept up to date to be of use. But some DNOs have, due to pressures of time and money, not maintained these systems, some of which date from the days of the nationalised industry structure. Instead, the knowledge and experience of staff is relied upon to compensate for missing data or inaccuracies. The loss of knowledge as people move can be damaging. In particular, centralisation of DNO functions has resulted in the loss of people with in-depth knowledge of a specific geographical area. This local knowledge used to compensate for missing or poor quality information.

  Knowledge management is an important issue for DNOs and exposes a shortcoming in the conventional approach. The methods used in planning and design must take account of this by facilitating the capture of the reasoning behind decisions as well as the decisions themselves. Knowledge modelling methodologies are available that facilitate the capture of knowledge from important staff, helping to spread that knowledge and provide insurance against their departure.

  The extent to which analysis tools and methodologies can support and exploit knowledge management is a key issue for investigation.

- ***Accessing and Managing Network Data from Multiple Sources for Multiple Uses:*** The data input requirement of the next generation of analytical tools is a major consideration. Power network managers will likely opt to avoid the collation of large data sets for analysis so the use of existing data sets and the clear specification (and justification) of additional data sets will be necessary. Data management is a key area for investigation and includes the interoperability of analysis tools and the management, integration and exploitation of enterprise information systems covering areas of geographical data, asset data, network technical data, customer data and many other data domains.

These needs provide a justification for a comprehensive investigation into analytical tools and methodologies such that tools are available in a timely manner to underpin the evolution of future networks.

Outline of Main Tasks

The proposed programme of work developed in this paper takes the following structure (Table 1):

No.	Task	Deliverables
1	• Analytical Methodology and Analytical Requirements	• Specification of framework and methodology for future analytical tools • Statement of needs for the analysis of future network architectures • Statement of possible tools and techniques and how they meet future needs
2	• Review of Analytical Tools for Power Systems	• Statement of commercially available tools that meet the needs of analysing future networks • Statement of research and development stage tools that address future needs • Report on good practice in practical use of existing tools to facilitate innovation in network design • Identified gaps between available tools and expected future requirements
3	• Prioritisation of New Analytical Tools	• Prioritised list of analytical tools explicitly showing the value for analysis of future networks
4	• Standards, Specifications and Research/ Development Programmes	• Outline standards for evaluation tools • Functional specifications for evaluation tools • Recommendations for research/development programme to generate know-how in gap areas

Table 1: Summary of main tasks in 'Tools and Methodologies' work stream.

These four streams of work are developed in the following sections.

Task 1: Analytical Methodology and Analytical Requirements

A clear specification of the architecture and over-riding philosophy of a tool-set to meet future needs is required so that tools, data requirements and expected outputs can be clearly understood.

The general framework within which existing analytical tools operate is illustrated in Figure 2. This shows that analysis essentially sits between data and information and the making of decisions. In the operations phase this might involve the collection of power network measurements collected through RTUs (at the data level) and the transmission, collation and archiving of this data in the information management level. At the analytical tools level a control engineer might process the information or a control room tool might analyse the incoming data. In both these cases, a decision for control action will be made based on this analysis. In the planning phase the same framework applies for the analytical tools used in planning. Data might be collected from asset inspection sheets or third party inputs and this data will be managed through saved network models and enquiry registers. Analysis will be performed on this gathered data and information using power system analysis tools and asset management tools. Again decisions will be made by planning engineers on the correct course of action based on the analysis. Sometimes asset management tools will produce recommendations directly thus incorporating analysis and decision making.

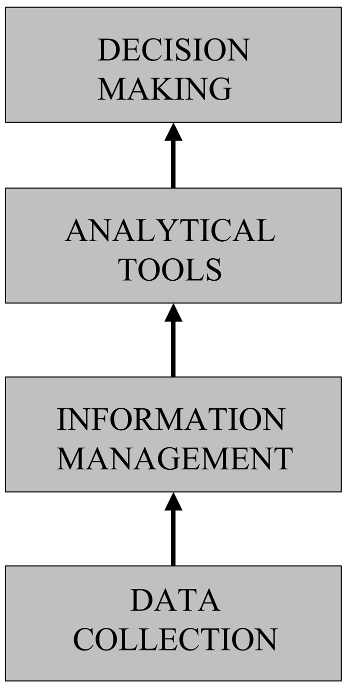


Figure 2: Context for analytical tools.

It is envisaged that this basic framework will change as illustrated (simply) in Figure 3. The most prominent needs of future analytical tools (and the impact on the surrounding framework for analysis) are noted and further outline discussion of these points is provided below. This task must resolve the issues of the framework for analysis, the high level methodologies employed and the requirements of the analytical tools that will sit under the framework and methodologies.

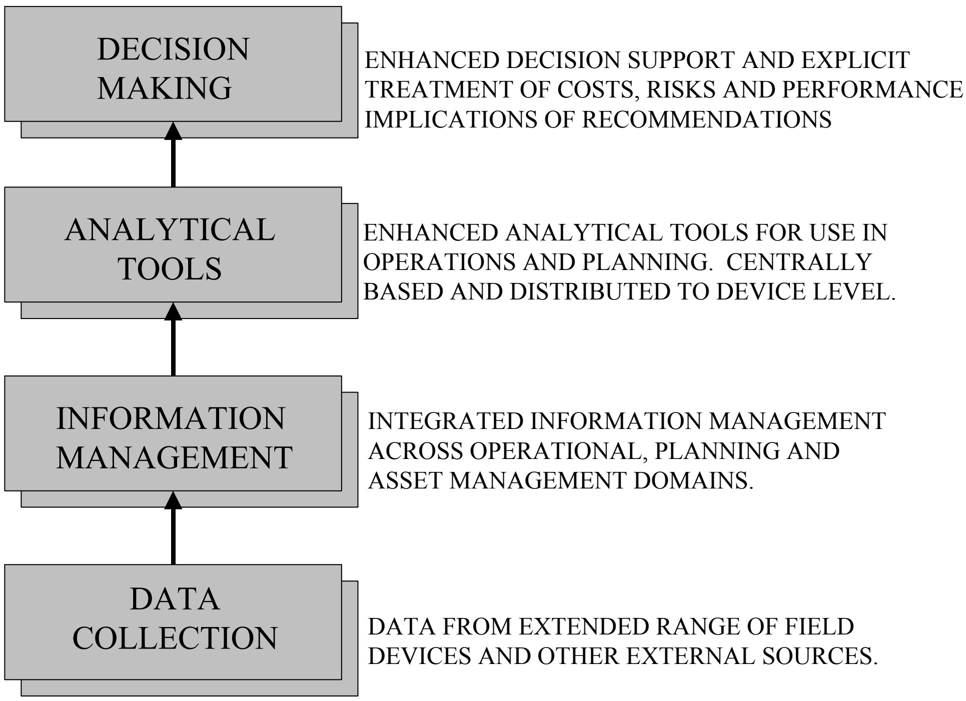


Figure 3: Future context for analytical tools.

It can be seen (from these illustrations) that significant changes might be required to achieve methodologies capable of meeting the challenge of new network architectures. The high level methodologies for analytical tools must be investigated as an integral part of this project. This will help to secure an outcome that is not simply a collection of tools but rather a rational framework which meets the needs of all stakeholders in future power networks.

Desirable analytical tools can be identified for distribution network analysis in the transition towards future network architectures. It is of crucial importance to evaluate analytical methods from diverse fields and adopt ‘best practice’ for distribution network analysis. This following list of features of planning and analysis tools serve as a starting point for the future study of requirements in tools and methods. In summary, network planning and analysis methods might have the following attributes (grouped according to key issues):

Key outputs:

- Key performance indicators to provide the means of assessing the impact of new equipment on incentivised performance:
    - Customer Interruptions (CI)
    - Customer Minutes Lost (CML)

- Short Duration Interruptions (SDI)
- Other emerging measures of DNO performance such as DG connections and losses.

- Price Control Review cases for CAPEX and OPEX
- 'Internal' business cases for system development project proposals
- Asset condition and remnant life assessments
- Asset management decision making outputs to underpin the evolution of network architecture
- Explicit representation of technical, financial and business risk
- Commercial and market outcomes (e.g. energy prices, ROCs prices, constraint charges, etc.)

