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Reflections

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Prepared by:

KEMA Consulting

Lead authors:

Jonh Scott, Peter Vaessen and Frits Verheij

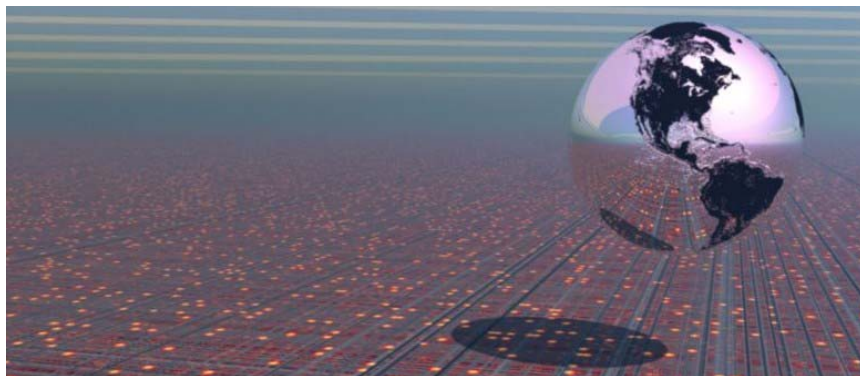
Reviewer:

Pier Nabuurs, CEO KEMA International

Smart Grids for the Future

Reflections

on Smart Grids for the Future



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Executive Summary

"we are contemplating here a key enabler for the third industrial revolution"

This Reflections paper has been commissioned by the Ministry of Economic Affairs and prepared by KEMA Consulting. While it has drawn on expertise within The Netherlands and offers thoughts for policy consideration by the Ministry, it is set in the context of global developments and offers an international perspective.

The key messages are as follows:

- Large scale renewable energy and significant quantities of distributed generation call for a new electricity grid design.
 - A transition to Smart Grids is a fundamental move away from classical grids to embrace a broad span of new concepts that embraces technology, business and customers. Some observers describe this as being part of a third industrial revolution.
 - Smart Grids combine the familiar and the innovative, integrating centralized generation with new distributed and renewable resources. Customers will have greater choice and be participators in energy, rather than passive users.
 - Smart Grids are a key enabler for the implementation of government energy and environmental policies.
 - The successful transition to Smart Grids requires attention to a range of issues that go beyond technology and include commercial and regulatory dimensions.
 - There are identifiable barriers to a smooth transition, but with a strategic approach these can be addressed.
 - An important responsibility rests with government, regulators, network companies and other stakeholders to dismantle barriers and, where appropriate, introduce incentives for engagement with due reward for managing risks successfully.
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Chapter 1

Tomorrow's Electricity Networks

1.1 The Context for Change

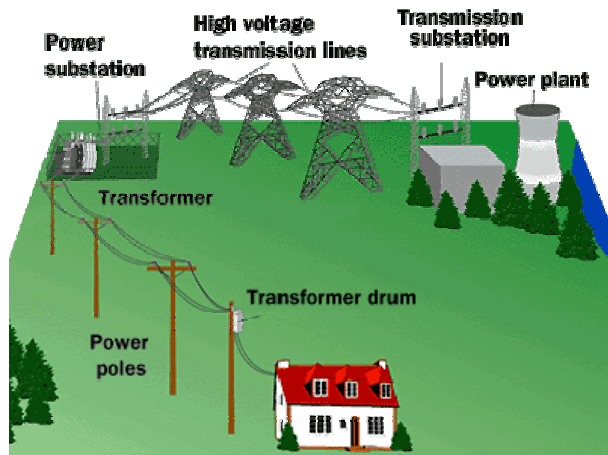
Today's electrical power system is a large and sophisticated technological entity with a history of more than 100 years. The system and the product it transports are taken for granted by many, yet electricity is crucial to everyday life.

"a paradigm shift heralding benefits for governments through to end-customers"

This dependence appears set to increase as society utilises ever more sophisticated technologies at home and in business, as the migration continues towards electricity being a larger share of our energy consumption, and as policies for more sustainable energy are translated into practical actions.^{1 2}

Nearly all forecasters foresee society making increasing use of this intangible yet most convenient energy carrier. The existing power system has grown organically. Each new development in society was accompanied by its own incremental modification to the network, with the most obvious characteristics being the continuous increase in scale and interconnection for increased efficiency and reliability. Until the end of the 20th century, the majority of all the power came from central generating capacity. The power system, the transmission and distribution networks, are in organizational terms a serial process having the sources and co-ordination at one end and demand users at the other. The diagram that follows is a simplified representation of classical grids as found across the world.

" the classical grid design can be found the world over"



Power grid distribution lines can be above or under ground.
Acknowledgement: Marshall Brain³

Things have started to change and are still changing. The development trends observable for decades and represented in the diagram above no longer hold good.

" a potentially powerful and extraordinary combination of opportunities"

New ownership structures and regulatory frameworks have emerged, in response to the deregulation of the electricity sector and the introduction of competition. At the same time international and national policies for sustainability have started to increase the amount of renewable energy used to produce electricity. Concerns for climate change are not only prompting government policy development, but also awakening a new interest in energy with end consumers and society at large.

A potentially powerful and extraordinary combination of opportunities can be observed today:

- New technologies are emerging for electricity generation
- These result in a dispersed rather than centralized approach
- New technologies are emerging for more efficient utilisation
- Modern communications and business systems can now facilitate customer participation on a wide scale
- Electricity grids are commonly fifty years old or more and a major renewal programme is needed as they enter the end of their reliable and economic life
- Renewal enables new material and new technologies to be deployed that can increase performance and operating efficiency (e.g. embedded systems and real time monitoring)
- Electricity grid development will form part of the national and supra-national response to concerns for energy security and robustness in the changing world energy context⁴

These factors would appear to present a uniquely helpful opportunity for cost effective and strategic change: society is facing compelling needs, technology and business are offering new capabilities, and grid renewal provides a rare, timely and cost-effective window of opportunity. The challenge is to harness these factors so that timely and orderly change can be brought about in this complex sector.

The challenges are not to be underestimated: observers speak of radical shift, of paradigm change, and make reference to a 'third industrial revolution' that might be considered a not immodest description.⁵

***"a vision
shared by
today's
stakeholders"***

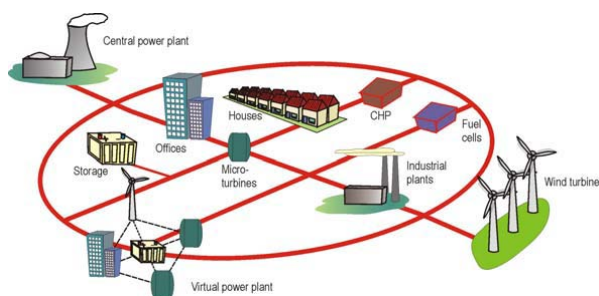
1.2 What are Smart Grids?

In recent years work has been undertaken in Europe and internationally to formulate a vision for the future of the electricity networks and their users. In this context a vision might be described as the concepts for the future system, as seen jointly by today's stakeholders.

"an international consensus is emerging"

The Smart Grids vision as described by the EU Technology Platform⁶ has many similarities to those emerging internationally⁷. Energy generation and transmission and distribution networks are seen to be operated differently in the future, and end customers will have greater choice and incentives for participation and energy awareness.

Dispersed Generation (DG) and Renewable Energy Resources (RES), including e.g. wind, solar, biomass and gas-based micro-technologies are expected to supply at least 15% of all electricity requirements in 2010 in the European Union⁸. Small to medium sized (<100 kW – 50 MW) conversion technologies, including high speed micro and mini power turbines, reciprocal machines, fuel cells, power electronics, and energy storage, will be installed on the electrical network over the next years⁹. Their share will continue to increase in the decades after 2010. As a consequence visions of a future power system that look like an energy web emerge, like the one depicted below.



"a more internet-like electricity system"

This diagram communicates the concept of a less hierarchical electricity system, having both dispersed and centralized generation sources. Conventional grid infrastructures continue to have an important role, but have to develop new architectures and control philosophies.

The concept of a Smart Grid is sometimes described as 'more internet like'. This can be helpful in describing the idea of much

greater distributed intelligence on the networks, more autonomous behaviours by equipment and network zones, and a design flexibility that enables a high degree of freedom of action by its users.

"Smart Grids is a broad concept"

The Smart Grids concept is wider than smart metering, although this is a key element. There is impact on grids at all levels from high voltage (transmission) to lower voltages (distribution). Some of the most fundamental rethinking of classical grid design is needed at the medium and low voltage layers.

There is no internationally agreed definition of a Smart Grid. A suggested definition is shown in the panel below.

“A Smart Grid generates and distributes electricity more effectively, economically, securely, and sustainably. It integrates innovative tools and technologies, products and services, from generation, transmission and distribution all the way to customer appliances and equipment using advanced sensing, communication, and control technologies. It enables a two-way exchange with customers, providing greater information and choice, power export capability, demand participation and enhanced energy efficiency.” EPIC adapted

"there is not a single blueprint for the future"

1.3 Achieving change

In view of the radical changes being contemplated, there is not a single blueprint for the future. A transition to Smart Grids can not be an 'Point A to Point B' undertaking: it will be an evolutionary process that encounters risks that will need to be identified and minimized at each stage, but with the prize of significant benefits for Member States and for the European Union. In view of the international nature of the issues there would appear to be high potential economic value, with export opportunities for the early movers.

