ENERGY FOR THE FUTURE
BRITAIN'S ELECTRICITY SUPPLY – HERE TODAY BUT WHERE TOMORROW?

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1. INTRODUCTION AND GOVERNMENT INTERVENTION

It seems unlikely that the majority of the population are particularly interested in the ownership, internal organisation and control of our electricity supply industry. In the past decade, however, they have become interested in much of the technology that now characterises the industry even if their knowledge of it is partial or superficial. What all customers are interested in, nevertheless, is a reliable, secure and affordable supply of electricity. These issues affect every customer as well as the prosperity and security of the nation.

Because of its importance to all consumers both individually and collectively, Her Majesty's Government (HMG) has constantly intervened in the organisation and regulation of the electricity supply industry (ESI) irrespective of the state of the nation or ownership of the industry.

Fig 1 indicates briefly the 13 separate interventions by HMG since the conclusion of World War 1. This does not include other interventions by the Regulator who has overseen the industry since the early 1990s.

1919 **Electricity (Supply) Act** – Electricity Commissioners established
1922 **Electricity (Supply) Act** – Additional powers given to Commissioners
1926 **Electricity (Supply) Act** – CEB Created: National Grid planned
1935 **Electricity (Supply) Act** – Additional powers given to CEB
1947 **Electricity Act** – Industry nationalized
1954 **Electricity Reorganization (Scotland) Act** – SSEB set up
1957 **Electricity Act** – Electricity Council and CEGB formed
1969 Proposals for wholesale reorganization. Electricity Authority to be established to plan and control the industry
1976 White Paper proposes one single Authority in England and Wales for the industry

1980 Secretary of State for Energy announces no changes in organizational structure of the industry

1989 **Electricity Act** – Privatisation of generators and distributors

2000 **Utilities Act** – Closer alignment of regulatory structure in England, Scotland and Wales. The Act also provided a legislative framework for new electricity trading arrangements (NETA)

2003 **Energy White Paper**

2004 **Energy Act** – "Cleaner, greener power" via implementation of commitments made in the Energy White Paper (2003). The Act will also create single wholesale electricity market for Britain (BETTA)

Figure 1: HM Government Intervention in the Electricity Supply Industry since World War 1

Put in its simplest terms electricity supply is too important nationally for the ESI to regulate or control itself irrespective of ownership.
Government interventions are usually instantaneous by nature but have long term effects in an industry that cannot change its activities or investment programme overnight. Investment in the ESI is seldom short term even though HMG may change its mind quickly. Furthermore shareholders require secure and predictable returns which may not always follow the changes imposed upon the industry.

This presentation seeks to look at the inexorable pressures brought to bear by HMG, Regulator, public opinion and indeed the wider global community set against the requirements of running a competitive and strategically important business. History should never be ignored if the events of the present and particularly the future are to be understood and shaped in a way that fulfils the basic requirements of a secure supply at an affordable price. To this now must be added a third determining element, namely, the impact on the environment.

2. THE ENERGY WHITE PAPER

HMG's Energy White Paper, published in February 2003, is the most important Government intervention since the Electricity Act 1989 which privatised the industry in Great Britain. Whilst the immediate actions following

from the White Paper are fewer than those arising from the Electricity Act 15 years ago, the far reaching effects are arguably much greater. The goals of the new Energy Policy set out in the White Paper are as follows:

- To put ourselves on a path to cut the UK's CO_2 emissions by some 60% by about 2050, with real progress by 2020.
- To maintain the reliability of energy supplies.
- To promote competitive markets in the UK and beyond, helping to raise the rate of sustainable economic growth and improve our productivity.
- To ensure that every home is adequately and affordably heated.

Whilst the goals of the White Paper can be summarised under four main headings as above, it seems clear from the language and emphasis used that the protection of the environment emerges as the most radical and some might say, important issue. This is illustrated by extracts from the first few paragraphs of the summary of the Energy White Paper.

> "Our Energy Future – Creating a Low Carbon Economy."
> "Cleaner, Smarter Energy: policies for a Low Carbon Future."
> "We will put ourselves on a Path Towards a Reduction on Carbon Dioxide Emissions of some 60% from Current Levels by about 2050."