Menu of techniques (in power system analysis and networks business management):

- Integrated techno-economic modelling of both CAPEX and OPEX options
- Decision making tools and methodologies to assist in prioritisation and selection of options
- Multiple criteria (or objective) framework for analysing different issues (e.g. technical, financial, risk, policy) over a wide range of performance indicators
- Wide ranging time scales for studies ranging from microseconds (for power electronic and harmonics issues) to planning horizons of years (for annual assessments of losses and lifecycle assessments for power plant)
- Models appropriate to analysis, anticipated novel devices and emerging business processes
    - Dynamic issues for small-scale power generation in lower voltage networks
    - Treatment of power electronics in power system dynamic simulation
    - Planning for active management of networks (e.g. comparison of options to identify best option or compare against traditional network reinforcement options)
    - Integrated energy and communications systems analysis, incorporating protection and control
- Probabilistic methods, scenario analysis and risk analysis to address the inherent uncertainties, stochastic nature and risk management objectives in emerging and future power distribution systems
- Fast simulation methods to enable decentralisation of analysis and decision making in distribution system operations and optimise the trade-off between communication of data and local processing
- Case based reasoning to provide a means of storing and retrieving previous analytical and planning activities that can be 'recycled' for a new problem

- Simulation across the Internet through the use of Web services technology to optimise the sharing and processing of power systems data

Data, information and knowledge issues:

- Maximise use of existing databases and models for more effective analysis and planning (e.g. linking of planning and analysis tools to operational and asset management data)
- Exploitation of GIS data and GIS technologies
- Produce tractable planning records to facilitate reuse of data, models, solutions and planning rationale and provide leverage to future activities
- Knowledge management in technical analysis to support the goal of establishing best-practice and to capture valuable knowledge from scarce experts
- Data models and the transferability of data between software applications including the use of the Common Information Model (CIM) for data and model exchange

User features:

- Support objectives in other activities (e.g. procurement, asset management, etc.)
- Address a reduced analytical capability in the power industry by enhancing planner productivity and providing robustness to limited planning resources
- Make appropriate use of computer-based tools including simulation, optimisation, graphical interfaces, bulk data handling facilities and mathematical decision techniques
- Modularity, in terms of access to analytical components and providing means of integrating analytical modules and interfacing with other applications
- Effective representation and exchange of models and data to support the goals of compatibility, co-ordination of simulation and establishing best-practice
- Automated and/or interactive as appropriate
- Insightful to the planning problem and solutions
- Interaction and integration of online operational and offline planning tools

Clearly this presents a long list of possible features of future analysis tools. The intent is not to suggest that all these methods should be incorporated in a future set of tools and methods but that they should be considered for selection of a set that best meets the needs of the industry in future.

In addition to these requirements of tools and methods is the issue of adoption within the power community. Barriers to adoption include:

- Potentially large data handling overhead (which must at all times be balanced with the benefits the data exploitation brings)
- Availability and ownership of data required by new tools and methods
- Inertia within organisations preventing the uptake of new product offerings (this might reflect the reasons listed below)
- Costs of new software tools
- Costs of data collection and management
- Training of staff in use of new tools
- Migration of data from existing sources to new tools

The outcomes of this task are a clear statement of analytical needs (with available techniques that might meet these needs) for future power systems and a framework that supports the use of these tools within the network utility context.

Task 2: Review of Analytical Tools for Power Systems

It will be essential to build a common view of the state of the art in power system analysis and related power networks enterprise software to compare with that which might be required for analysing future power systems. Previous attempts to review the functionality of commercially available power system analysis tools have been undertaken and the value of such a review has been established (See Table 3 and Table 4 in the Appendix). A similar review of a wider range of analytical tools will provide a clear picture of where new tools are required or where recommendations might be made to adopt existing tools more widely. In particular it will be of great interest to include in this review the availability and application of financial, economic, environmental and decision making analysis tools.

It should be noted that the review of analytical tools undertaken should cover both online operational analysis and offline analysis for planning. It is foreseen that the interaction of offline and online analytical tools will be an interesting area of investigation.

An important aspect of this task will be to discuss with analytical software developers and vendors their views on the future development of analytical software. Subject to the natural constraints of commercial sensitivity, this might provide an interesting view of likely developments in tools that might influence the ultimate recommendations of this work package. Working with and around the software developers natural inclinations not to share details of planned product developments is a key enabler in this work.

The main outcome of this task is a clear statement of commercially available and research stage analytical tools with the potential to underpin the analysis of future power distribution systems. In addition, the gaps between what is available both commercially and as outcomes of research, and the requirements of future networks will be stated explicitly. These gap areas will be carried forward to Task 3 for assessment of their value in contributing to the support of analysis of future network architectures.

Those tools that already exist and can make a valuable contribution to the analysis of future networks but are not widely used at present should be highlighted. Recommendations will be made to facilitate their wider application within the industry and this will address the issue of how the tools might be used in a cost effective way. The cost of implementing existing tools is a key issue for power network stakeholders.

Task 3: Prioritisation of Analytical Tool Development

Based on the scoping of possible analytical tools in Task 1 and the review of existing tools in Task 2, this task deals with selecting analytical tools (from those that are not available now) to be developed further.

Several factors must be considered in this task but the two of prime importance are likely to be the effort to make available and the value they will bring in analysing future power networks. In addition, the likely monetary cost of the tools and the data management cost should also be considered, as these are major factors affecting the future utilisation of the tools.

In conjunction with the results from Task 2 it should be possible (on completion of this task) to map out the value of each existing and new analytical tool, the existing or potential breadth of usage and the costs of development, purchase, maintenance and use.

Clear recommendations on the analytical tools that should be developed will be delivered so that the work of specifying these tools can be undertaken in Task 4.

Task 4: Standards, Specifications, Research/Development Programme for Tools and Methodologies

The outcomes of the previous three tasks will provide the foundation for development of standards and specifications for the next generation of tools and methods for analysing power systems. Standards and specifications are essential for highlighting to the market place the most valuable direction in which to focus product development efforts. In addition, open standards and specifications allow the interoperability of products from different vendors.

A clear statement of the likely interaction (if not integration) of analytical tools must be provided so that the implications of not only the analytical tools but also the framework in which they sit can be understood.

The development of standards provides a means to disseminate accepted architectures and functionality of analytical tools to the software development community.

The study proposed should establish a working proposal for a framework for analysis of future networks as understood by the Technical Architecture project. This will draw on the requirements identification plus the findings in other parts of the Technical Architecture project such as the ‘future scenarios’, ‘stakeholders’, ‘asset management and skills’ and ‘standards’ activities.

Next Steps

This paper has outlined four work tasks to be undertaken by contractors to the Technical Architecture project from 2005 onwards. These tasks will deliver an analytical strategy that will support the development of novel power system architectures to meet the challenges of sustainability, competition and social welfare in future years. An industry-wide working group must review this proposal and form a detailed work programme based on these tasks in the light of other industry wide initiatives at that time.

Timing and Cost of work

It is believed that a proficient team of power system analysis specialists can complete the work specified in this paper in one year.

The programme of work identified in this paper requires the following (Table 2) resource for satisfactory completion:

No.	Task	Resource Requirement
0	Steering group meetings and overall task management	Contractor Effort: 8 person-days Steering Group Management and Review: 8 person-days
1	Analytical Methodology and Analytical Requirements	Contractor Effort: 50 person-days Steering Group Management and Review: 6 person-days
2	Review of Analytical Tools for Power Systems	Contractor Effort: 40 person-days Steering Group Management and Review: 6 person-days
3	Prioritisation of New Analytical Tools	Contractor Effort: 20 person days Steering Group Management and Review: 4 person days
4	Standards, Specifications and Research/ Development Programmes	Contractor Effort: 40 person-days Steering Group Management and Review: 6 person-days

Table 2: Resource requirement for ‘tools and methodologies’ work stream.

Appendix: Extract from previous review of power system analysis software tools

Planning / Analysis Packages	Voltage Transients	Short-Duration Voltage Variations	Long-Duration Voltage Variations	Voltage Fluctuations	Voltage Phase Balance	…
ASPEN DistriView					Basic	
CAPE					Basic	
Contingency Study						
CYMDIST (CYME)					Basic	
PSCAD/EMTDC	Basic	Basic	Basic	Basic	Basic	
EUROSTAG	Advanced	Advanced	Advanced	Advanced	Basic	
IPSA	Basic	Advanced	Advanced	Basic		
…	…	…	…	…	…	…

Table 3: Extract from review of power quality analysis functionality in proprietary software tools.

Software Package	New Models Functionality		Compatibility with other packages		….
	Entirely New	Modification of Existing Data	Input Data From Other Programs	Output Data to Other Programs	…
EUROSTAG	Yes	Yes	Results & measures from external packages can be included.	EUROSTAG can output data to other packages such as spreadsheets or word processors.	…
NEPLAN	Yes	Yes	Data can be input from: PSS/E, DIgSILENT, PRAO, Sicad and DVG.	Files can be exported to a variety of other packages e.g. MS Excel. Neplan also allows import/export to GIS and SCADA systems.	…
…	…	…	…	…	…

Table 4: Extract from review of additional functionality in proprietary analysis tools.