"electricity grids have unique characteristics that must be considered"

Unlike the radical changes that we experience in, say, consumer goods (mobile phones, home computers for example) the development of electricity networks has a number of unique characteristics that must be recognized when considering the implementation of the new Smart Grids concept.

- New technologies have to be introduced to an existing electricity system which is a highly integrated entity
- New technologies must work seamlessly with legacy systems
- Grids have evolved on a recognizably common path but with material differences in their engineering detail¹⁰
- One size does not fit all at the implementation level
- Change has to be implemented without interruption to service quality or continuity
- The system can't simply be 'rebooted': the design, testing and support of new elements must be of the highest order
- In service demonstration, on a real network, is essential to prove new technologies: laboratory tests are insufficient.
- The technology alone is not enough: commercial and regulatory frameworks must be considered when introducing new thinking
- These factors are likely to affect companies in their management and strategic directions.

1.4 Is there an alternative?

Dispersed generation and renewable energy sources are already part of today's power system. They have been connected to the network, but do not take part in power system management. This 'fit and forget' policy is possible as long as the share of these sources is low and sufficient headroom exists such that operational limits for the network are not encroached.

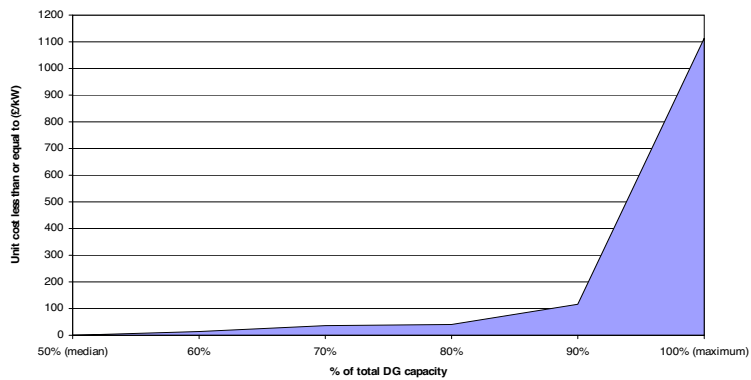
"Fit and forget has severe limitations for the future"

However, if a 'fit and forget' policy continues, a point will be reached where the system become increasingly difficult to manage, with high associated connection costs and inefficiencies,

and increased unreliability with more outages. These connection costs can be material as demonstrated in a study of the UK case¹¹.

The graph below indicates the non-linear nature of running out of headroom and reaching network limits. It indicates that, for British Distribution Network Operators, 50% of the Distributed Generation (DG) projected for 2010 can be connected at no additional cost reinforcement cost. Beyond this point the costs rise non-linearly as headroom in the network is exhausted and traditional solutions are deployed at an accumulating cost.

DNO unit cost estimates for DG connections to 2010



source: Ofgem

"there is significant potential for innovative solutions"

There is evidence that innovation is required, ie the transition to Smart Grids, to enable increasingly high penetrations of DG to be accommodated without entering this cost escalation situation. The EU Technology Platform have identified that there is significant potential for innovative solutions¹². These would apply in areas such as fault level limitation, voltage control, and in the automatic protection systems that are necessary to intercept power system faults.

There is some quantified evidence from the UK to support this

"a strongly positive Present Value"

engineering view¹³. Ofgem undertook a Regulatory Impact Assessment to identify the cost-benefit of incentivising the network companies to use new technologies to assist the connection of DG. The analysis undertaken by independent consultants showed the following positive Present Value:

Estimated Costs of New Technology Solutions	Sum of the Present Values for all innovations identified
€38m	€160m
@ 6.5% discount rate	

1.5 The Hallmarks of Smart Grids

The consensus on the likely form and content of Smart Grid networks can be described at a high level. The panel below summarises the key descriptors that are anticipated for such grids in the context of large power systems.

Recognising a Smart Grid:
<ul style="list-style-type: none"> ✓ Centralised plus de-centralised generation ✓ Pan-EU interoperability: power flows & services ✓ Bottlenecks and loop flows minimised or eliminated ✓ Two-way distribution network flows ✓ Less distinction between Transmission & Distribution ✓ Customer information displays ✓ Customer interaction and participation ✓ Variability & intermittency of generation sources ✓ Customers rewarded for exported power & services ✓ 'Internet-like' architecture: dispersed intelligence and power flows from T2D, D2T and C2C

These capabilities cannot be achieved efficiently with today's network and communication architectures, or today's range of power system and consumer equipment and facilities.

It is the view of the EU Technology Platform¹⁴ however that there

"much of the technology is close to commercial readiness"

is much potential technology which is close to commercial readiness and does not need fundamental research to achieve successful application in the next 5 to 10 years. There are also areas that require more fundamental attention and these will need to be addressed to provide the seed corn for the future. The enabling technologies include the following.

Smart Grids Enabling Technologies:

- Control of bulk power transfers
- Renewable generation large scale
- Renewable generation small and micro scale
- Combined Heat and Power integration
- Smart Meters and interfaces
- Intelligent Appliances
- Transaction & Settlement systems
- ICT & Power Electronics
- Bulk energy storage
- Integration of electric vehicles
- Integration of the Built Environment

"the trend is for a fundamental shift away from classical grids"

It is evident from the above that the trend is for a fundamental shift away from classical grids; that many of the technologies are close to deployment in the market but need tailoring to specific applications and proving on real networks; and that the implications are far reaching. The Smart Grids concept can be expected to bring very positive opportunities for a wide range of stakeholders including end customers who until now have largely been passive demand-takers. Achieving such radical change will require the active and imaginative support of government, regulators, manufacturers, academia and, last but far from least, the network companies.

"active and imaginative support will be needed"

1.6 Policy Considerations

To assist policy debate, the table below identifies key issues and makes recommendations for action.

Chapter 1: Tomorrow's Electricity Networks Policy Considerations

- ◆ **1/1** A fundamental message that is reinforced throughout this document is that ‘the technology alone is not enough’: in other words, the technical, commercial and regulatory aspects must be addressed in an integrated way for a successful transition to Smart Grids. This needs to be recognised and addressed by all the stakeholders so that the natural barriers between disciplines are made more permeable and joint action is undertaken.
 - > **Proposed action: the government, in conjunction with the regulator, should consider establishing a Smart Grids Transition Platform that brings together senior representatives of the Dutch stakeholder community with the task of promoting the efficient and effective implementation of Smart Grids. It will be important to determine effective mechanisms and Terms of Reference for this Platform, and in particular to ensure that it is a true stakeholder forum and does not become a substitute central planning organisation, which would be counter productive development. Related points are raised in Chapter 3 and 6.**

- ◆ **1/2** There is a risk that the replacement of ageing network may proceed on a like for like basis, which has the potential to close off the opportunity for introducing Smart Grid architectures for another 40 years, the typical lifetime of the network equipment involved.
 - > **Proposed action: the Smart Grids Transition Platform referenced above should be asked to address this issue and report regularly and openly on the progress of transition and provide reassurance that opportunities related to the replacement of ageing network are not being lost for development of Smart Grids.**

Chapter 2 The Drivers towards Smart networks

2.1 The EU Drivers

"a significant European policy programme"

The European Union has raised the profile of energy and its associated policy developments. The principal and current strands of work are:

- Policy development to address supply security
- Policy development to strengthen markets and regulation
- Policy developments for environmental sustainability

The EU underpins the above by:

- An ongoing and substantial research programme (FP7)
- Creation of 5 related stakeholder Technology Platforms¹⁵
- CEER and ERGEG to promote effective regulation¹⁶

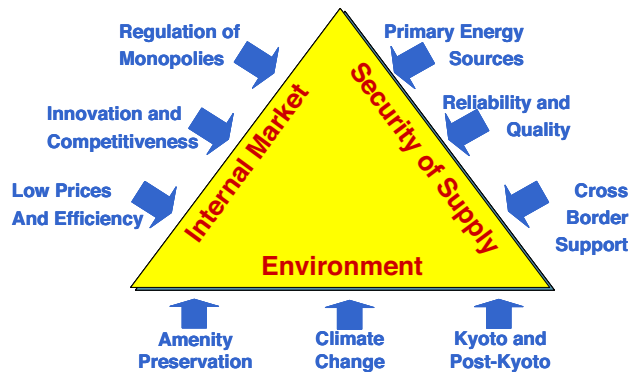
This significant policy programme and support framework aims to meet the sometimes conflicting goals of:

"effective analysis and risk management will be needed"

- i) SUPPLY SECURITY & QUALITY**
- ii) SUSTAINABILITY**
- iii) COST EFFECTIVENESS**

Supplementary goals include supporting the Lisbon Agenda that promotes innovation and economic value for the EU¹⁷. A balance will have to be struck between a number of trade-offs. Effective analysis and risk management will be needed.

The EU Technology Platform has summarised the drivers for change as shown in the diagram below:



The EU Technology Platform Drivers for Change

The development of Smart Grids, across the whole supply chain from generators to end users, and at transmission and distribution network levels, has an impact on every element of policy outlined above. Smart Grids are a key enabler for change and failure to implement them will almost certainly frustrate the delivery of wider European and national energy policy goals.