Whilst the energy debate has intensified since the White Paper was published, it is worth reminding ourselves of what has actually happened in the 2½ years since that event.
These can be summarised as follows:

- Passing of the Energy Act, 2004.
- Sharply Rising Fuel Prices.
- Increasing Fuel Poverty.
- Uncertain Generating Plant Spare Capacity Margin.
- Renewables: Behind the Target Set and Limited to Wind
- Increase in CO_2 Emissions.

It is as well that any radical thinking looking ahead several decades, must allow time not only for the policy to become clear and understood but also a reality. It is unfortunate that the events of the past 2½ years or so have failed to coincide with the goals of Government policy. It must be stressed, however, that it is as yet "early days".

3. THE BIG PICTURE

In drafting the Energy White Paper and indeed formulating Government Energy Policy as a whole it is inevitable and perhaps desirable that a much wider range of policies and trends are considered which form the very basis of our society today.

In Britain as well as the rest of the western world, priorities and concerns are at work in our society which include but are not limited to the following:

- Concern for the Environment
- Health and Safety
- Security
- Competition
- Short Termism and Profit
- 'Ultimate' Democracy
- Low Rate of Growth of Utility Products
- "Little Knowledge is a Dangerous Thing" and the Internet
- Widening gap between rich and poor

Awareness of the impact on the environment of virtually everything we do as individuals or as a result of every industrial process constantly presses in upon every member of society and corporate entity. Virtually all new legislation has this aspect in mind coupled with the effects of health and safety at work and in the home. In both these respects practices and procedures which were in place and acceptable 20 years ago are no longer acceptable or even permissible.

Security, of the person, of the supply of goods and services and of financial transactions, have much greater importance than at any time since the end of World War 2.

Competition in the provision of most goods and services has been an intrinsic part of our way of life for more than 200 years and now includes the products of utilities.

The requirement to produce consistent profit underpinned by frequent reporting to management and shareholders can inhibit long term innovation and investment particularly in utility industries with low growth rates.

Our democracy allows and encourages participation in virtually all processes that are seen to be in the public interest. Whilst this is desirable it inevitably slows down processes and particularly as a result of the widespread availability of the internet, individuals' views, whether specious or not, must be considered and responses provided.

Translating these forces at work in our society into those which specifically impinge upon the ESI, the following list may be drawn up.

- Environmentally Friendly Generation
- Fuel Choice and Emissions Trading
- Difficult Site Selection and Undergrounding
- Not in my Back Yard (NIMBY)
- Pressure Groups for and Against Proven and Unproven Generation Technologies
- Satisfying Governments and Regulators
- Ignorance, Spin and PR
- Rising Costs and Project Overruns
- Targets, Damned Targets and Penalties
- Profit

This list of widely different pressures for change in the ESI have given rise to intensive and widespread debates of recent years. These great debates can be summarised under the following headings:

- Renewables: Trying to Pick Winners
- The Nuclear Debate
- Gas and Electricity Infrastructures – Time to Invest more heavily?
- Fuel Mix Prices and Security
- Life with less Carbon.

4. RENEWABLES: FACTS, MYTHS AND DOUBTS

Concern for the environment leading to Government endorsement and hence introduction of renewable electricity generation technology can probably be traced back to the non-fossil fuel obligation of 1991. Before this the ESI carried out a great deal of inconclusive research but could also point to a handful of demonstration projects.

The Government's encouragement of renewable generation can be summarised by listing the following initiatives:

- Non-Fossil Fuel Obligation 1991
- Climate Change Levy 1999
- Performance and Innovation Unit's Energy Review 2001
- Introduction of Renewable Obligation Certificates (ROCS) 2002
- Energy White Paper 2003
- Extended Targets and Extra Money 2004

It remains clear that the introduction of and trading in Renewable Obligations Certificates (ROCS) lies at the heart of the Government's policy for requiring a growing amount of electricity to be produced from defined renewable sources. Indeed, the Government's target of 10% of electricity to be produced by 2010 and 15% by 2015 relies on the current and foreseen values of ROCS which are presently trading at about twice their par value.

A list of those technologies which are eligible for the issuance of ROCS appears in Fig 2.