Appendix 7 – Standards Investigation

Author: Mike Kay

1. Introduction

The DTI/Ofgem Technical Steering Group is currently running a project to investigate the issues surrounding the likely technical architecture of future electricity distribution networks. The Project's principle aims are to sketch out the likely issues for a post 2020 network, as it develops towards a 2050 network, and is currently divided into the following areas:

- Regulation and Culture;
- Commercial and Procurement;
- Light Current Equipment and Requirements
- Future Scenarios – "Outside the Box" and Transferable Technologies
- Skills, Maintenance and Support
- Tools and Methodologies
- Future Energy Deployment and Design
- Impact of Standards and Migration Planning
- Network Design Stakeholders

This specification for future work covers the "Impact of Standards and Migration Planning" study for the Technical Architecture Project.

2. Aim of "Impact of Standards and Migration Planning" Study

Changes in international and national policies, and the resulting legislation, directives and standards, are already having an effect on UK distribution networks, and will continue to do so. Conversely the changing distribution network designs will need new standards and amendments to current standards.

The aim of this study will be to:

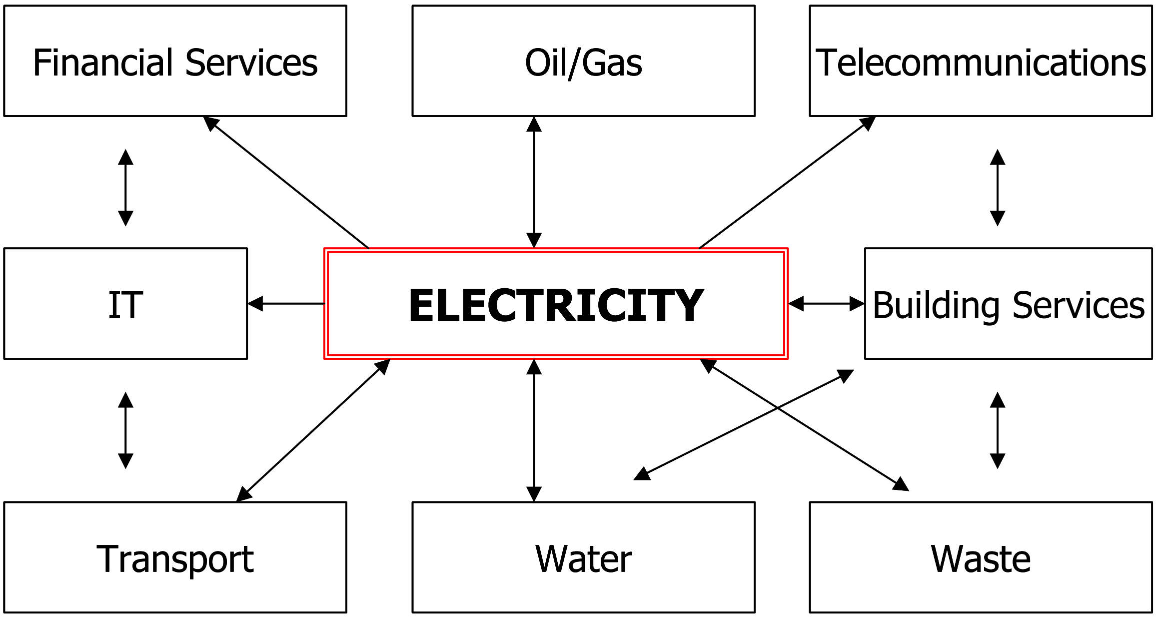
- identify the likely areas of policy, legislation, directives and standards which could change over the period up to 2020 and which will affect the UK distribution networks over the period up to 2050
- identify the likely groups of standards which will be required, or which will need to be amended, as a result of the changing design of UK distribution networks
- identify the policy making and standards bodies involved and evaluate their existing and future interactions
- make recommendations to improve their effectiveness, and ensure that a coherent and timely approach is taken

3. Background

3.1 Current and Future Changes in Policy, Legislation and Directives

There are many areas of legislation, policy, and directives that could affect the standards that will be required for the distribution network and its assets.

Energy Policy issues are the key drivers but areas such as transport infrastructure changes, health and safety regulations, environmental legislation, building and planning regulations and telecommunications requirements for example, will all shape the legal, regulatory and physical infrastructure within which the networks will have to develop and operate. The following chart shows some of the industries related to and dependent upon the electricity supply industry.



There are a number of changes from the last few years, which are already starting to have an effect on the future planning, design, and operation of UK distribution networks, and the standards used.

The European Union produced a Green Paper in 2000 'Towards a European Strategy for the Security of Energy Supply'. This proposed a strategy to diversify energy imports, to reduce energy consumption in Europe through improved energy efficiency, and to increase the use of renewable energy sources. The European Directive on 'The Promotion of Electricity Produced from Renewable Energy Sources in the Internal Electricity Market' was subsequently adopted in 2001. This sets a 21% target for electricity from renewable sources to be achieved by 2010 for the enlarged EU.

The UK Government's Energy White Paper set a target for a 60% cut in carbon dioxide emissions by 2050. Shorter-term targets have also been set by the Government for 10% of all the electrical energy supplied in the UK to be generated by renewable sources by 2010, 15% by 2015 with the aspiration to achieve 20% by 2020. A significant proportion of this renewable generation is being connected to the distribution network. This is increasing the intermittency of generation connected to the system, and is giving a greater focus on matching generation to demand. Measures being considered include inter-tripping and active control of distributed generation, demand side management and energy storage.

Increased distributed generation can also lead to difficulties with power flows, short circuit levels and voltage control. Solutions being considered include equipment upgrade or replacement, network reconfiguration, fault current limitation, active control of voltage regulators within networks, and, again, active control of generators and demand.

New equipment is being developed and used to meet these new requirements. For example, there are new models of electricity meters that make it possible to meet demand management requirements and introduce multiple tariff structures. Automatic remote meter reading is likely to be introduced at some time which will make it possible to read meters more frequently and efficiently.

It is not only the electricity supply industry that is undergoing change, for example, Part L of the Building Regulations is to be changed to require developers to meet far more demanding carbon emission standards when designing new buildings. This will reduce new building energy consumption, and could increase the use of micro-generation. This will have an effect on the demand profile that UK distribution networks will have to supply. Increasing penetration of micro-generation will eventually affect how lower voltage distribution systems are designed and operated.

The forthcoming Waste Electrical and Electronic Equipment (WIEE) and Restriction of Hazardous Substances (RoHS) directives will emphasise the need to review product design and life cycle thinking, by introducing cleaner, more sustainable design approaches to deal with product end-of-life management.

European transport policy is to promote an environmentally friendly mix of transport services, hand in hand with measures to open up the markets. Current UK Government transport policy is for faster, greener and more reliable transport that will meet long term economic, social and environmental goals. It is expected that there will be greater use of shared transport and more investment in public transport, particularly buses. A focus on energy efficiency and a reduction of the reliance on oil in road transport will continue the drive towards the development of alternative technologies, including hydrogen fuel cells. Solar powered highway infrastructure is currently being tested as a pilot on the M27. More widespread use of this type of technology will change the pattern and size of electricity demand.

Primary legislation can have an important influence on whether or not new practices, new designs and new standards can be adopted rapidly. For example, health and safety legislation in the UK is rather different to that elsewhere in Europe. For example the adoption of explosive fault current limiters in the UK has not yet been possible.

3.2 Ongoing and Future Changes in Standards

The standards relevant to the Technical Architecture Project fall into two groups. In the first group are those that could affect the distribution network because they will change the demand patterns, location and magnitudes, or the size, type and location of generation, or the specification of the equipment that can be installed.

The second group consists of those that will need to be created or amended to enable changes in network design and specification. For example new standards have been and are being developed as a result of the new types of generation being connected to the system. ER G83/1 for micro-generation is one example. Existing standards are being reviewed and changed, for example the P2/5 security standard which is being updated to take into account the contribution that distributed generation can make to system security.

For the active control of generators, demand and networks, standards to ensure fast, reliable and resilient communication and control will be required, possibly between network components and devices on the customer's side of the meter, ie demand side measures. Standards to ensure compatibility between different devices will also be required.

3.3 Policy and Standards Making Bodies

There are a number of policy forming and standards setting bodies involved. The majority of new legislation implemented by the UK Government has resulted from policies and secondary legislation (directives and regulations) coming from the EU. For example, the European Commission's Directorate-General for Energy and Transport develops and implements policy in these closely linked areas.

EU directives are formed by agreement within the European Commission after consultations with the various bodies that will be responsible for endorsing the laws derived from the directive in member countries. These bodies more often than not cooperate with the industries that the directive will affect to ensure that the law will be enforceable and will be deemed possible to comply with.

The British Standardisation Institute (BSI) provides UK industry and other stakeholders with their major access to and influence on standardization, both in the European arena (with CEN, CENELEC and ETSI) and internationally (with ISO, IEC and ITU). The BSI entrusts the preparation of standards to various technical committees that receive input from business managers, trade unions and technological experts.

The standards underlying the design and operation of distribution networks arise from a number of sources, as shown on the chart.