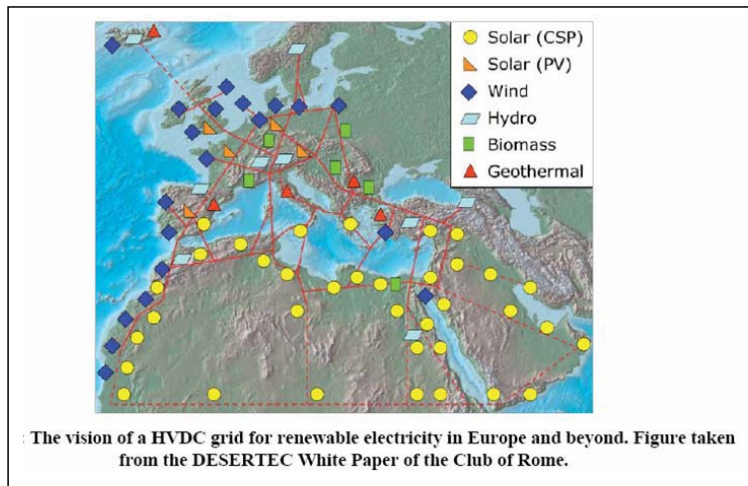
"reputations of stakeholders may be at risk"

Owing to the strong inter-dependencies, it can be expected that ineffective or untimely delivery of Smart Grid capabilities will draw adverse criticism upon both those who are responsible for the networks and others in the supply chain from policy and incentives, to technology and deployment.

2.2 The Wider Trends

While the Smart Grids discussion can be contained within a European and Member State context, there are global drivers at work also.

"there are potentially significant developments at our boundaries"



For example, at Europe's boundaries there are significant new energy opportunities as indicated by the map below:

Looking further a field, climate change concerns are creating a global trend for increasing contributions from renewable energy. This is summarized in the graph below which shows overall global increases of 3 times present production by 2010 and 5 times by 2020. EU member state targets are not inconsistent with this scale of challenge.

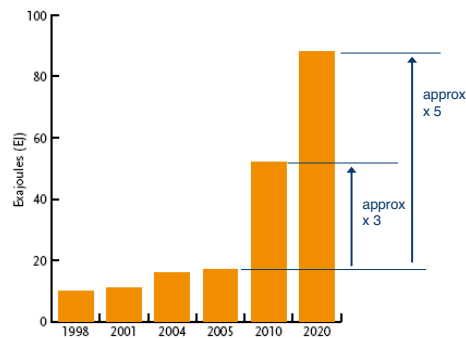
"global trends indicate the potential for exporting proven solutions"

The challenges for Europe might increase beyond this as the major intermittent energy sources will be concentrated in specific regions. Offshore wind power is likely to be installed mainly in North-western European waters (according to the European Wind Energy Association 70 MW offshore wind power in 2020 and 150 MW in 2030 being 50% of the estimated 300 MW by then). The biggest volumes of solar-PV will most likely be installed in the Southern European countries and Northern Africa.

Renewable energy deployed at this magnitude will be a non-trivial issue for grid operational management as well as presenting

challenges for grid connection and capacity bottlenecks. It presents new demands for efficient balancing and for ancillary services: interestingly the global nature also indicates the potential for export of technology solutions and operational know-how from Europe.

What will be truly saleable will be the proven, not the theoretical, product and service solutions.



Projections for Global Renewable Energy 2010 & 2020

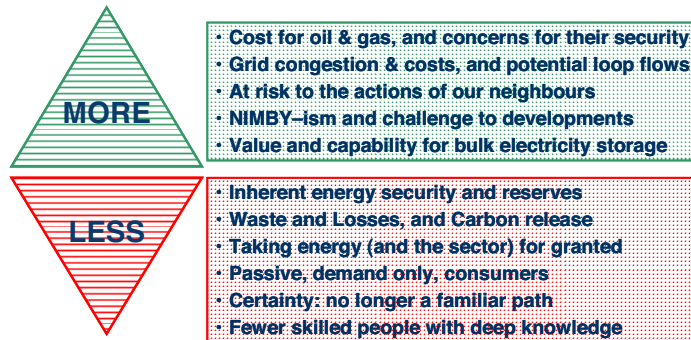
Note: Projections of modern renewables (including small hydro, excluding large) based on 11.5 percent growth per year, over the period 2001-2005.

Sources: UNDP, UNDESA, and WEC, 2000 and 2004; REN21, 2006; And IEA, 2006

***"far beyond
the confines of
traditional
networks"***

2.3 Anticipated Context

The graphic below summarises the changes that might be anticipated as context for the development of Smart Grids.



"demanding issues for management"

The factors identified are broad in nature and reach far beyond the normal confines of traditional networks and their operation.

The transition to Smart Grids will be examined in more detail in Chapter 4. What is evident here is that the context is likely to become more complex and more sensitive. Also, closer examination shows that some of the anticipated trends may reinforce each other in unhelpful or unhelpful ways. For example, less certainty and the need for fundamental rethinking, is at variance to there being fewer skilled people available. On the other hand, end consumers being less passive and more participative, is usefully reinforced by energy and the sector being taken for granted less in the future.

"end to end knowledge is increasingly scarce"

Returning to an earlier observation that 'the technology alone will not be enough' it can be seen from this short discussion that the issues involved encompass societal and demographic issues, and impinge on national energy strategies and security. These are likely to be demanding issues for management. They will require highly effective communication to politicians and civil servants, to end customers small and large, and to the public in general. Furthermore, a long term and imaginative programme will be required to address the skills issues.

The demographics of the sector are generally adverse with many

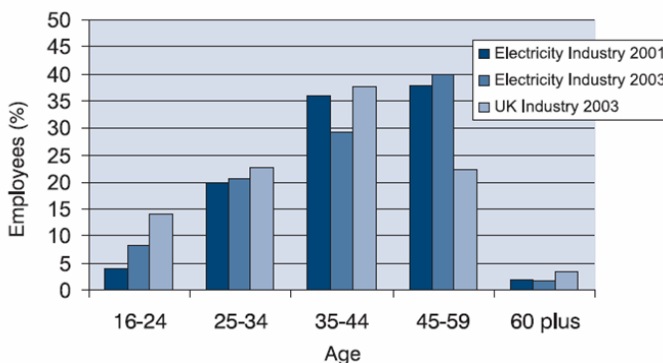
deeply knowledgeable people currently retiring. It is unwise to embark upon fundamental change to electricity to grids without a full understanding of their underlying engineering and physics, and an appreciation of why current grids are designed as they are. Engineers with an 'end to end' knowledge of how electricity grids work are becoming increasingly scarce.

This issue arises regularly now in international conferences and seminars: companies report difficulties in recruiting new engineers, the number of university undergraduates taking power engineering courses is in decline, and poaching of staff is reported anecdotally. There are however encouraging signs of new initiatives, such as the IET Power Academy¹⁸ in the UK which is having success in reversing these trends. In the UK this model is currently being extended to create a Research Academy to encourage a small number of good graduates to continue into power system PhD research rather than be tempted immediately by the salaries offered in industry (or more damagingly in the finance sector where their analytical skills are rewarded highly).

"it's a long game"

As an example, the graph below shows the age profile for the UK power sector. The data baseline is 2003, now five years later the largest grouping will have moved into the 60plus category and will have retired or will soon do so.

"the problem is being masked"



It is however a long game and companies need both a strategic approach and encouragement. Company management face the risk that development of new staff will be thwarted by other companies who have not invested in training and recruit aggressively from those who have. There is an important balance to be struck here between healthy market forces being encouraged to operate, and a measure of joint action that gives confidence to companies and raises standards.

"the grey market may mask a hazard"

A subtlety that may be noted here is that there is a considerable 'grey market', probably in both senses, of ex-industry staff of a certain age group operating as freelance contractors. This is a most valuable pool of expertise. However it i) masks the fundamental problem, ii) involves engineers who are unlikely to be passing on their knowledge or developing succession plans, and iii) will inevitably reach a point where the engineers involved retire fully and the pool of resource shrinks rapidly.

"other sectors present major new interactions for grids"

Similar concerns about demographics and skills arise in The Netherlands. Age profile issues have been noted by the network companies and universities have commented on a strong reduction of Dutch students with an interest in electrical power systems since the 1990s. In recent years a reverse trend is shown although many university places have been taken by students from outside The Netherlands^{19,20}. Furthermore, students are increasingly tempted to leave engineering when they graduate: the finance sector in particular values the analytical skills of these young people and pays salaries that commonly exceed those offered by network companies.

2.4 Developments in Other Sectors

It is beyond the scope of this report to address other sectors in any detail. However, in regard to Smart Grids, particular note should be taken of the following:

**"a new and
substantial
interaction"**

The Built Environment

Town planners, architects and others are giving significant attention to the impact of climate change and the challenges of carbon reduction through attention to building design, community layout and transport integration, energy efficiency, energy utilization and control, micro-generation, combined heat and power and so on. Radical changes in these areas is likely to have consequences for electricity networks and for the behaviours and expectations of network customers.

The Transport Sector

There are many developments taking place in transportation, both public and individual. One of the most important for consideration in the context of Smart Grids is the development of electric vehicles. For example, an electric vehicle with battery storage is potentially a new and substantial electricity *demand*, a potentially controllable demand, a potential *source* of power (exporting back into the grid, or to supply a house), and a potentially controllable source of power *export* that could provide fast-acting and economic system reserve. With large numbers of cars, commercial vehicles and buses, the gross capability is highly significant in the scale of national electricity grid systems. The development of communications and control capabilities could in due course make such deployment a practical proposition. It is also an interesting possibility that a storage capability in electric vehicles could be integrated with the network to address the challenge of variable output from generation such as wind farms and marine sources. Storage in all forms is likely to have an increasingly important role in the Smart Grids of the future.

2.5 Policy Considerations

To assist policy debate, the table below identifies key issues and makes recommendations for action.