Source	Eligibility
Landfill gas	✓
Sewage gas	✓
Energy from waste	Only non-fossil derived energy will be eligible. Energy from incinerating mixed waste will not be eligible. Energy from the non-fossil derived element of mixed waste using advanced technologies will be eligible.
Hydro exceeding 20MW declared net capacity (dnc)	Only stations commissioned after the date the Order is made.
Hydro 20MW or less dnc	✓
Onshore wind	✓
Offshore wind	✓
Co-firing of biomass	Eligible until 31 March 2011 for up to 25% of a supplier's obligation. At least 75% of biomass fuel to be energy crops from 1 April 2006.
Other biomass, e.g. agricultural and forestry residues	✓
Geothermal power	✓
Tidal & tidal stream power	✓
Wave power	✓
Photovoltaics	✓
Energy crops	✓

Figure 2: Sources of Energy Eligible for the Renewables Obligation

Despite the existence of significant financial incentives it is now widely accepted that the Government's target for renewable generation in 2010 will be missed. Whatever the level of penetration turns out to be in the future it will obviously depend upon the future value of the ROCS and its sustainability. The value necessary to encourage future investment in renewables seems only enough at present to encourage onshore wind generation and it may well be the case that different ROC categories will need to be introduced with increasing levels of certainty if other technologies, including offshore wind, are to be widely introduced without reliance on the strong balance sheets of developers.

Apart from the issues surrounding the future value of ROCS there are many other hurdles which must be overcome by developers, financial institutions, manufacturers, network operators and the regulator if the Government's objectives are to be achieved.

These include but are not limited to:

- Planning & Organised Objections
- Shortage of Technical People and Informed Opinion
- Manufacture and Building Rates
- Firm Capital and O&M Costs
- Grid System Limitations
- Distribution System Limitations
- Price Reviews
- Offshore Track Record and Unknowns
- Intermittency, Spare Capacity and Storage
- Overall wholesale electricity prices
- Specific “City” Fears for Renewables

Fig 3 indicates my own impression of today’s odds which may be attached to the different technologies that could make worthwhile contributions to our electricity supply arrangements in the future. It should be noted that two non-renewable technologies are also included in the list.

Technology	Contribution	Odds Against
Energy from Waste	1	10/1
Small Hydro	1	Evens
Offshore Wind	4	9/2
Co-firing of Biomass	2	5/2
Energy Crops etc	2	4/1
Geothermal	1	66/1
Tidal	1	9/2
Wave	3	8/1
Photo voltaiics	1	10/1
Micro CHP	1	4/1
Coal Gasification	4	5/1
		100/1 Bar

Figure 3: New Generation Technologies – Racing Certainties?

5. NUCLEAR – LISTEN TO BOB HAWLEY!

6. CARBON AND ALL THAT

At the heart of the Government's so called climate change policy lies the limitation in the production of CO_2 and other greenhouse gases not only arising from the ESI but all other sectors. It is important to realise which sectors are currently the major contributors to the production of CO_2 and, if logic applies, where the greatest efforts should be made to contain and reduce these levels. Fig 4 shows electricity generation as the third largest contributor.

Two points are noteworthy. Transport has the fastest growing levels of CO_2 production and also has the greatest number of sources. Electricity production has the smallest number of individual sources making legislation less difficult to apply.

User/ Polluter	Percentage of Total UK CO_2 Emissions
* Transport	26
Industry	24
Electricity Generation	22
Domestic	14
Commercial	12
Other	2

* Fastest Growing, international air and marine transport not included

Figure 4: Who are the Carbon Culprits?

The EU Emissions Trading Scheme was introduced earlier this year. In the ESI widespread debate continues on the real effect on costs of production and the development of techniques designed to reduce the production of emissions or their storage. The current market-based scheme, whilst operating satisfactorily, will be reviewed in a few years when it is hoped it will give signals for long term investment, a feature absent from the present scheme.

Early consideration is now being given to the sequestration and burial below ground of carbon dioxide arising from electricity production We can, however, be certain that the unit cost of generation from hydro carbon sources will be increased and the operation of the EU Emissions Trading Scheme will be complex giving employment opportunity to many and even the possibility of being open to abuse. What is also certain is that on cost grounds the introduction of this scheme will help promote the economic case for renewables and nuclear power.