Some of the standards and guidelines in the diagram above are also applicable to the UK transmission networks and their respective system operators.

3.4 Need for Effective Interaction Between Policy and Standards Making Bodies

Effective interaction is required to ensure that the further development of electricity networks is carried out in an efficient, timely and effective manner, and so that technical innovation is not stifled and market solutions and business practices are accommodated. It is also important to have consistency between different standards groups.

It is essential that representatives form the UK Government, business and industry are involved in the modification of current standards and drafting of new standards. This will ensure that their interests are incorporated into international policy, legislation and standards.

The UK is well placed to have a more significant role as it remains a major player in the EU not least because it supplies a significant part of the EU budget, but has strong relations with many Eastern European new entrants to the EU.

4. Scope of Work

The scope of the work can be separated into seven stages. The study will require the consultant to liaise closely with the appropriate stakeholders including but not limited to the DNOs, the DTI, standards bodies and the technical architecture project group.

Stage 1. Identify the likely areas of policy, legislation, directives and standards which could change over the period up to 2020 and which will affect the UK distribution networks over the period up to 2050.

This stage requires a detailed assessment of the key areas and policies that will have an impact on future UK distribution networks, their design, the assets and the standards required. This stage provides a foundation for the remainder of the work. It will also provide input into work being carried out by others to develop future technical scenarios.

The areas covered should include all sectors and activities which could result in:-

- *changes which affect the demand patterns, location and magnitudes*
- *changes which affect the size, type and location of generation*
- *changes in planning, health and safety or environmental requirements*
- changes in regulatory requirements, for example, for efficient and reliable networks, ie different requirements for losses and for customer interruptions
- changes in network technical requirements, for example, active network control, resilient communications and intelligent metering

These may include, but not be limited to:

- Energy (the Energy White Paper, 2003 lays out the DTI's plans to 2050)
- Transportation (the Transport White Paper, 2004 lays out the Department for Transport's plans to 2030)
- Telecommunications
- Planning, health and safety, and environmental legislation and directives
- Building regulations

The likely changes and their timing needs to be reviewed, recognising that they will be dependent to some extent on the results of the next, and subsequent, UK General Election.

Possible new areas of policy and regulation should also be identified, for example the protection of critical infrastructure from threats such as terrorist activity and increased flooding.

Stage 2. Identify the likely groups of standards whose creation or amendment would affect future distribution networks

These are the standards arising from the changes in policy, legislation and directives identified in stage 1. The focus should be on those that are not directly associated with distribution network design, operation and assets.

They should be those standards from across the sectors that indirectly affect distribution networks, through changing demand, generation, design or specification.

The scope of work includes identifying the standards that are likely to be amended, and the standards planned or likely to be required in the period up to 2020. This stage will also provide input into the work being carried out by others to develop future technical scenarios.

An interim report will be required upon completion of stages 1 and 2 of the work. This will be reviewed and agreed by the Technical Architecture Project Team before the next stage of work commences.

Stage 3. Identify the likely groups of standards which will be required, or which will need to be amended, as a result of the changing design of UK distribution networks

The input to this stage will be the future network scenarios (being developed by the Technical Architecture Project Team), the various reports on future network design commissioned by the DGCG work-streams under the auspices of the DTI New and Renewable Energy Programme, and the first two stages of work.

The scope of this third stage is to review the future network designs and operation, identify any new types or dispositions of network assets required and any changes required in the design and specification of existing types of assets.

The consultant should then identify the standards, guidelines and codes that will need to be amended, and the standards, guidelines and codes planned or likely to be required in the period up to 2050.

The review should also identify any primary legislation, which may require changing, to allow standards to be revised or new standards to be introduced.

A timeline for the development and amendment of the different standards should be estimated, taking into account the slow rate at which distribution assets are replaced, and the required rate of change of the distribution network.

Stage 4. Identify the main policy making areas and standards bodies, both national and International, that need to cooperate to produce the framework for future investment in innovation and development of the UK distribution networks.

It will be necessary to identify the appropriate policymaking and standards bodies (both national and international) that provide the framework for these areas and gain an understanding as to their current structures and working practices followed. The current governance arrangements for electrical standards in the UK, as outlined by Ofgem and developed by the Code Review Panels, should also be examined.

Stage 5. Analyse and evaluate the interaction between the relevant bodies

With globalisation dictating a move towards the integration and alignment of worldwide standards, the present framework within the UK must be assessed to determine its efficiency and ability to influence changes made at the highest levels.

Critical analysis should be carried out on the interaction between the bodies identified in stage four of this work. The purpose of this stage is to measure the effectiveness of the existing structures at incorporating the requirements, views and concerns of the distributors and government into the different legislative and regulatory frameworks that affect the distribution networks in the UK.

Any factors that may influence the future composition and cooperation between these groups will be identified and incorporated into this analysis.

This stage of work should also examine the timescales that the different bodies currently work to for developing new policy, legislation, directives and standards. Any planned changes should also be identified.

Best practices from standards making bodies working in fast-moving industries, for example, IT, should be investigated, and assessed for their applicability. Relevant best practice from other countries should also be investigated.

Stage 6. Recommend actions to improve the future effectiveness of policy and standards making bodies

Recommendations should be made for ways to improve the effectiveness of the present structure, give consistency between different standards groups and promote an environment conducive to technical innovation and development. Recommendations could include:

- Prioritisation of legislative changes required.
- Designation of new posts within national and international legislative and regulatory consulting bodies which would be filled by appropriate people to ensure that the voices of the distribution network licence holders are heard and that effective 'cross pollination' is achieved throughout the different sectors.
- Forming new workgroups or committees to have specific inputs to the policymaking and regulatory bodies.
- Altering existing practices so that communication and awareness between the various bodies is stimulated and improved, and existing processes are speeded up.
- It is anticipated that there may be a need for some forms of control measures/targets to be set in place in order to implement and manage the proposed structures. This stage of the study should include and identify any appropriate checks and balances required to implement the changes recommended.

It must be recognized that the Technical Architecture Project is concerned with issues surrounding a post 2020 network, as it develops towards 2050. Any recommendations made as part of this work must be sustainable and effective over the long term.

Stage 7. Test recommendations on the five future technical scenarios identified by the Technical Architecture Project

The final stage of work will be to revisit the future technical scenarios identified by the Technical Architecture Project Team, and ensure that the recommendations cover the full range of possibilities considered.

Programme and Deliverables

The deliverables from the project are to be:-

- interim report, to be delivered at the end of stages 1 and 2
- draft final and final report covering all seven stages

The programme should allow for a delay of [*to be defined*] between completion of stages 1 and 2, and commencement of stage 3. This is to allow the Technical Architecture Project Team to finalise the future technical scenarios for the networks.

Appendix 8 – Professional Engagement

Beyond Compliance

A sector unprepared for change?

A paper for discussion

John Scott (IEE Professional Networks)

1……The Challenge to the Sector

Electricity networks are a foundation of today's society, so much so that the service they provide is largely taken for granted. These networks are moving from a period of stability to a time of great transition. This change is being driven by the now emerging need for age-related renewal on a large scale, and by the increasingly pressing demands to harness cleaner and renewable sources of electricity generation.

This sea change should be a time of significant opportunity for businesses, the power sector, and for consumers. However, preliminary work has revealed a serious gap in the sector's capability. This gap is its failure in working horizontally, ie across the sector, in ways that bring advantages to business by minimising risks, finding cost-effective solutions to common problems and shaping the longer term environment in which these companies operate.

2……The Challenge to the Organisations

There are many parties involved in undertaking this change to the networks, extending far beyond the network owners themselves. Investment is clearly needed in the networks and, if this is not to be an undue burden on consumers' bills, innovative technical and commercial approaches need to be developed. Replacing like with like will not be efficient, particularly in responding to the entirely new demands of 'embedded' renewable generation sources.

Furthermore, in times of change, manufacturers need effective signals from their markets and must shape their product offerings in an increasingly global context. Investment combined with innovation will need the concerted response of many parties, from research organisations and universities, to manufacturers, developers and the network companies themselves.

There is an immediate challenge here – if this is to be done efficiently and in a timely way, achieving 'joined up thinking' for the benefits of all parties, how can this be undertaken now there is no longer a centrally planned system?

The last time major investment took place to design and build the networks we have today, we had a centrally planned electricity system under single (nationalised) ownership; this had its advantages and its drawbacks. We now have a liberalised business structure, comprising many independent companies, which brings its own strengths and challenges. These need to be harnessed to respond to the issues that lie ahead.