Chapter 2: The Drivers towards Smart Networks Policy Considerations

- ◆ **2/1** This chapter demonstrates that a sense of urgency is needed. Delays to Smart Grid implementation will jeopardise the achievement of carbon reduction targets and the delivery of security of supply policy goals. If the networks are not ready for significant increases in renewable energy, for much greater customer participation, and for pan-European interoperability it is likely that there will be considerable reputational damage to the parties concerned, and wider export opportunities will also be lost.
 - > **Proposed action: the Smart Grids Transition Platform (see Chapter 1) should commence the creation of a common vision for the future of networks and examine scenarios for the medium and longer term, including identification of critical paths and barriers, to provide assurance of a timely Smart Grid transition.**

- ◆ **2/2** The global nature of Smart Grids challenges is also an opportunity for export growth and sales within the EU and beyond (and associated employment in The Netherlands).
 - > **Proposed action: the Smart Grids Transition Platform should undertake a strategic assessment of likely export markets and volumes. This would provide a reality check on export potential for The Netherlands and determine how best to take advantage of export opportunities.**

Chapter 3

The Key Stakeholders

3.1 The Principal Players

In a complex sector such as electricity supply that has high strategic importance, involves large customer numbers, and is facing radical change it is not surprising that there are many stakeholders.

"a common vision but quite different aspirations"

Stakeholders, by definition, are those that have a shared interest in the success of a venture. They are, conversely, like minded in wanting to avoid failure and its consequences.

Stakeholders are likely to have differing motivations for change, need quite different incentives to stimulate action, and will each see the issues through 'different eyes'. Communication therefore has to be tailored to each audience rather carefully, even though the underlying message is a common and consistent one.

To simplify a complex landscape the table that follows sets out five broad categories of stakeholder. It is useful to consider what the contributions and drivers of each may be. The members of a broad stakeholder grouping can genuinely aspire to a shared vision of the future, but have quite differing motivations and 'value propositions'.

Key Stakeholders and their headline aspirations	
Governments	<ul style="list-style-type: none"> ➤ A policy delivery mechanism for greener energy and greater energy efficiency ➤ Action to enhance security of supply
Regulators	<ul style="list-style-type: none"> ➤ Need to have assurance of the need case ➤ Mechanisms to ensure efficient investment
Manufacturers	<ul style="list-style-type: none"> ➤ Clarity about future product requirements ➤ Client engagement and demonstration to prove new products on networks
Network Companies	<ul style="list-style-type: none"> ➤ Concrete actions, what and by when ➤ To better understand the opportunities and the risks
Customers	<ul style="list-style-type: none"> ➤ Have more choice, quality, security and efficiency ➤ Involvement, understanding and witness to others

The headline aspirations shown above are of course only indicative; each stakeholder will bring their own agenda determined by a mix of their own business priorities and their state of readiness for moving ahead with Smart Grid developments. Nevertheless it is informative to examine the categories of aspirations indicated. They can be summarized as follows:

"understand the aspirations and the leadership roles become evident"

Key Stakeholders and Value Propositions	
Governments	<p style="text-align: center;">STRATEGIC BENEFIT BUSINESS CASE (Cost Benefit) THOUGHT LEADERSHIP CSR (Corporate Social Responsibility) COMMUNITY & SOCIAL LEADERSHIP</p>
Regulators	
Manufacturers	
Network Companies	
Customers	

Clearly there are quite different drivers at work here and the 'convincing case' for one party may be of little relevance to another.

An example might be the priority that Regulators or Companies puts on a cost benefit case; in effect wishing to be assured of a commensurate financial return on the investment made. However this is rarely the logic used by an end customer: taking a domestic parallel: "you don't refurbish your kitchen because there will be a positive net present value"!

"the convincing case for one party may be of little relevance to another"

People refurbish their kitchen for much more subtle reasons: it may be the satisfaction of having the latest designs, or the convenience of a more ergonomic and efficient arrangement, or perhaps the desire to demonstrate to friends and neighbours that they are trend setters and fashion leaders.

The parallels for end customers to invest in smart energy technologies may not be dissimilar. Indeed there is anecdotal evidence of householders putting solar panels on their roof to 'make a statement to their neighbours about local energy profligacy'. Similarly, parents may choose to install smart devices to encourage their children to take a closer interest in the environment. Neither of these situations depends on a cost benefit case.

"but, rightly keen to receive a due financial return"

The above notwithstanding, where end customers provide a service such as demand responsiveness or generation export they will rightly be keen to receive a due financial return.

The opportunity for each group to show leadership and encourage Smart Grid development similarly differs. A simplified analysis is shown below:

	Lead by their	displaying
Governments:	Policy	Consistency
Regulators:	Incentives	Facilitation
Manufacturers:	Products	Inter-operability
Network Companies:	Initiatives	Proactivity
Customers:	Demand	Passion

As the analysis above indicates, each stakeholder group has a key contribution to make to Smart Grids transition, but it is not only what they do but how they do it.

3.2 The Wider Context and its Challenges

A more comprehensive list of Smart Grids stakeholders is shown in the table following.

A Wider Stakeholder List:	
➤ T&D network companies	➤ Academia
➤ Generators	➤ Research institutions
➤ Suppliers/Retailers	➤ Consultants & Specialists
➤ Shareholders	➤ Finance providers
➤ End customers	➤ Insurers
➤ Governments	➤ Company staff
➤ Regulators	➤ The Electric vehicle sector
➤ Manufacturers of engineering products	➤ The Built Environment sector
➤ Providers of ICT and business solutions	➤ The general public

"there are further interests and sensitivities to be addressed"

A little examination reveals further interests and sensitivities to be addressed. For example, finance providers will be interested in risk and its management, and the general public will be interested in matters that affect the 'public space' and are will make their

views known in the planning and consents processes for new infrastructure.

"a new dimension of corporate activity"

The wider list reveals new audiences for energy interactions in the Smart Grids context. It points to the need for powerful new communication capabilities by the traditional networks sector, and correspondingly a need for them to understand in some depth the interests of the other parties. The electric vehicles sector and built environment sector are two important new stakeholder groups where 'energy and networks intersect'. These were discussed briefly in Chapter 2. An effective response will warrant a new dimension to corporate communications activity. There will be considerable scope for co-ordinated or joint action. If the messages from various companies are (apparently) inconsistent, great damage is likely to be done and credibility can quickly be lost.

"credibility can quickly be lost"

Arguably the most challenging communications interfaces will be with the general public and end users. Mass communication to groups such as this is more problematic than interfacing with specialised sectoral interest groups.

Referring to communications alone is potentially a misleading simplification. The scale of the Smart Grids revolution will raise issues that are matters for policy makers and society at large, and not simply the traditional electricity sector. This brings us back to the trade offs mentioned earlier between sustainability, security, cost and quality.

"compelling and exciting"

A particular challenge for communication to the wider public will be how to present Smart Grids issues in a manner that is compelling and exciting; that takes people's interest; that motivates them to change their behaviours and engage in new opportunities. While energy may have been taken for granted for many years, there are aspects that are attention-grabbing: for example the climate change and sustainability dimensions, and

the rising and unpredictable costs of energy.

3.3 Policy Considerations

To assist policy debate, the table below identifies key issues and makes recommendations for action.

<p>Chapter 3: The Key Stakeholders Policy Considerations</p> <p>◆ 3/1 It was identified in Chapter 1 that successful transition to Smart Grids requires the active engagement of all the stakeholders. Chapter 3 has analysed this further and shows that Smart Grids may offer each stakeholder quite different value propositions.</p> <p>> Proposed action: in creating the Smart Grids Transition Platform (Chapter 1 refers), the government and regulator should undertake a stakeholder analysis and ensure that the membership of the Platform and its Terms of Reference recognise the diversity of interests.</p> <p>◆ 3/2 In a liberalised market there are many players who operate with a large degree of independence. Furthermore, Chapter 3 has identified that there are issues that go beyond the traditional electricity sector and will impact on other sectors and society at large. In this context there is a new importance for achieving consistent and effective communication, explanation and persuasion. There is also the risk of inconsistent communication messages with potential damage to the credibility of all concerned.</p> <p>> Proposed action: the Smart Grids Transition Platform should address the task of ensuring co-ordinated and highly effective communications.</p> <p>◆ 3/3 In the medium term new stakeholders will become party to Smart Grid developments, such as those concerned with electric vehicle transport policy, and those addressing the built environment (Chapter 2 refers also).</p> <p>> Proposed action: the Smart Grids Transition Platform should maintain a horizon-scanning activity to identify the convergence of interests that will arise between sectors that have until now been quite independent. The Platform should take the necessary steps to integrate them as stakeholders in a timely way.</p>

Chapter 4 Transition from Today's Grids

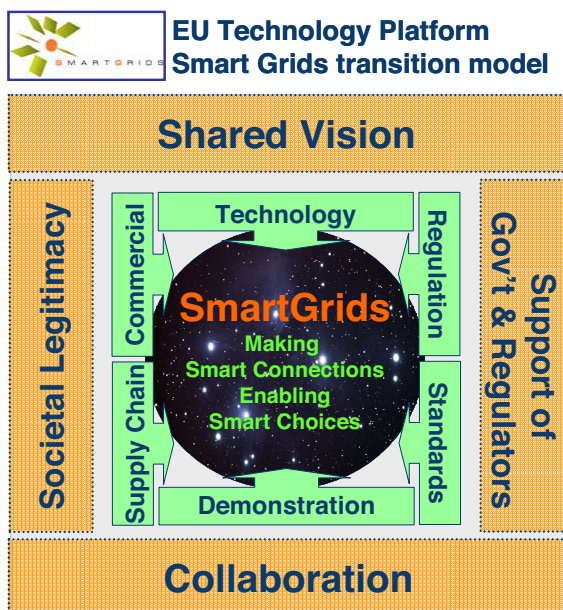
4.1 The Elements of Transition

"decompose the challenge"

To consider the process of transition to Smart Grids in a practical way and understand the policy implications, it is necessary to decompose the challenge to its characteristic elements.