7. FUTURE DEMAND AND ENERGY EFFICIENCY

Forecasting the long term future demand for electricity is notoriously difficult and has seldom been accurate. This arises because future demand is dependant on so many factors each having its own set of assumptions which may or may not turn out to be true. These include but are not limited to the following:-

- GDP
- Development (or decline) of traditional industrial processes
- New industry processes
- National, sectoral and individual economic activity
- Prices of other goods and services, wages and disposable incomes
- Taxation
- Technical innovation and new products
- Government policy

Historically over the past decade demand for electricity in energy terms has been rising at an annual rate of between 2 and 3 per cent per annum together with a continuation of the trend of an improving load factor.

Electricity price rises and social attitudes may put some downward pressure on future growth in demand but the Government's Energy Efficiency Commitment (EEC) coupled with its fuel poverty elimination policy are more likely to have a somewhat greater effect on future demand. Nevertheless the Government's recently revised EEC targets appear optimistic given the record of achievements in energy efficiency since serious and continuing efforts were begun some 10 years ago.

The overall effect of legislation, attitude and economic development suggests more moderate growth in demand for electricity in the foreseeable future.

8. COSTS AND PRICES

The preceding sections have dealt largely with the individual means of generating electricity concentrating almost entirely on those technologies which are likely to find new build opportunities in the foreseeable future.

It is therefore worthwhile making clear what contributions are being made by differing technologies in the current plant mix. These are illustrated in Fig 5.

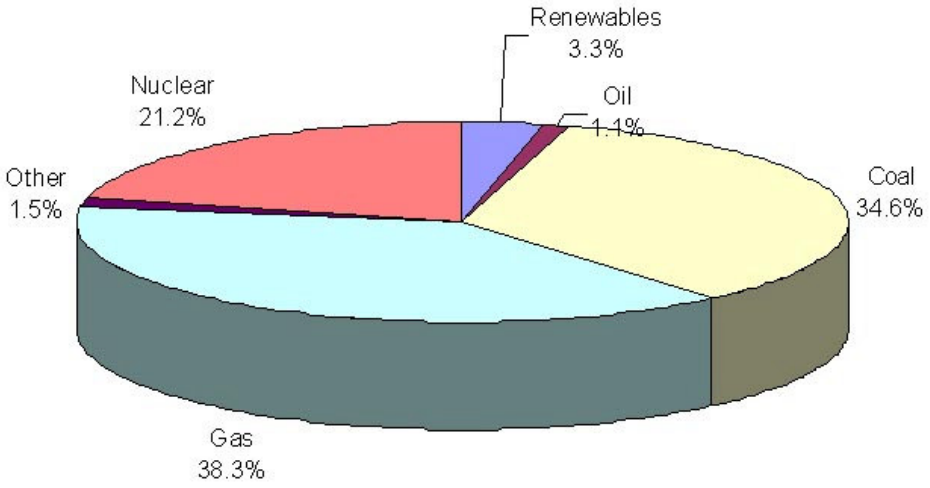

Figure 5: UK Electricity Generation 2004

This pie chart should be regarded as satisfactory in terms of the current diversity of sources of energy indicated. Unfortunately the future is likely to see significant changes in the allocations shown. Renewables, though small, will grow, gas generation also seems set to increase significantly after about 2008 whilst coal seems certain to shrink until or unless new technology is proven. The role played by nuclear power is still uncertain. Should it remain so much longer, gas appears the most likely to provide for increased future load growth, and retirement of old plant. This solution should not conceal the issue of security of supply of gas from abroad as well as the effects on supply to gas fired power stations in the future.

Previous fuel policies as well as paying due regard to security, considered cost as at least the next most important factor. Despite the rising importance of the impact on the environment no future plant mix should ignore the effects of cost of production and Fig 6 drawn from a recent Royal Academy of Engineering study sheds significant light on this aspect. The conclusion is self evident and helps explain the present plant mix in the UK. Since renewables are effectively 'subsidised' by customers it is not inconceivable that the same principles could apply to other forms of generation thought appropriate for security or environmental reasons.