3……Today's Business Framework

The liberalised business context is not without its constraints and controls. The principal elements that shape the sector's activities are:

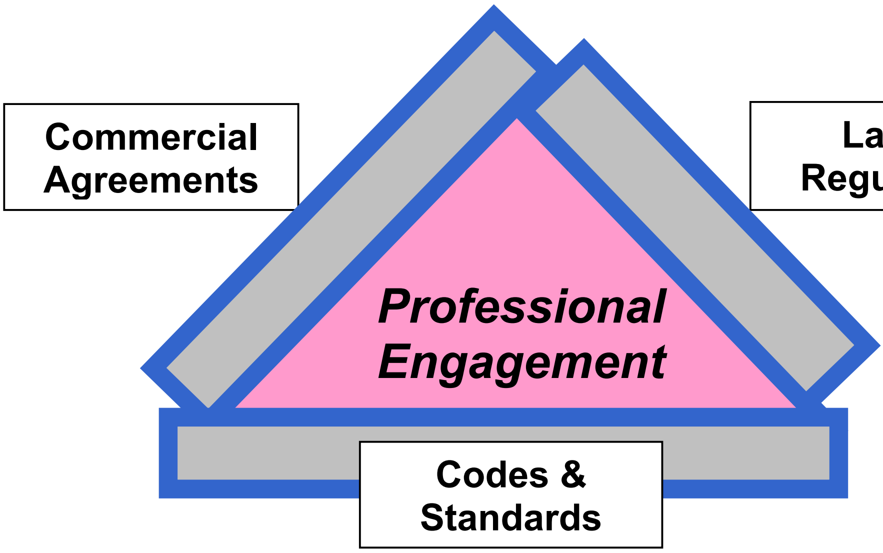
1) **The Legal and Regulatory frameworks**

2) **Commercial contracts and agreements**

3) **Technical Codes and Standards**

However, while these things may form the basic 'rules' for business, there is a further dimension needed, particularly in a time of substantial change where the framework elements themselves are likely to have to be adapted and extended. The further element is the interaction of the parties concerned, the so-called '*Professional Engagement'* that must take place within any sector where change is dynamic and response is needed in the interests of customers and wider society. It is this engagement that underpins the success of a liberalised environment; the parties concerned have to operate in an organic and responsive way; there is no longer the hand of the central planning agency to co-ordinate, to share information, and to adapt and shape the framework of rules.

The diagram below summarises this:



The diagram, while simplifying a complex sector, nevertheless provides a reminder that the formal structure interfaces through the professional engagement of the people that comprise the research companies, the equipment manufacturers, the network owners and operators, and government and regulators.

Professional Engagement becomes a more critical activity at times when the pace of change is rapid, where there is technical complexity, where new must be integrated with old, and where new commercial arrangements must be developed to facilitate technical development. This is a situation that moves ‘beyond compliance’; it is necessary for the compliance framework itself to evolve.

This theme of Professional Engagement has been explored by the Technical Architecture project, led by the Institution of Electrical Engineers[10].

4……Professional Engagement: what the project has revealed

Soundings taken at seminars and through interviews, confirm that Professional Engagement is currently at a low ebb in the electricity sector. This is the result of several factors that include a long period of stability and little need for innovation, the regulatory pressures on network companies for greater cost-efficiency, the fiercely competitive environment in which the plant manufacturers operate, the decline in students taking power systems engineering courses and the consequent reduction in university departments and research activity.

A further observation reported is that at the time of privatisation the network companies moved to strongly independent positions; this isolation was probably an over-cautious response to their new legal and commercial obligations, combined in some cases with a desire to establish independent identities and signal to staff the end of the former nationalised industry ‘club’. A far less extreme position would now appear to exist, but the returning pendulum has a long way still to travel. A helpful development in this regard has been supply business separation which eases the position on commercial confidentiality for network companies.

Evidence of low engagement is shown in the near-absence of representation at events and seminars, little authorship of papers or articles to journals and conferences, and the decline to a trickle of people applying for chartered status. There has not been a network company senior manager in the position of IEE president since the late1980’s. Furthermore, at the corporate level there is almost no profile in the engineering domain where companies could be shaping sectoral technical policy. (There are a few notable exceptions to this general statement.) Looking further a field, there is little or no participation of these companies in European activities, whether the premier two-yearly conferences of CIRED and CIGRE, or participation in European research projects. In Europe no British companies are project sponsors even though 50 per cent funding is available, and despite the risks of not engaging with policy developments that may translate into European law or standards and become mandatory here in the Britain.

In a situation where Professional Engagement is lacking, business activity can be pictured as akin to a Motorway journey, taking what appears to be the shortest route from A to B, battling down the fast lane with no interaction with other people (and hoping for no unexpected hold-ups).

Extending the analogy, and in contrast, another way of getting from A to B would be to turn off the Motorway and choose an Alternative Route. The non-motorway roads may not appear to be so direct, but they provide different views of the world, more opportunities for interaction – and may indeed be faster in the long run. It is these

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[10] This project was commissioned by the DTI/Ofgem Distributed Generation Co-ordinating Group to address the vision for future networks and the need for co-ordinated approaches. The work is being led by the DGCG’s Technical Steering Group in conjunction with the IEE Professional Network (Power Systems & Equipment).

interactions that lead to new knowledge being gained along the way and, more often than not, the individual being better equipped for the next task.

Panel 1 summarises some of the factors that have been identified in today's sector for staying on the Motorway and avoiding wider interaction. This situation has evolved over recent years in a period where the sector had no strong requirement to innovate and where competitive and regulatory pressures have led to unprecedented streamlining in companies. Arguably, the regulatory frameworks themselves may incentivise companies to concentrate on shorter term goals. While pressure for cost-efficiency is a stated regulatory aim, an exclusion of longer term thinking would be an unintended consequence of the regulatory framework.

Panel 1: Barriers to Professional Engagement (Incentives to Stay On the Motorway)

- Deeply ingrained 'silo mentalities'
- Narrower training has resulted in a lack of awareness outside an individual's own field
- An attitude that says "It's not my job to think more widely" (and I will be criticised if I do)
- Wider professional engagement is not seen as the real job, it's regarded as soft stuff – an overhead
- A 'no risk' and short-term culture
- Continual change makes continuity problematic
- Company loyalty has been lost in many cases

5……Professional Engagement: Business Benefits

Professional Engagement is about business advantage. It is also reported frequently to be a source of personal satisfaction which is a positive feedback mechanism. The importance of wider engagement within a company and across one's sector is recognised at many levels including senior management. It is sometimes described as networking, building alliances or 'walking the talk'.

Long term businesses, such as those associated with electricity networks, can't hope to be successful in the long run if they don't lift their sights from the outside lane of the motorway, establish an external corporate profile that enables influence to be brought to bear, and create trust through building professional contacts. The same principles apply to activities within businesses and at all intermediate levels of seniority. The challenge to businesses will be felt when they have to change gear, moving to a higher pace of investment or develop competences in new areas of network technology or operation.

At an operating level it is Professional Engagement that brings new intelligence, finds solutions, identifies and mitigates risks and costly mistakes, and builds the competence and confidence of staff. These basics have become lost in recent years resulting in companies that fail to show leadership in their sector, have almost no engineering profile and, at worst, appear lacking in competence or willingness to pull their weight.

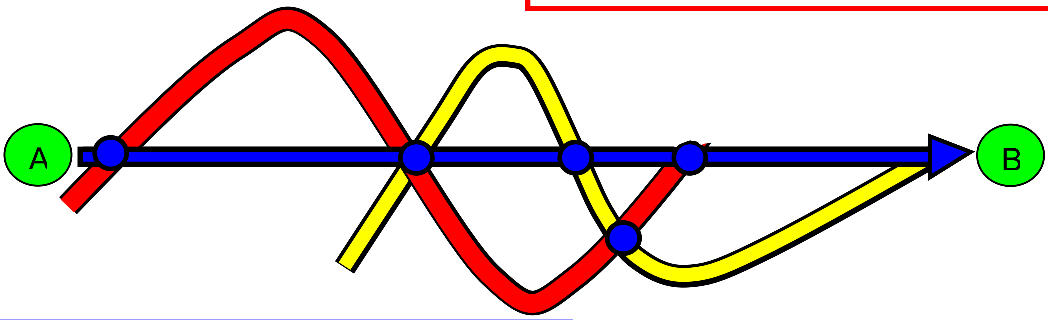
To gain the corporate and the personal added value described here, it is evident that time has to be committed and communication broadened. This 'time out' needs to be seen as an investment rather than an overhead.

6……A Model for Professional Engagement

The diagram that follows provides a picture of the Motorway and Alternative Routes analogy. It does not propose that either way is wrong or right, rather that a choice should be made consciously, recognising the pros and cons of different routes. It also suggests that the path from A to B can be a mixture of routes. Knowing which route to take can be viewed as a professional competence and, given the pressures of day to day business, this competence can be honed to recognise how to do it efficiently and effectively.