The European Technology Platform have developed a model that may be useful here to provide a form of check list to ensure that no important aspects are overlooked.

The diagram below summarises the Platform's model for Smart Grids.



Explaining the model briefly:

The Platform's shorthand, non-technical, message to describe Smart Grids is shown in the centre

"Making Smart Connections, Enabling Smart Choices"

This is theme explained in the short video released recently²¹ by the Platform to help communicate Smart Grids in non-technical language. The inner group of key enablers and messages are:

"the key enablers for innovation"

The Key Enablers for network innovation	
Technology	<ul style="list-style-type: none"> • There are real technical challenges • They are largely solved or are solvable • But technology alone is not enough
Regulation	<ul style="list-style-type: none"> • Regulatory frameworks may have unintended barriers to innovation on networks • New regulatory policy takes time to implement
Standards	<ul style="list-style-type: none"> • Standards and protocols underpin open systems • A Plug & Play approach is needed • There are no quick changes made here
Commercial	<ul style="list-style-type: none"> • Market frameworks and settlement systems may not facilitate innovative solutions • Attention to intellectual property is needed • Export opportunities will exist here
Supply Chain	<ul style="list-style-type: none"> • Innovative solutions need wide deployment • But supply chains have limited capacity • Manufacturing, materials, services and skills
Demonstration	<ul style="list-style-type: none"> • Demonstration/pilot projects are key • Operational proving is a critical step • Beware the pitfalls for first movers (see on)

The outer group, that provide the important wider context for innovation on networks and the associated change activities are:

"the essential context for innovation"

The Elements that provide the context for innovation	
Shared Vision	<ul style="list-style-type: none"> • Multiple parties must form a common view of success for the stakeholders • A shared and living Vision is a must for 'joined up thinking' in an evolving sector
Support of Government & Regulators	<ul style="list-style-type: none"> • Major change requires alignment of policy priorities and co-operation • Framework changes, particularly involving different sectors, need proactive support
Societal Legitimacy	<ul style="list-style-type: none"> • Consents for development will be needed; also <i>Permission to Operate</i> in the widest sense • Trust & social impact requires special attention
Collaboration	<ul style="list-style-type: none"> • Collaborative working underpins integration and efficient development • It is the way a market handles complexity • It should not be confused with collusion or anti-competitive behaviour

This model begins to draw out the multi-party roles and their contribution to delivering innovation to networks in a liberalised market. The elements form series/parallel activities in practice and, while it may be attractive in concept, there is little practical value in attempting to construct a 'process flow diagram'. The business dynamics are too complex, especially where novel technologies are concerned, to set down a step by step model.

However some indication of process connectivity and associations can be constructed and these are shown in the diagrams that follow, described as strands of activity.

The first strand is the

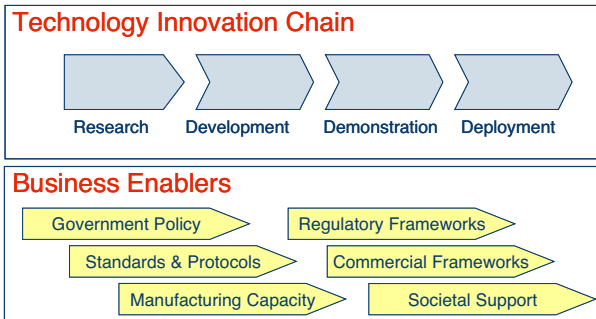
Technology Innovation Chain

and the second strand is the group of

Business Enablers

Where the Business enablers are not aligned they become critical path barriers resulting in blockage, hesitation or delay.

The Two Strands of Transition



This indicates a 'public/private partnership' in the fullest sense, and reveals the range of skills and depth of knowledge required

"a helpful simplification of the real world"

Considering the first strand, the Technology Innovation Chain: this series of elements comprising Research, Development, Demonstration and Deployment is well known, is applied to many sectors, and is commonly abbreviated to R,D,D&D. This model is a helpful simplification of the real world which in practice has greater connectivity and numerous feed-back and feed-forward loops.

"a unique hazard"

However there is an important point to be observed that the steps in the chain are very different in character and, for innovation on electricity networks have a uniquely problematic element. This is the Demonstration stage. It is a hazard that does not arise in other sectors where operational proving can to be undertaken without exposure to general customers. Furthermore innovation in other sectors rarely has disruptive failure modes that may result in the destruction of the equipment under demonstration.

Demonstration is key to commercial deployment because it forms the essential final proving stage. No network company will purchase a product from a manufacturer on the basis that it is proven, unless there is evidence of its operation on a real grid. Laboratory tests have a key role to play and indeed can accelerate and de-risk the deployment process, but they are not a full

"The Netherlands has world class facilities to offer"

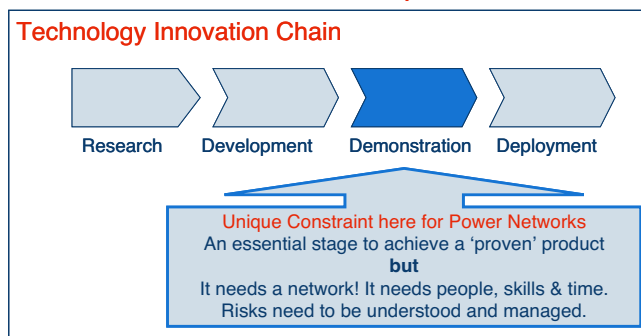
substitute for exposure to the realities of the operational grid environment. For example, field operational experience includes exposure to weather, to electrical interference, to distortion of the pure sinusoidal waveform, and to short circuit currents and voltage dips caused by faults on nearby equipment.

There is considerable scope for modern laboratory facilities to bring further advances in this area. Laboratory testing and certification on a component and subsystem level is efficient and effective, particularly where innovation is concerned. It can also provide a quality control and assurance mechanism. Device operability and interfaces can be proven, leaving full system proving to be undertaken by operational demonstration. The Netherlands is strongly positioned as regards world class laboratory facilities, for example KEMA's high voltage and high power laboratories and the new power electronics laboratory now being commissioned at the Arnhem site.

"an element of risk that has to be managed"

However, while operational experience (often termed pilot or demonstration projects) is of value to the network companies it is not without an element of risk for them that must be managed well. New technology may have early-life problems and mal-operate: it would be of serious concern if this for example affected the continuity or quality of supply to network customers. Indeed the network company are likely to suffer both complaints and regulatory penalties if customers are adversely affected.

Network Innovation: a unique hazard



***"industrial pull
 as well as
 technology
 push"***

The diagram above summarises this sensitive point. It is an issue that can benefit from a dialogue with regulators and consideration of incentives. It shows vividly why progress cannot be made without network company engagement; there has to be 'industrial pull' as well as 'technology push'. The network companies also have to have available sufficient knowledgeable and experienced staff to deploy on new technology projects. These issues are discussed further in the later chapter on Potential Barriers.

4.2 The Character of Transition

Transition from classical grids to Smart Grids is not a 'Point A to Point B' task: there is no blueprint. Smart Grid networks are an evolving vision, a set of emerging concepts and principles that are gaining international endorsement. The elements have to be developed stage by stage, and proven and integrated with legacy systems.

The creation of a vision was formerly the role of the central planner. In today's liberalized market this should become a joint activity of all the stakeholders. The role of the regulator warrants consideration: many regulatory bodies adopt a high level approach and limit their involvement to creating a level playing field. Where this is the case, it can be argued that there is much

"the risk of substitute central planning"

to be gained by their participation as a facilitator and co-contributor in the vision process (after all, development of the regulatory framework should be part of the vision).

Where regulators get closer to the detail there is a likelihood that they will become substitute central planners. Perversely, network companies may not discourage this as it removes risk from themselves ('the regulator told us to do it...'). Where this happens it does not bode well for the liberalized market and for customers in the long term. It is likely to result in a dependency culture where companies fail to develop new strategic capabilities and the skills to manage innovation successfully. Arguably it undermines Member State capability in Smart Grids and seriously reduces the likelihood of export potential.

"a recipe for failure"

As noted earlier, in this environment the challenge is much wider than technology alone. New items of equipment or novel system architectures may encounter unintended barriers in commercial and regulatory frameworks. These can be addressed through industry change control processes, but that takes time. It also requires the issue in question gaining sufficient priority to compete with a long agenda of other issues that will typically be going through the same machinery. Leaving these aspects until last is a recipe for failure: commercial and regulatory aspects need to be identified at the outset and addressed in parallel with technology. They also benefit greatly from the facilitation and constructive support of policy makers and regulators.

"need for commensurate reward"

A key issue for regulatory consideration is the treatment of innovation expenditure by network companies and the incentives needed to reward them for managing it well. No commercial organization takes on risks voluntarily unless they can anticipate a commensurate reward for successful outcome. This issue will be addressed further in a later chapter where an illustrative case history from the British experience is presented in brief.

4.3 Some Practical Comments

Global interest in Smart Grids is accelerating with numerous research projects starting up, and new commercial conferences announced weekly. While this is a healthy sign of a sector that is awakening to the challenges, there is less obvious engagement from one of the critical path players: the network companies.