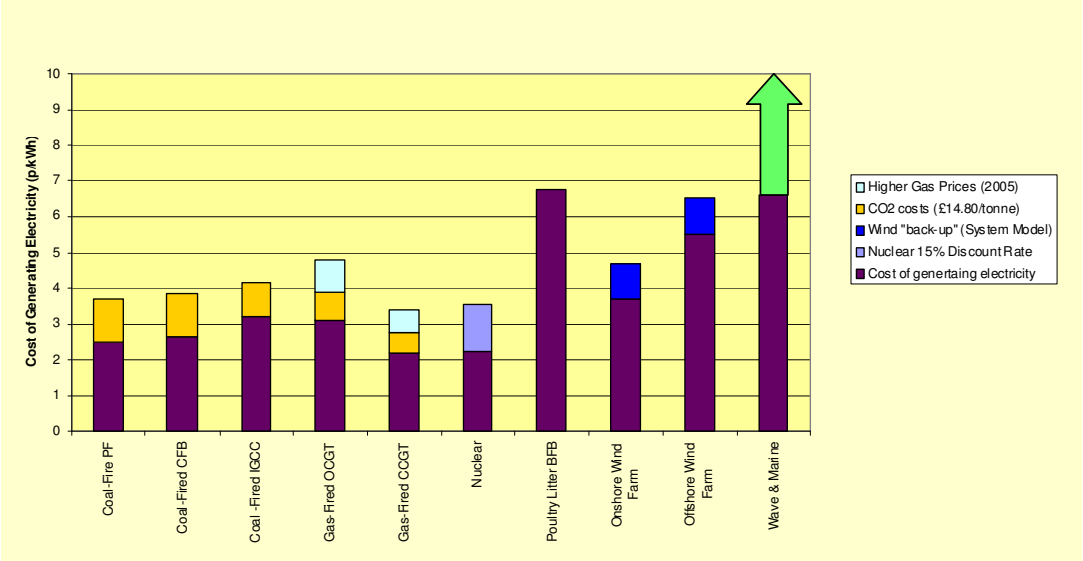

Figure 6: Cost of Generating Electricity (pence per kWh)

Besides the cost of production the cost of electricity to customers also includes the cost of transmission and distribution and Fig 7 shows what domestic consumers in England and Wales have seen over the years since ESI privatisation in England and Wales by way of changes in their price of electricity. A downward trend during the 1990s was followed by a spread of prices following the opening of the market to all customers but most dramatically over the past 24 months they have seen startling increases as a result of sharp rises in the price of oil and natural gas.

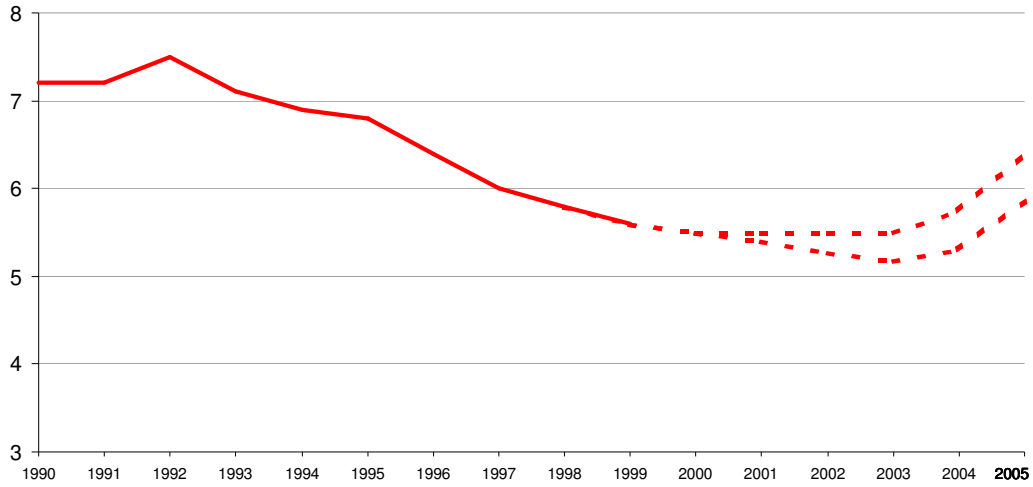

Figure 7: Domestic Price Reductions Since Privatisation in England and Wales

It is likely that customers, both industrial and domestic, will see further price rises in the future.

A significant part of any customers bill comprises the cost of transmitting and distributing the energy to the end user. Much of the infrastructure upon which the industry is dependent was built up over the past 50 years or so. Many of these assets are approaching the end of their useful lives despite life extensions and need for systematic replacement. Moreover, the extension of both transmission and distribution systems to accommodate higher levels of renewable generation will lead to significant new build in those areas of production.