Professional Engagement: choose your routes

Choose Alternative Routes
- Benefits to the company, the wider sector, and individuals
- Diverse opportunities for 'Professional Engagement'
- Important where there is complexity in a project
- See the bigger view; whole life cycle issues
- Looks further but may be quicker in the long run



Take the Motorway
- Fast and direct; minimum distraction and interaction
- Best when solution is defined and proven
- May be lowest cost, for the short term
- Helpful where Confidentiality is genuinely a necessity
- You accept the risk of unexpected delays; alternative options may be restricted

7……The Benefits of Professional Engagement

Panel 2 summarises some of the advantages of taking the Alternative Routes; in other words, the incentives for turning off the Motorway. The benefits are often, but not necessarily, for longer term business advantage.

They sometimes provide immediate solutions or business leads (ie short term benefits) but more usually shape the business context, developing the profile of the company and the competences of its individuals. In times of change it is engagement of people across a sector that accelerates work completion and the delivery of new agreements, or new standards or products. These issues point to deeper-rooted matters, they reflect a company's approach to business, and are particularly important to its reputation and long term success.

Panel 2: Benefits of Professional Engagement (Incentives to Turn Off the Motorway)

- Breadth of skills and experience brought in to the business; network of contacts, intelligence
- Interaction accelerates the pace of change in a sector
- A quality self-check and external reference point
- Avoiding known pitfalls; access to historical knowledge that may have been lost in the company
- Usually encounters an enabling style that gets things done; a vision for the possible
- Strengthens commitment to professional standards; a source of job satisfaction
- It stretches people; refreshed skills and enthusiasm are taken back to the company

Confidentiality is frequently quoted as the reason for not engaging more widely across the sector. This is rarely a problem in practice – but requires a measure of self confidence and understanding by the individuals concerned. Where it is cited as the reason for not engaging more widely, it may point to 'hiding behind contracts', but is also evidence of a lack of understanding of professional engagement and how to handle sensitivities that arise from time to time. There is evidence that the regulated companies are now establishing a more measured stance to confidentiality and are expanding selectively their areas of collective activity.

8……Personal Styles and Attributes

People who find the right times to turn off the Motorway and take the Alternative Routes, are those who see their value and are willing to make the time available; they are often regarded by others as the 'professionals' of the sector and are the people who influence the future.

Panel 3 summarises the behaviours and styles that can be recognised here.

All of these require, or benefit from, coaching and advice; from observing in others how to do it well and from learning the lessons of experience.

In every case, however, the individual requires the backing of their manager or their wider company. This is not only for advice and shared experience, but for making time available and for this being seen as ***an essential part of the job***, not a diversion from the real task.

A dimension that also requires consideration is that of the challenges that may be faced, personally, by those who engage with their sector to develop a vision the future. How do these individuals address the risk of being seen by their company colleagues as engaged in something peripheral to the core, or in activities that do not bring immediate and tangible results? Collaborative activity may be viewed as threatening a company's competitive position, including that of regulated (mutually benchmarked) companies. This context requires individuals to position themselves with deliberate care and indicates a professional hallmark of high order.

Panel 3: The Hallmarks of the Professionals

- They are seen as the strategic thinkers
- They engage beyond their own remit (their silo) and balance technical, commercial and wider factors
- They develop judgement and their advice is regarded as impartial
- They promote information flows and lessons learned
- They balance company confidentiality with open professional dialogue
- Their wider engagement indirectly builds their personal standing, enabling them to influence better both company and sector decisions
- They manage the visibility and perception created by their activities, as seen by their company colleagues

9……Where is this Leading ?

The Technical Architecture project has identified that the current low levels of Professional Engagement are a serious impediment to developing the networks in an efficient manner to meet the joint challenges of renewal and renewables.

The sector is, in the main, operating as if it is 'on the Motorway' but the challenges of asset replacement and the development of active networks to incorporate distributed generation require a different approach. They require an understanding of the Alternative Routes, when to take them and how to benefit from them. Replicating yesterday's technologies or simple scaling up of existing investment processes are unlikely to be the route to business success.

These are issues for the sector at large, involving the companies, institutions and regulators. They cannot be solved by an instruction or a tick in the box and new behaviours need to be led from the top if they are to become established as norms. The issues present an important challenge in today's business context and need imaginative solutions, fit for the future. New approaches need to be seeded, and champions and coaches brought into play. This paper seeks to further the debate and develop the thinking; there is a need to identify individuals and organisations that have a vision for the future – and how to get there. These will come to be regarded as the real professionals, the leaders in the sector.

If the sector is to equip itself for change, establish its vision and reassert its leadership, it will need to achieve the following:

- **A new and active level of Professional Engagement that enables commercial organisations to thrive in a period of change, and bring benefits to themselves, their customers and wider society.**

- **Strengthening Professional Engagement to enable the sector to be adaptive and effective in the absence of central planning. This will extend to positioning in European and world markets.**

- **Establishing Professional Engagement as a competence that is championed by managers, companies and institutions. It will include mechanisms by which those coming into the sector acquire these skills.**

V1.4.4
Compiled by John Scott from the work of the Technical Architecture project
Updated 12 May 2005
IEE Professional Networks

[11] This project was commissioned by the DTI/Ofgem Distributed Generation Co-ordinating Group to address the vision for future networks and the need for co-ordinated approaches. The work is being led by the DGCG's Technical Steering Group in conjunction with the IEE Professional Network (Power Systems & Equipment).

Appendix 9 – International Activity

International Activities on Future Electricity Networks

Author: Prof Goran Strbac, DTI Centre for Distributed Generation and Sustainable Electrical Energy

1. Background

In order for the Technical Architecture activities to be effective it is important to be aware of all relevant work and developments in the international arena and to establish links with the key international institutions and groups active in the areas that are of interest to the TA project.

Within this theme some of the major international activities associated with the long term development of electricity systems have been identified and briefly reviewed. This was primarily focused on and work carried out in the US and EU. In this context this contribution

(i) summaries various key initiatives and programmes in the US and EU undertaken to support the development of future electricity systems and

(ii) provides recommendations for conducting initial work to inform the TA team about the key international initiatives relevant to the TA project.

Specifically, the review of recent work and initiatives underlines significant similarities (and highlights the differences) in the views between US and EU regarding the key challenges facing the electricity supply sector:

- Aging equipment and infrastructure
- Uncertainty in future energy policies and the regulatory framework
- Substantial recent decline in the level of research and development spending by the electricity industry
- Relatively slow acceptance of new technologies
- Reduction in skills base and relevant R&D capacity
- Integration of renewable and other distributed generation as a response to climate change challenge (particularly EU)
- Constraints in power supplies and delivery system to meet growth in demand (particularly US)
- Difficulty in building investor confidence and attracting capital investment in industry (particularly US but more recently EU as well)

As these challenges begin to be recognised by the policy makers, there is now momentum being built to develop comprehensive national strategies for delivering efficient, (more) reliable and robust electricity delivery systems (networks) for the future.

2. Summary of major initiatives in the US

A US national vision and roadmap process has been launched to engage industry, states, and other stakeholders in a coordinated national effort to strengthen America's electricity sector. An important part of this effort involves having the federal government work more closely with the states to implement a national vision and roadmap for electric power technologies. This process produced "Grid 2030," America's vision for the future electricity system, and the National Electric Delivery Technologies Roadmap, an action agenda for collaboration on grid modernisation activities. These documents can be downloaded from http:/www.electricity.doe.gov.

Furthermore, Office of Electric Transmission and Distribution was created in August 2003 by the US Secretary of Energy to actively work in the area of networks. The scope of activities includes research, development, demonstration, technology transfer, electricity modelling, policy analysis and outreach. With the national vision and roadmap as a guide, the Office activities focus on areas that complement and support the work of electricity industry stakeholders, the Federal Energy Regulatory Commission, national laboratories and universities.

There have been several initiatives[12] undertaken at the Federal level, including

- *GridWorks*: Given that the electricity system is becoming increasingly constrained Department's new GridWorks initiative is introduced to modernise key grid components such as transformers, conductors, switchgear, and to develop technologies that overcome these constraints. This initiative should stimulate innovation and mobilise equipment manufacturers to ensure that system requirements match with the attributes of new technologies. Programmes are being developed for testing and demonstration of advanced components and new technology in this area.

- *GridWise*: Advanced communications, control methods, and information technologies are largely absent from electricity systems, leaving system operators and planners without valuable information for integrating dispersed resources, loads into grid operation and development. The Department's new "GridWise" initiative is intended to encourage the use of real-time information, integrating distributed intelligence using sensors with demand response programmes to maximise reliability and system efficiency while providing customers with new choices. GridWise will define an information architecture that incorporates new information technologies in grid operation in order to accelerate market acceptance and optimise system performance.