"healthy signs but key players are missing"

This situation is a potential show-stopper for the reasons of 'industrial pull' described earlier. Furthermore, it can be tempting in a multi player environment to hold back and let others go first, with the intention of being a 'second wave follower' when the issues are better understood and the uncertainty reduced. Evidently not every player can go second.

The table below sets out some practical pointers for consideration. These are gleaned from many sources and are a pointer towards successful practices elsewhere. Noticeably, innovation good practice sometimes runs counter to business-as-usual practices.

"innovation good practice may be at variance to a business-as-usual approach"

Transition Good Practice: Learning by Doing

- ✓ Start somewhere! But make it part of a strategic plan.
- ✓ Gain experience of new technology and the management of it. Consider any new aspects this brings for procurement processes, testing, operation and support.
- ✓ Develop a vision with other stakeholders; take initial steps; regularly review and recalibrate.
- ✓ Don't expect to produce a conventional cost-benefit for new technology: costs and benefits are likely to have wide tolerances
- ✓ Don't over analyse: Ready, Fire, Aim (Start > Test > Refine)
- ✓ Mass roll-out is unlikely, but it may be appropriate for some situations (eg smart metering)
- ✓ Network 'hot zones' for smart technologies are more likely
- ✓ Demonstrations on real networks are key to progress: be systematic
- ✓ Anticipate uncertainty & ambiguity. By definition innovation has greater risks than proven technology. Identify and mitigate them.

4.4 The Role of Standards

"essential but not sufficient"

Standards are a well established concept in the electrical sector: they encourage best practices, reduce risks, and facilitate open systems. They are a good example of effective co-operation between parties who in other circumstances are exposed to fierce market competition or regulatory benchmarking. This co-operation takes place at the strategic, non-competitive, stage in product development.

"professional engagement is a key success factor in engineering"

It is a self-defeating, but observable situation that this form of professional engagement is sometimes lacking. For example, delegates at conferences may be entirely non-participative for fear of breaching their company confidences or being seen to proffer some collusive behaviour. This is understandable in part, but is unnecessary and very damaging. Professional engagement is key to success for the sector as well as for companies. But it is a competence to be learnt and understood. There may be fine lines to be drawn at times but it is the role of the true professional to handle such circumstances. Where engagement has been absent for some time there may be need for encouragement and coaching.

"standards alone cannot lead Smart Grids deployment"

Returning to the question of standards, it is a fallacy to believe that standards can *lead* the deployment of Smart Grids. In an ideal world, a Smart Grid standard would be published and then all parties could operate independently while complying with the standard and so maintaining a common approach that enables open systems. This model might work to some extent in other sectors, such as consumer goods, but it does not apply to electrical grids.

The main reasons for the difference in the networks sector are:

- i) new technology has to be adapted to each grid location uniquely (both to achieve integration with legacy systems and local differences of detailed design such as earthing arrangements)
- ii) network assets have much longer lives than, say, consumer goods. It is estimated by a major manufacturer that the relatively new IEC 61850 standard (substation communication protocols and data model) will require 15 years before it applies to 75% of a typical company system. This is because standards implementation is dictated by plant refurbishment cycles.
- iii) Unlike IT equipment, the system cannot be simply rebooted if there imperfections in, say, its data exchange interfaces. Network equipment operates in a demanding and failure-intolerant situation and must be developed and proven to a rigorous degree, regardless of whether it complies with a standard.

Standards are a useful tool for driving commonality on grids but alone cannot achieve an equipment design or network architecture. In view of their important contribution, however, it will be important that The Netherlands continues to contribute actively to international standards developments and, indeed, puts forward new standards where there are opportunities to take a lead.

4.5 Policy Considerations

To assist policy debate, the table below identifies key issues and makes recommendations for action.

Chapter 4: Transition from Today's Grids Policy Considerations

- ◆ **4/1** This Chapter has identified the six key enablers (Technology, Regulation, Standards, Commercial, Supply Chain, & Demonstration) and four elements (Shared Vision, Support of Government and Regulators, Societal Legitimacy, and Collaboration) that provide the essential framework for a successful transition to Smart Grids.
 - > **Proposed action: the Smart Grids Transition Platform should consider and, if necessary, develop this model to identify gaps and opportunities and initiate actions to progress Smart Grid deployment.**

- ◆ **4/2** It is evident that Smart Grids transition is not an 'A to B' activity; in view of the complexities a more organic and iterative process is necessary to achieve transition and to develop and refine the concepts.
 - > **Proposed action: the Smart Grids Transition Platform should ensure that a development mechanism is put in place that can accommodate an evolutionary approach, including the tracking of pan-European and international developments.**

Chapter 5 Investment & Resources Needed

5.1 The Context for Investment

***"there is no
costed plan to
follow"***

The nature of the transition to Smart Grids has been discussed previously: it is an evolutionary process for which there is no single blue print, and therefore there is no 'costed plan'.

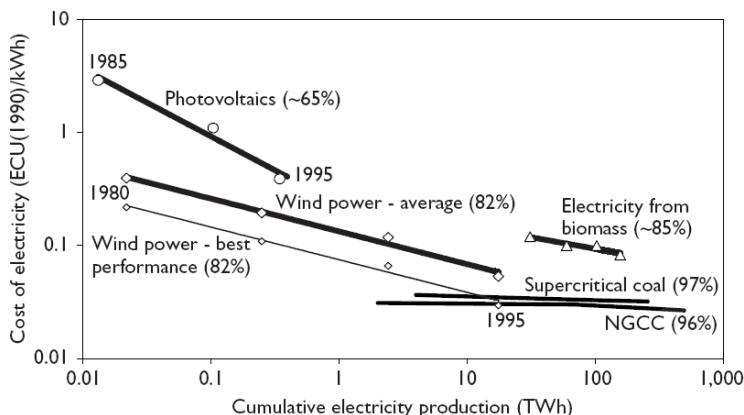
This does not of course mean that the financial aspects should be treated on a laissez faire basis. Indeed, special financial attention is required to evaluate the likely costs and benefits of emerging technologies, and manage investments as they take place. In view of the potentially high costs involved for network infrastructure, and its long life of typically 20/40 years, it is a priority to ensure the effective and efficient use of funds and to avoid poor utilization or stranded assets.

Cost uncertainty is problematic for developing business cases in this area of work. It can be anticipated that there will be a price premium for first-application devices (there will typically be a single supplier, it involves bespoke specialist work, and there are no scale-production benefits available at that stage).

The expected price behaviour of energy technologies can be examined from the perspective of learning curves (sometimes termed experience curves). This approach can be helpful in formulating strategies for emerging technologies. It reveals a 'progress ratio': for example a progress ratio of 82%, means that price is reduced to 0.82 of its previous level after a doubling of cumulative sales. The diagram below is representative and is from the IEA²². The graph is on a double logarithmic scale and the approximately linear trends hold across several orders of

magnitude. The graph shows learning curves for electrical technologies in Europe over the period 1980 -1995. The progress ratios are shown as percentages and it can be observed that about 80% has been typical for the sector in the past.

"price impact of doubling the installed capacity"



The data for the above analysis is drawn from electricity generation, but as a guideline it can provide useful insights to the characteristics of the infrastructure sector where the underlying technologies share many common engineering aspects.

Note that a progress ratio of 80% means that prices can be expected to fall by 20% for each doubling of installed capacity. This is important when considering the energy area where installations can be relatively expensive and typically are not deployed in high volumes in the early stages of commercialization.

" a cost reduction of 2 to 3 times"

Trends in energy technologies reveal that volume production may reduce unit prices by a factor of two or sometimes three times²³.

The foregoing explains one of the reasons why scaling-up and wide area roll-out of Smart Grids is a key dimension: one-off installations not only bring little benefit to customers as a whole,

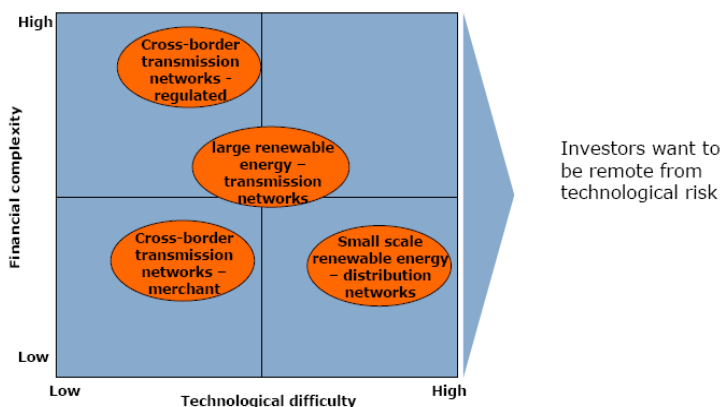
"wide area roll-out is a key dimension"

but learning curve price reductions are lost. This aspect is an important consideration in strategic planning and cost-effectiveness calculations.

5.2 Risk and Uncertainty

New technology is accompanied by an element of risk. Not all innovations succeed and become proven and commercially-available products. The effective risk management of the Technology Innovation Chain, described in the previous chapter, will be of importance not only to the network companies but also to funding institutions and shareholders.

The diagram below shows some of the trade-offs.



Source: Mansour, Rabobank 2007

"Investors want to be remote from technological risk"

Risk Management is a well-developed tool in corporate business, it is also applied extensively in safety and operational contexts. There is less experience in the electricity networks sector of utilizing it for innovation management and there is likely to be considerable scope here for refinement and useful development.