9. GENERATING PLANT MARGIN AND SECURITY OF SUPPLY

The excess of available generating plant over the level of demand for power, referred to as the plant margin, has always been of considerable debate particularly, of course, at times of approaching system winter peak demand. It is only in recent years that the public seem to have been alarmed by the reduction in plant margin, below 20%, as generating companies have declared some of their plant unavailable in response to the market. There seems little doubt that for the next few years however the market will continue to perform in the same way and adequate security will be provided although tight gas supply may alter this over the next 2 winters. What is less certain is

that the market will provide for the building of new plant to cover future load growth and the retirement of old plant. If the market does not respond in the way it is expected to induce generating companies to build new plant, Government intervention in the interests of security of supply is inevitable. Uncertainty over the future of nuclear will exacerbate this situation.

Another aspect of security concerns the well publicised blackouts in the recent past. The effects of these are all too obvious and the blame is usually laid in some way upon the whole process of privatisation. This appears to be too bland an answer. Reference to blackouts in other parts of the world as well as in the UK seems to indicate a number of causes, sometimes more than one, relating to a specific incidence. These causes include:-

- Disaggregation of a previously aggregated industry resulting in impaired communications between competing firms
- Breakdown or malfunction of control, protection and communication equipment
- Reduced maintenance levels
- Disappearance of expertise and experience
- Operation nearer transmission limits due to increased trading opportunities
- Lack of investment in transmission and interconnecting systems

The spate of blackouts occurring about 2 years ago seems, at least for the present, to have been halted but detailed reporting of the causes of the events must lead both Government and Regulator to seek firm assurances that the weaknesses identified have been permanently eradicated.

10. TRANSMISSION AND DISTRIBUTION

The engineering of the physical assets that make up the nation's 400 and 275 kV grid system and the underlying distribution system operating at 132 kV and below has undergone relatively limited change at least in terms of design over the past quarter of a century. This situation, however, is about to change if the targeted levels of distributed generation eventuate. Most of the change will initially be seen in the design and operation of the distribution systems as

increasingly significant amounts of distributed generation are connected to them. Figs 8 and 9 illustrate the principle. Fig 10 indicates the sharp contrast in the way in which new generation has been connected in the past as compared with much of the generation in the future.