[12] W Parks, US DoE, Transforming the US Electric Grid to Strengthen Reliability, Security and the Economy, IRED, December 2004

Other initiatives include application of high temperature superconducting materials and other advanced materials in the electricity sector. Furthermore, information management, wide-area measurement, disturbance recognition, and visualisation tools are beginning to be used by grid operators to process real-time information, accelerate response times to problems in system voltage and frequency levels, and achieve compliance with reliability and security standards. These are considered to be critical to ensure that appropriate responses to disturbances are created before widespread blackouts can occur. This also includes the development of interconnection technologies and standards to enable seamless integration of distributed energy and loads with the local distribution system.

In Oct 2004, The Electricity Innovation Institute (E2I), an affiliate of the Electric Power Research Institute (EPRI), recently announced the completion of the initial phase of the Intelligrid Architecture (formerly known as the Integrated Energy and Communications System Architecture)[13]. The Intelligrid Architecture is intended to integrate two systems in the power industry: the electrical delivery system and the information system (communication, networks, and intelligence equipment) that controls it. In order to effectively move the industry toward the above listed goals, the power delivery systems should increasingly rely on the information system. Primary energy plant and system together with the information systems are proposed to be developed in parallel in order to allow advanced communications and networking technologies to work with intelligent equipment to execute increasingly more sophisticated system functions. This is probably the first comprehensive communications architecture that is conceptualised for power delivery systems of the future. This also includes Open Communication Architecture for Advanced Distribution Automation environment, one of the EPRI's initiatives in this area. The objective was to develop a unified vision for upgrading the power system that is aimed at ensuring the compatibility with future technologies such as distributed energy resources including demand response.

In addition, significant investment has recently been deployed in supporting fundamental research conducted by National Laboratories and selected Universities, including development of National Programmes (through DoE) to encourage sharing of test protocols and results and pooling of testing facilities and laboratory infrastructures. There has also been considerable interest in the interaction between energy and transport systems in the form of Grid-Connected Hybrid Vehicle systems and possibilities for the integration of these systems.

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[13] Frank Goodman, Communication Architecture for Future Integration of Distributed Energy Resources, IRED Dec 2004.

3. Summary of major initiatives in the EU

The (short term) visionary targets of the European Community are to increase the share of the renewable energy resources between 1997 and 2010 from 14 to 22 % as well as doubling the contribution of the cogeneration plants for heat and power (CHP) on the total electricity production from 9 to 18 %. Consequently, the share of renewable and distributed energy will cover 40 % of the whole electricity production in 2010. On the basis of this commitment, national governments have developed individual targets for renewables and CHP. These were then followed by the development of a range of national policy instruments to incentives connection of this generation to the grid.

Issues associated with supply and network security, service reliability and asset replacements are now beginning to interact with the deployment of renewable energy sources and other forms distributed generation technologies. This has recently opened the question of the integration of these new generation technologies in both operation and development of EU electricity systems.

The EU commission supported these objectives through its framework research and development programmes associated with deployment and integration of renewable and other new generation technologies. Furthermore, national research and development programmes have also responded by increasing research and development activates associated with new and renewable technologies.

There have been a significant number of R&D projects supported by the EU commission and this will continue within current Framework Programme FP6 and future FP7. Key focus of the presently running projects is IRED[14] group, which is a large Cluster of EU research projects that is coordinated by ISET (Germany). There are seven projects under FP5 dealing with the integration of Renewable Energy Sources and Distributed Generation. This cluster represents a total budget of about €35 million. More than 100 participating institutions from research and industry sectors are contributing.

Key activities of IRED include

- Exchange of information between relevant research organisation, industry, regulatory bodies and government agencies at the European and international level.

- Initiation of strategic actions such as international co-operation, organisation and a co-ordination of common initiatives on standards, testing procedures and the establishment of common education.

- Identification of research priorities in the areas of integration of RES and DG.

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[14] Integration of Renewable Energy Sources and Distributed Generation into the European Electricity Grid

IRED organised the First International Conference on Integration of Distributed Energy Resources, held in Brussels in Dec 2004. The DTI Centre for Distributed Generation and Sustainable Electrical Energy is a member of the IRED Cluster and can provide relevant contacts and information to the TA project.

Recent Electricity Technology Roadmap Initiative (produced by KEMA in collaboration with EPRI in April 2002) explores a period of fast regulatory, political, technological and institutional change in the electricity sector and in the society. The report argues that strategic choices made in this period of change can have profound consequences on whether future opportunities are opened or closed, and whether threats increase or are eliminated, recognizing the reluctance to proceed with important changes, given the extreme uncertainty under which decisions must be made. Key conclusions and recommendations that are considered to be particularly relevant for TA project are:

- Strategic and technology initiatives are needed to address climate change concerns. It will be essential to avoid conflicting, short term responses that tend to lock in existing technology, constrain efficient economic development and slow the technology innovation needed for long tern sustainability.

- New infrastructures will emerge from the convergence of electricity and communications infrastructures. This will open the gateway to new intelligent electricity services for unprecedented levels of reliability, comfort, convenience, speed, efficiency and adaptive intelligence.

- Key to realisation of these opportunities will depend on the ability of the electricity delivery systems to both meet the increasingly diversified requirements of a competitive marketplace and maintain service reliability and power quality as transactional volume and open-access complexity increase, given that the current power delivery grid was not designed to meet these emerging demands.

- Robust electricity-based technological innovation is an essential basis for this future. This is critical as a significant, sustained pattern of under-investment in both energy R&D and electricity-related infrastructure threatens long-term economic prosperity, environmental health and security

4. International Organisations

International Energy Agency: Implementing Agreement on Electricity Networks

The IEA provides support for international co-operation and collaboration agreements in energy technology R&D, deployment and information dissemination, called IEA Framework for International Technology Co-operation. The Framework sets out the legal and management support for the activities of more than 40 active technology agreements in the programme, called Implementing Agreements. Recently, DTI has proposed development of a new Implementing Agreement to deal with electricity networks. This would serve as the major international collaborative forum, allowing for the effective exchange of information and data and also in-depth research and analysis in relation to specific technical, regulatory, commercial and institutional issues in the area of electricity networks.

Although the portfolio of issues that might be addressed via the proposed Implementing Agreement is potentially wide ranging it is proposed that the Agreement should aim to identify and pursue actions that would facilitate the deployment of renewable and distributed generation, maximise its potential benefits in term of quality of supply network reliability and resilience and address system levels issues such as intermittency and dynamic stability.

It is anticipated that this agreement will be established in 2005, and this would be an opportunity for the interested parties to set the agenda for various Annexes dealing with the wide range of issues associated with future electricity networks, including both operation an development aspects.

CIGRE, CIRED, IEEE, IEC and others

These internationals organisation are active in a number of areas that are of interest to the TA project. It is expected that their work will be available to TA team as a number of companies and individuals that are associated with the TA projects are likely to be already actively involved with one of more of the above international organisations.

5. Recommendations for initial future work

The initial literature survey presented above shows a considerably activities in the area of interest of the TA project and clearly supports the case for the establishment and further development of the TA project.

The initial project could have two key objectives

(i) identify and review relevant work that is carried out by various international organisations and propose how the results of such work could be used by the individual projects of the TA activity,

(ii) identify international groups, institutions and organisations that are involved in activities relevant to TA and review and select corresponding programmes that would be of particular interest to TA agenda

(iii) Review UK involvement in the operation of these international organisation and propose how it could be enhanced

Key deliverables of the initial project would comprise of

- a report on the international programmes conducted or in progress that are relevant to the TA project, including recommendations regarding the potential use and application of the results by individual TA projects
- data base of relevant institutions, organisations and groups that conduct work relevant to the TA project
- data base of individuals associated with TA activities and their role in various international organisations identified above
- a proposal how TA could interact with such groups including estimate of resources required.

The proposed task are listed with an outline timescale in terms of lapsed months

Task No	Month	Task Descriptions
1	1-2	Identify and review relevant international work
2	3-4	Propose how such work could be used by the individual projects in the TA activity
3	5-6	Review and select programmes and on-going activities of key international organisations that are of interest to TA
4	7-8	Review UK involvement in international organisation and propose how it could be enhanced

Appendix 10 – The skills challenge

Thematic Description: The skills challenge for the 21st century power networks

Author: M Lees.

Background

Today we have an electricity network that is designed, constructed, operated, maintained and repaired according to practices and procedures that have evolved over many years. The network assets have well defined functionality and networks are designed to make best use of this functionality. Current practice is well defined in sets of recommendations, safety rules, operational rules, engineering recommendations, standards and specifications.

We are now at the start of an evolution to a new technical architecture, which will incorporate new assets, which will have enhanced functionality or additional functionality to the existing assets. Consequently, in parallel with the evolution from old to new assets, evolution in operational practice will be required to accommodate these new assets.

Current asset and operational practice relies upon existing asset management processes, which are defined within businesses and follow a cycle of planning, design, procurement, commissioning, operation, repair, replace, decommission. New assets are available and will be developed in the future which have different capabilities or enhanced functionality compared with current assets. They will be combined to produce asset groups and circuits with different capabilities than the existing circuits and groups of assets. There is knowledge of this capability, which currently resides in the organisations that are developing these assets (e.g. manufacturers, technical consultants, universities), but there is a larger set of knowledge which will be developed when these assets start being used by network operators.