Projects are known to fail for reasons that are broader than technology issues alone. It is observable in the sector that new

"projects fail for broader reasons than technology"

technologies face issues such as: failure to integrate seamlessly with existing legacy systems, resulting in field staff eventually disabling them to avoid repeated warning messages and call-outs to site, or equipment working as designed but insufficient attention having been given to spare parts support and maintenance skills to keep it operating, or an emotional reaction to change elsewhere in the organization that says 'I don't know anything about that... and I'm going to ignore it as far as possible..'. In this last example it is interesting to contemplate whose role it is to educate and enthuse the wider organization about new technology being deployed in the business.

"every project needs a champion"

The short answer is perhaps that every innovative development in a company needs a champion, someone who is the reference point, a person who is committed to success, and a person with the access and authority to all the necessary parts of the organization.

Some Characteristics of Innovation Champions

- ✓ They have a clear Vision, a mission definition, and can communicate it
- ✓ They have courage
- ✓ They are motivated and can handle set backs
- ✓ They keep things simple and get started quickly
- ✓ They have trust and breed trust in others
- ✓ They are altruistic and put the mission before themselves
- ✓ They need and utilize team support
- ✓ They know how to put things in place, and when to step aside and let others run with the project
- ✓ They have internal fire!

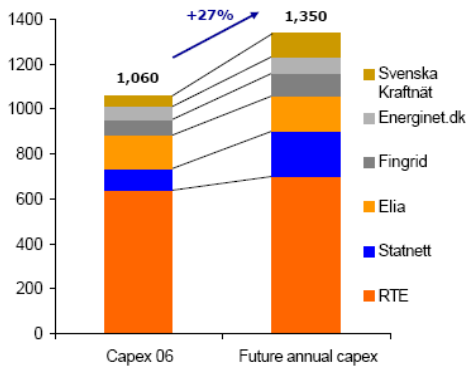
"the cost dimensions are significant"

5.3 Cost dimensions

Analysis has been undertaken in recent years by reputable bodies to assess the likely scale of investment in electricity systems, including networks.

The costs dimensions are significant for the longer term and represent annual spend that is materially higher than current levels. In the immediate future the trend appears to be picking up and the diagram following indicates a rise of annual investment of some 27% within the time horizons of company business plans, say 5 to 7 years.

TSO CAPEX levels, 2006 and projections (EURm)



source: Mansour, Rabobank, attr S&P and TSO reports

For information, the table following provides some order of magnitude information.

EU electricity investment by 2030 is expected to exceed 1,000 G€
EU T&D asset replacement and expansion including Smart Grids to 2030 is likely to be in the order of 500G€
Data and information investment for markets and regulation is estimated to need 20G€
Current EU electricity sector has annual turnover of €112 bn and annual investment in the sector is some €22 bn per year.
European TSOs forecast mid term (up to year 2013) investments to be circa EUR 4bn per annum
Cross-border investments forecast to increase from current EUR 200m per annum to EUR 700-800m per annum
430m customers are served by grids in Europe
Today's cost of a 1GW off-shore wind farm is approximately €2.5bn

Data sources are listed in the end notes²⁴

5.4 Policy Considerations

To assist policy debate, the table below identifies key issues and makes recommendations for action.

Chapter 5: Investment & Resources Needed

Policy Considerations

- ◆ **5/1** In view of the importance of roll-out and scaling-up (and avoiding one-offs), it can be effective if policy and incentives are structured to stimulate and reward successful *strategic programmes*, rather than piecemeal projects and fragmented activities.
 - > **Proposed action: the Smart Grids Transition Platform should consider the encouragement of strategic programmes as a stakeholder group and develop ideas for further consideration and implementation by policy makers in government and regulatory bodies.**

- ◆ **5/2** Noting the breadth of stakeholders identified, it is helpful to have openly available reference material such as ‘technology road maps’ that can inform and inspire action and supportive initiatives. This should extend beyond technology to address all stakeholder interests including for example funding and skills issues.
 - > **Proposed action: the government should consider the status of existing strategic plans and ‘road maps’ (such as the Dutch Electricity Technology Road Map) and initiate updating and broadening to cover all stakeholders, as necessary.**

- ◆ **5/3** This chapter has identified the importance of champions in organisations who bring forward innovation and ensure its successful implementation.
 - > **Proposed action: all parties should look for and encourage champions of the future in their respective interest areas. A systematic approach that identifies potential, develops, encourages and rewards is the most likely to be effective.**

Chapter 6

Potential Barriers to Progress

"the new order has identifiable barriers"

There has been remarkable innovation in the past and the electricity networks we take for granted today are greatly to the credit of the engineers and business managers who developed them. However, the world has moved on: there has been a long period of relative stability with only incremental investments, the innovators of yesterday have retired, and there are new challenges ahead.

Furthermore, and most fundamentally, the business structure of the sector has changed through liberalisation and unbundling, resulting in the move away from centrally planned nationalised network companies. The new order finds itself with a number of identifiable barriers to innovation: some are unintended consequences of new regulatory structures, others are deeper rooted in management behaviour or the business and academic environment. The situation across EU Member States may not be identical but there are strong commonalities.

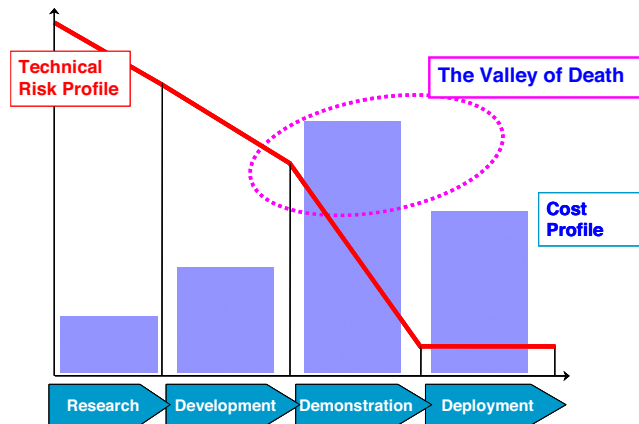
6.1 Research & Technology Transfer

" a wide and deep malaise"

Anecdotal evidence indicates the decline seen in R&D activity is being experienced more widely in Europe since liberalisation. Furthermore, analysis conducted for the European Commission shows that while millions of Euros have been spent on energy research, and a respectable 89% of projects delivered new knowledge and patents, less than 15% resulted in commercial applications. This is a worry as the projects were not 'blue skies' or high risk and a much higher deployment rate would be hoped for. This indicates a wide and deep malaise that will not be overcome without specific and persistent action.

This last point suggests that there are problems to be addressed in the overall innovation chain. One recognisable issue is the so-called Valley of Death problem that can be outlined by reference to the diagram following.

"into the Valley of Death..."



"costs climb at the demonstration stage"

This picture shows in a highly simplified way the Technology Innovation Chain (R,D,D&D) and how cost and technology risk vary through the stages. Technical risk falls progressively, but with the greatest gain being during the Demonstration stage. On the other hand, the Cost of the project is almost an inverse of the risk position: Research and Development stages are relatively inexpensive, but costs climb at the demonstration stage and then fall back to a greater or lesser extent in the Deployment stage, depending on progress through the Learning Curve described earlier. Of course, while unit cost can be expected to be lower at the deployment stage, the total cost may be higher, depending on the number of devices deployed.

Researches may have a limited interested in deployment and other skills and resources need to be brought in to contribute at this stage. The knowledge transfer from researchers requires careful attention and it is wise to give this consideration during

the development stage, not waiting until demonstration or there after.

The Valley of Death arises as a project is poised at the end of a successful Development stage, perhaps in a university or research institution, and is looking to move to Demonstration. The following barriers are routinely experienced and in combination commonly cause projects to fall by the wayside:

- The funding needed for the Demonstration stage is relatively high and external funding sources need to be considered, both public and private.
- Funders rightly wish to understand the risks which, while they reducing at this stage, are not at a minimum.
- Academic bodies are commonly provided with public funding, but this is for 'Research & Development' not for Demonstration. The project is likely to be ruled ineligible for funding through this route.
- European State Aid rules impose comprehensive restrictions on governments providing funding for demonstration. This is to protect the competitive market from state subsidy in what is in effect the development of a product.
- Energy innovation, unlike consumer goods, usually results in an 'undifferentiated product' in the sense that a premium price cannot be charged to willing early adopters. This can best be seen in the generation sector where few people would be willing to pay a premium price to be the first to buy, say, electricity from marine current turbines or hydrogen fuel cells. Electricity is electricity, unlike fashion goods where one handbag is clearly different from another and this is reflected in the prices!

"delays can only be tolerated for so long"

The experience in the Valley of Death is commonly one of protracted negotiations and delays. Meanwhile the researchers with deep project knowledge lose confidence in progress being made and drift off to other projects where they may become

inaccessible. In a similar way, industrial co-funders may have given an indicative commitment to collaboration, but project delays can only be tolerated for so long and the offer is likely to be withdrawn.

6.2 Commercial & Regulatory aspects

The great majority of business frameworks, both commercial and regulatory are relatively new, having been created at the time of liberalization. Liberalisation took place, helpfully, during a period of relative technology stability but this had the consequences that innovation may not have been given much attention, or indeed any, in the formulations and when the privatized companies came under pressure to improve their efficiency it was an understandable business area to pare back.

"a positive case history"

The short case history in the panel following is from the UK and is illustrative of both the problem of declining innovation activity and a solution that has been proven by practical results.