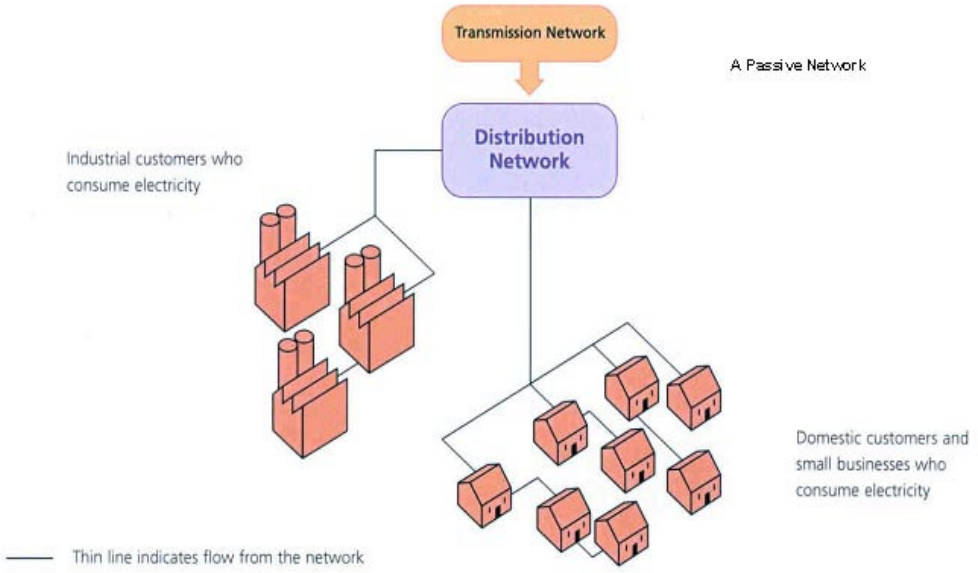

Figure 8: Distribution Network – Today

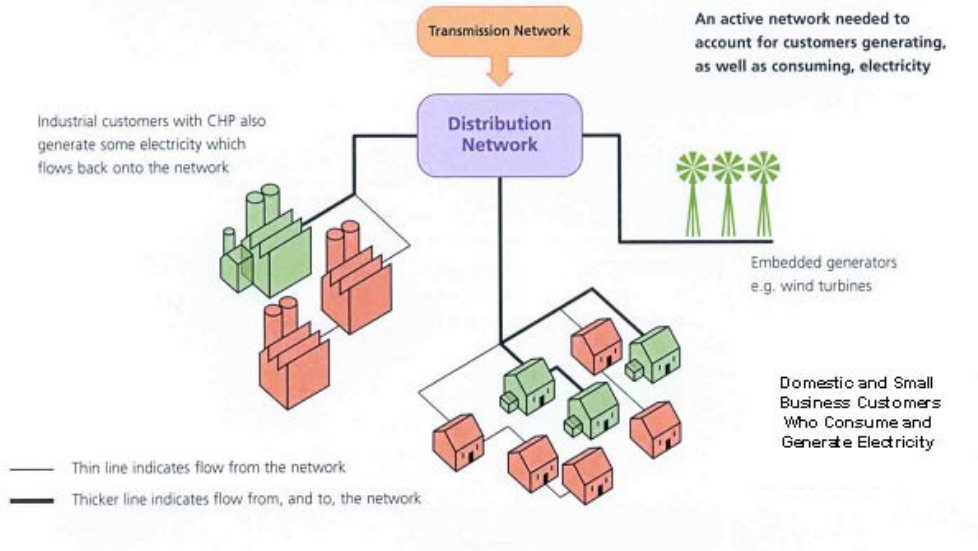

Figure 9: Distribution Network – Tomorrow

DECADE	SET SIZE MW	CONNECTION VOLTAGE, kV
1920's	50	132
1980's	660	400
2000's	2	33

Figure 10: Connecting New Generation to the system

The largely passive distribution network of today with power cascading from the transmission system to the customers over a passive distribution network will be replaced by these networks becoming active and ripe for the introduction of innovative techniques. With significant distributed generation, distribution networks will become active in helping to control power flows, voltage and security. Information technology and advanced communication techniques have not arrived a moment too soon!

Insofar as the extension of the 400 kV grid system is concerned, it is unfortunate, if not ironic, that the greatest concentrations of renewable energy are to be found at the extremities of our island, particularly Northern Scotland. Here demand is low and existing supply arrangements largely adequate. Conversely demand is growing most rapidly in the South East. Potentially high concentrations of remote renewable energy, eg offshore wind in Scotland, will have to be delivered over new 400 kV circuits to the existing system to the South and new or upgraded circuits provided where the demand is growing fastest. In this latter respect the number of new underground circuits will inevitably increase bringing with it higher costs of energy delivery.

The difficulties in building new 400 kV circuits are acute and planning issues remain a possible source of serious curtailment of the development of a

significant renewables programme. Large onshore wind farms eg >500 MW will only be developed in the Outer Hebrides and the Northern Isles if satisfactory transmission links to the mainland can be built and these costs borne equitably.

Whilst much of energy policy and public interest in electricity supply centres on generation, there are no fewer issues to be addressed and technologies espoused in the transmission and distribution sectors of the industry in the future. Some of these issues are listed below.

- Unforeseen Load Flows
- Increasing Circuit Loadings but need to Reduce Losses!
- Intelligent on-line Control and Relaying
- Actively Managed Distribution Systems
- Plant Life Extension
- Condition Monitoring and Data Interpretation
- Environmentally Unfriendly Materials
- Data and Information Transmission
- Space Compression and Undergrounding
- New Cable Designs and Materials
- System Issues arising from New Cable Technology
- Power Electronics
- Security Standards and Performance Incentives
- Monopoly Businesses Embedded in a Competitive Industry

Transmission and distribution are natural monopolies and will remain so. In order that the security of these systems is maintained, the prices charged to users reasonable and new investment is provided where necessary, the Regulator, Ofgem, has a vital role to play. There is an urgent need to continue the development of incentives for good system performance and, particularly in distribution systems, the financial stimulation of innovation. It is also important that the regulator oversees the successful introduction of BETTA which has created a single electricity market in Great Britain.