There is a need to capture this knowledge and ensure that it is incorporated in the education of engineers. Education develops an individual's understanding of the subject area that is taught. Consequently the individual develops a broad ability, which can be brought to bear on problems and issues that were not in the specific example set that was used in the teaching process. The enhanced knowledge and understanding of engineers, resulting from this education, of the capabilities and advantages of these new assets, will lead to the engineers developing new network designs, which make the best use of these asset capabilities.

New network designs are new knowledge. This knowledge also must be captured and used to educate engineers. The new network design knowledge will result in the development of new operational practices. These practices can be usefully fed into training programmes to ensure that the specific skills that are required to carry out defined tasks efficiently, effectively and safely are imparted to those who need them.

However, the pressures that require the use of new assets and network designs are unlikely to be uniform across the network, so there will be parts of the network which can continue to be designed and operated much as they have been for the last 50 years. Existing assets have a long remaining lifetime and economic pressures drive for the greatest use that can be gained from those useful assets. Also the new assets will not be perfect; the new assets will have reliability issues. They will be subject to degradation and failure mechanisms that are possibly different from those of existing assets, and the impact of failure of the new assets on the network may be different.

Asset management must evolve from current practice to new practices which accommodate the new assets, whilst continuing to ensure that the best is obtained from the existing asset base. Underpinning this evolution is a requirement to understand and develop objective relationships between present and future performance of assets and the asset specific and generic engineering knowledge relating condition, degradation and failure mechanisms, operating context etc. which ultimately drives the current and future performance of assets and networks.

This requires creation of new knowledge and new engineering skills are required, e.g. understanding of risk and its analysis. Such processes are not part of the engineering degrees and may not be within the skill-set of existing staff.

The evolution of asset management will include greater degree of monitoring and measurement. This might require retrofit devices permanently fitted to equipment, devices incorporated by design within new equipment and portable instruments. There is a need to up-skill existing staff and to train new staff to understand diagnostic techniques and instruments. This leads to training requirements on a technical engineering level rather than a graduate engineering level.

New network designs are likely to be operated in a different way to current designs and that produces a requirement for training in new network operations for those who work on the network.

Education in the capabilities of new assets, new network designs, asset management knowledge etc. is also necessary for those who are developing standards and specifications to accommodate the new assets that are becoming available.

It is important to recognise that the requirement for an evolution in education and training is not just an issue for operators of networks. It is an issue for all of the supply chain associated with transmission and distribution of electricity. This includes manufacturing organisations, service providers to network operators (who could also be manufacturing organisations providing a complete package, or could be completely independent of manufacturing organisations and network operators), consulting organisations and R&D providers. The numbers of education and training specialists that will be required should not be underestimated. This is likely to have implications for both universities, specialist training organisations and in-house training facilities.

Way Forward

To deliver the overall objective, the Technical Architecture Project has been broken down into a number of individual work packages. It is recognised that these work packages cannot be undertaken independently of each other. Where subject areas overlap, coordination is required to ensure proposed outputs are complementary.

This work package will:

a) Identify the **high level** requirements for evolution of asset management processes to accommodate new assets and network designs within the current network framework.

b) **Define a framework** to ensure that appropriate knowledge for design, operation and maintenance of existing and new technologies is captured for the appropriate organisations to develop and implement training structures.

c) Have close links to all other work packages in order to ensure that all **relevant information and requirements** from all of the workpackages are captured and included in the education and skills requirements definition.

d) **Work closely with existing organisations** to facilitate a coherent approach to training needs to meet future requirements.

e) **Endeavour to quantify the issues**, to provide an objective assessment of the size of the problem, to what extent this can be addressed by training of existing staff and approximately how many new people are likely to be required to meet the demand.

f) Produce a profile of the number and type of people that will be needed, attempting to **provide a quantified view of 2010 and beyond.**

This workpackage will endeavour not to be prescriptive but rather facilitate the industry to implement best practice in training and ensure duplication of effort is minimised.

Tasks

Task 1: Identify current skills and trends

- Identify techniques and practices for supporting the existing legacy infrastructure based, where possible, on work already completed.
- Based on current trends attempt to quantify areas of skills shortages that will need to be addressed beyond 2010
- Based on the output of the future scenarios theme, estimate the profile and types of skills shortages due to normal retirement and replacement shortfall between 2010 and 2015 and beyond if feasible.

Task 2: Skills required for future Technical Architecture.

- Research and identify existing work completed in various organisations on this topic
- Identify the additional skills profiles likely to be required to design, operate and maintain future networks beyond 2010

This task will also identify the knowledge and skills requirements for both engineering graduates and technical grade staff; to take currently deployed technology and potential new technologies that are applicable to the identified future scenarios (output of future scenario literary review) into everyday business activity.

Task 3: Gap Analysis of Education and Training to enable future scenarios to be implemented

- Identify the current perception of requirements for training of staff for all organisations in the supply chain associated with Power Networks
- Identify training requirements for existing network operator staff, to facilitate migration to the new technical architecture
- Produce a co-ordinated training road-map to enable the development of the staff capabilities that are required to enable migration to the new Technical Architecture.

There have been a number of studies of the resource requirements of the power network sector and the education and training activities that are required to support this. This task is not intended to duplicate these studies, rather it will use the output of these studies to define both the current position and the current plans for changes in education and training to address the identified needs.

The focus of this task is to identify whether the knowledge and skills that have been identified in tasks 1 and 2 are already addressed, either within the current education and training processes, or by the changes in education and training that have already been identified. Where gaps are identified, then proposals will be made for changes to university degree courses, postgraduate courses, and training courses to incorporate the additional identified requirements for specific up-skilling and education of engineers and technical staff.

It is important that there is not a skills gap which may delay the new technical architecture, however it is equally important that education and training is not supplied inappropriately early in the evolution of the network and assets. This would not only be inefficient, it would also possibly be regarded as unnecessary and loose favour and importance in the curriculum. A crucial part of this task is therefore to identify practical timescales between the point at which an education and training need is identified and the point at which there is a body of people that have been educated and / or trained and have demonstrable competence in applying the education or skill that has been gained.

There are two aspects to this study. Firstly the summary of requirements produced in task 2 should be used in a survey of those who provide training in DNOs, TNO, Manufacturers, contractors, consultants, universities to identify the timescales to develop an education or training course, attract students and then run the courses and, by comparison with the scenario development Work Package, identify when these education and training issues need to be addressed. Secondly, the validity of this approach should be confirmed or otherwise through an assessment of recent changes in technical architecture of networks, eg. Introduction of SF6 switchgear, connection of wind farms, introduction of network automation, covered conductors etc.

The identification of current provision for education and training, will require detailed input from the Energy & Utility Skills Council, plus universities and training providers. Moreover, engagement with these bodies will be essential should gaps be identified, in order to ensure that the recommendations for changes in education and training are developed in partnership with these stakeholders and are therefore practical and can be delivered wherever possible within existing education and training frameworks.

A roadmap will be produced for the development of education and training programmes to address the identified gaps. This will provide a view of education and training required in order to provide the identified requirements beyond 2010.

Deliverables

Agreeing Scope of task

Prior to commencing work on the tasks, the contractor will provide, for approval, a written assessment of how they will tackle the tasks and how they will present the deliverables. Any proposed changes to the specification will be agreed before commencement of the work.

Identify current skills and trends

The deliverable from Task 1 is a report that describes:

- Skills requirements for both engineering graduates and technical grade staff which are needed to support the techniques and practices identified
- A quantification of the demographics to help identify the size of any particular existing area of concern.
- Skills profiles needed to maintain existing infrastructure.

Skills required for future Technical Architecture

Task 2 can only be delivered when the work packages that are feeding into the task, have formed a sufficiently clear view to be used for the purpose of the task.

The deliverable from task 2 is a report that describes:

- The current work already concluded that is relevant to this topic
- The additional skills sets required to deliver the new technical architecture

The report will include a map of possible routes for evolution of asset management of electricity network assets.

Gap Analysis of Education and Training to enable future scenarios to be implemented

The identification of current requirements within this task, has no dependencies on other Technical Architecture work packages. The remaining parts of task 3 follow the completion of task 2 and are therefore dependent upon other work packages.

The deliverable of Task 3 is a report that describes:

- the current perception of requirements for training of staff for operators of Power Networks
- training requirements for existing network operator staff, to facilitate migration to the new technical architecture
- any identified gaps in current education and training
- a critical appraisal of timescales to formulate and deliver education and training, based on recent experience.

The report will propose a co-ordinated training road-map to enable the development of the staff capabilities that are required to enable migration to the new Technical Architecture.

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