11. THE PEOPLE WE NEED

The number of people employed in the ESI is perhaps half what it was at privatisation 15 years ago. The range of skills now required is far broader with a much firmer grasp of subjects that were considered outside the perview of engineers. Good engineers have always understood enough of management, finance, law, public relations, as well as those at the core of their own profession. With the industry of the future we will rely on this to be a growing trend. This is true of the ESI itself but it is also true of the companies outside the ESI but upon which the ESI now depends.

In much of the ESI, self dependence on skills and experience no longer applies – outsourcing is now prevalent. It will be surprising, however, if some of the disadvantages of outsourcing do not cause utility companies to think again in the future about the extent to which this technique can be applied with overall benefit.

Privately owned business is run for profit and return to shareholders. Ever increasing need for efficiency, cost reduction and financial reporting on a regular and systematic basis characterise all successful modern businesses. The ESI is no different but it is much to be hoped that these activities, which absorb so much time, do not undermine the innovativeness and motivation of the most able people engaged in the industry.

CONCLUSION

Virtually the whole of this presentation has been concerned with the ESI in Great Britain. It is, however, worthwhile glancing at the rest of the western world to check that the issues which are of importance here are not irrelevant elsewhere and, conversely, that issues hotly debated outside the UK are not being ignored here. The following topics seem to characterise electricity supply industries elsewhere in Europe, North America and Australasia at least. With the possible exception of the pre-occupation in Europe of maintaining “National Champions” eg Electricite de France, Iberdrola etc the list is familiar in the UK.

- Increased Cross Border Trading
- Increased Consolidation of Ownership
- National Champions in Europe
- Increased Prices
- Competition Real or Imaginary
- Nuclear and Renewables – The Debate is Universal
- Burnt Fingers!

On the question of "burnt fingers", the past 10 years should have taught those companies who have had overseas ambitions how to manage their risks. Whether the lessons learnt in the past will have to be re-learnt by future generations remains to be seen.

This presentation began by asserting that the ESI would never be allowed to respond only to market forces but must also respond to Government legislation and to the promptings of the regulator.

We have seen how the nation's security, prosperity and its responsibilities to the global community is dependant upon the electricity supply industry and to this extent it must be an instrument of Government policy. The ESI has far too many stakeholders to remain static or slow to embrace change. Change in this context inevitably means innovation, some constraints, incentives and penalties. Since the industry cannot avoid its dynamic nature, Government and regulatory interventions in the future are inevitable. These are likely to include.

- Increased Energy Efficiency
- Fuel Poverty and its Reduction
- More Financial Support for Renewables
- Introduction of More Incentives for CHP
- Maintenance of System Security
- Resolution of the Nuclear Debate
- Fuel Supply Security

Whilst the timing, extent and mechanism of intervention may be uncertain the central themes over the next decade and a half are clear and as the ESI responds to these themes the following will be of importance:-

- Environmental safety and public health issues with attendant delays and cost escalation
- Increasing Government pressure on suppliers to make substantial improvements in energy efficiency
- Face “ultimate” democracy requiring increasing public support
- Develop half to full scale demonstration projects in coal gasification, energy storage, wave power and other nascent renewable sources
- After no more than 5 years participate in a new gas fired combined cycle generation programme
- See the beginnings in the same 5 year period of a new build nuclear generation programme
- Onshore wind generation will saturate towards the end of the period, offshore wind will develop but only in shallow water
- There will be transmission links to Ireland and adjacent continental European countries to facilitate more extensive trading
- Innovative development to produce active local distribution networks to accommodate increased distributed generation including renewables and CHP
- Oblige customers to pay significantly more for their electricity!

What is new is the simultaneous development of Governments’ environmental and energy policies in the UK and beyond which are so closely linked but whose solutions are often incompatible.

The electricity supply industry has faced these and many other lesser issues since its beginnings 130 years ago. That it has largely been taken for granted over that period is a tribute to it. I have no reason to believe that despite protracted debate both well informed and otherwise the industry will serve the nation well into the foreseeable future and beyond.

An alternative title of this presentation could have been “The Future of Britain’s Electricity Supply – Vision or Muddle?”. There is nothing to suggest that the two will not continue to co-exist into the future as they have since Queen Victoria reigned!