Case History: the British Distribution Network Operators

The British experience since privatisation in 1990 has been positive for customers in many important respects. Network costs have fallen by approximately 50% in real terms since privatisation while at the same time the quality of supply has steadily improved. Much of this has been achieved through excellent commercial innovation.

However the investment by electricity distribution companies in engineering Research and Development (R&D) entered a progressive decline and by 2002 was approaching zero activity. Interestingly, the regulator had never with-held R&D funds. Ofgem analysed the causes of this and concluded that the companies were operating in a rational way, given the regulatory framework. A contributory factor is that R&D is funded as Revenue expenditure and therefore comes under strong 'RPI-X' efficiency pressure with a relatively short term horizon, compared with the lifecycle of typical innovation projects.

To respond to this situation Ofgem introduced two new financial incentives; these have now been operating for over three years and have been reviewed and extended recently including application to electricity transmission and to gas. There has been comprehensive supportive feedback from the companies, manufacturers and from academia, and the investment in R&D has already returned to above 1990 levels. The R&D decline and the response to the Innovation Funding Incentive (IFI) is shown in the graph. This is an encouraging picture and shows that well designed adjustment to regulatory frameworks can be highly effective.

Some key aspects of the IFI structure are as follows:

"the companies set their own innovation agendas"

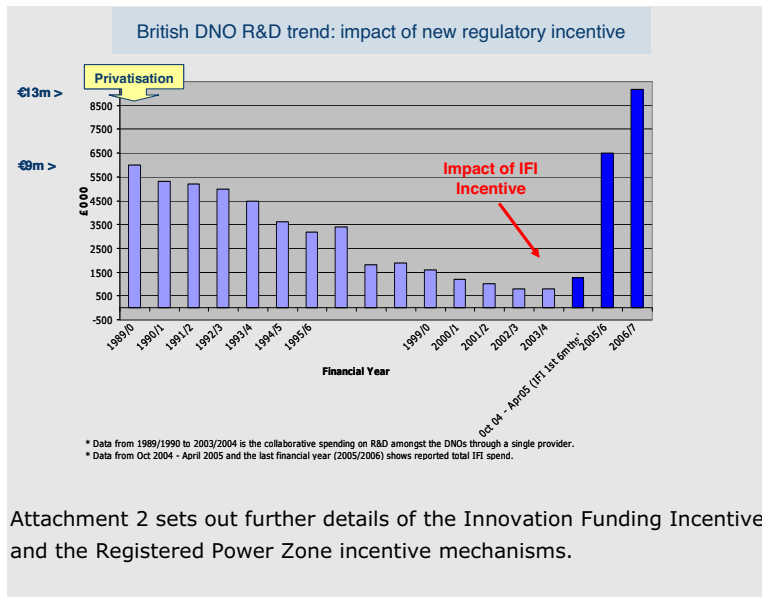
> Ofgem undertook an independent Impact Assessment before introducing this incentive. It indicated a strongly positive net present value. For a projected spend of €38m, the anticipated PV was €160m

> Ofgem does not determine the innovation programme or approve individual projects; projects must comply with a generic good practice guide agreed with Ofgem and in the custodianship of the companies' Trade Body, the Energy Networks Association, document reference G82 Issue 2.²⁵

"customers and companies both contribute to the costs"

> The IFI incentive allows network companies to spend up to 0.5% of their turnover on engineering R&D projects. 80% of their costs are 'pass through' to customers and 20% must be funded by the companies from their own resources. This funding is on a use it or lose it basis. All projects are reported openly each year on Ofgem's website.

> The present IFI programme represents some 180 projects, having a forecast NPV of €70m. No companies have yet spent to their cap. A number of companies adopt collaborative working for part of their project portfolio.



Attachment 2 sets out further details of the Innovation Funding Incentive and the Registered Power Zone incentive mechanisms.

"some barriers are subtle and deep rooted"

6.3 Attitudes & Behaviours

The potential barriers to successful innovation are subtle and may be deep-rooted. The track record for technology transfer in Europe was described earlier and is alarmingly low. In addition to the Valley of Death challenges and the potential for unintended regulatory barriers, there are other sensitivities to consider. These are noted briefly below.

- **Academia's incentives not aligned:** the situation is evident in some Member States that strong 'performance measures' are being applied to academic institutions and that these are linked to future public funding. The concept may be sound but its application may have unwanted outcomes, as is often the case with such measurement systems. If, for example, academic performance is judged largely by the output of

"enough good people?"

published papers, there may be a disincentive for the institution to carry R&D forward and commit time to demonstration projects.

- **Lack of industry skilled resource:** the need for both technology push and industry pull was discussed earlier. In particular the importance of network company demonstration projects was identified. Even where regulatory frameworks are aligned to assist this, project take-up may be suppressed by lack of suitable staff in the network companies. The importance of a 'project champion' was noted earlier, but this has to be a person with adequate technical depth and experience. Such people are in high demand in their organisations already and, as one company put it 'we don't have enough good people to commence more projects'. This is a thorny issue for companies that are under strong efficiency pressures as 'good people' are also relatively expensive people. New approaches are being developed in some companies to utilise an element of out-sourcing as a solution.
- **Unconvincing excuses:** from time to time comments can be heard from companies not engaging in innovation that may be convenient and comfortable, but are misplaced and unhelpful. For example, *"it's not our job to innovate, that's the manufacturers' role"* or *"we aren't doing anything because the regulator hasn't told us what to do"* or *"our company policy is that it pays to be second".....*

"intervention may be needed"

Addressing the above (and these concerns will not be applicable universally) is a subtle challenge involving other parts of government (eg education rather than energy) and company resourcing strategies and cultural attitudes. Policy intervention and facilitation by government and regulators may be needed to achieve enduring changes to priorities and attitudes.

6.4 Policy Considerations

To assist policy debate, the table below identifies key issues and makes recommendations for action.

Chapter 6: Potential Barriers to Progress Policy Considerations

- ◆ **6/1** This chapter has identified the difficulties that can be observed across Europe for network innovation to achieve successful transfer to commercial deployment.
 - > **Proposed action: the Smart Grids Transition Platform should consider the refreshed ‘road map’ (Chapter 5 refers) and address potential barriers, noting particularly any that arise specifically in the Dutch context.**

- ◆ **6/2** The chapter also notes the deep-rooted nature of many of the barriers. They are unlikely to be resolved without concerted effort and the attention of senior people in government, regulatory bodies and industry.
 - > **Proposed action: government should consider how the profile of these issues might be raised and the engagement of senior people obtained. A constructive step might be to require the Smart Grids Transition Platform to report its activities and progress annually and openly to government at a senior level.**

Chapter 7

Status of Worldwide Developments

***"an evident
upsurge of
interest"***

7.1 International Co-ordinating Activities

In the last five years there has been an evident upsurge of interest in Smart Grids around the world. The number of commercial conferences and their varied locations is an imprecise but illuminating indicator for this. In Europe the perception is of about one event each month. More substantial is the evidence of work programmes commissioned by governments, regulators and wider stakeholder groups, and the product developments starting to come forward from manufacturers.

An internet search engine provided with the complete phrase 'smart grids' produces in excess of 20,000 references which on inspection are commonly, but not exclusively, from European or North American sources. This location emphasis may of course be influenced by the way the search engine works.

Some examples of established work programmes are shown below.

<p>EU Technology Platform: SmartGrids www.smartgrids.eu</p>
<p>NL EOS Energy Research programme www.sentermovem.nl</p>
<p>USA Gridwise Alliance www.gridwise.org note also the EPRI IntelliGrid Consortium, the DOE Modern Grid Initiative, and the Galvin Electricity Initiative</p>
<p>UK Energy Networks Strategy Group www.ensg.gov.uk</p>

7.2 International project activities

As would be expected at this stage in development, there are many research projects addressing Smart Grids but a smaller number of practical applications.

“ a much smaller number of practical applications”

Examples of application projects being undertaken with the participation of commercial organizations are as follows.

USA <i>Con Edison</i>	Smart Metering AMI MDM implementation
USA <i>Duke Energy</i>	Smart metering Field demonstration
NL <i>NUON</i>	Smart Metering
ITALY <i>ENEL</i>	Completed roll-out of approximately 30 million smart meters.
UK <i>EON Central Networks</i>	Connection of wind generation using dynamic line rating technology (Ofgem Registered Power Zone scheme)
UK <i>Scottish & Southern Energy</i>	Connection of renewable generation on Orkney island in Scotland using active network management (Ofgem Registered Power Zone scheme)
UK <i>EDF Energy</i>	Connection of wind generation using novel voltage control technology (Ofgem Registered Power Zone scheme)
UK <i>EDF Energy</i>	Connection of biogas generation using novel voltage control technology & modelling (Ofgem Registered Power Zone scheme)
North AMERICA and EUROPE	There are numerous smart metering trials, large and small, many at the stage of approval but not yet implemented.

	Italy's ENEL SpA is widely considered to be at the vanguard. Following closely are Scandinavia, the Netherlands, Australia, the United States of America and Canada all of whom are currently implementing or evaluating large scale smart metering trials.
GREECE <i>EU Demonstration Site</i>	The Kythnos Island micro grid: this integrates a 10kW PV source, a 53kWh battery, and a 5kW diesel generator in a micro grid with 12 houses.
The NETHERLANDS <i>EU Demonstration site</i>	Continuon MV/LV facility: 315 kW of PV, mains interfaced, integrated with 200 cottages at a holiday camp.
GERMANY <i>EU Demonstration site</i>	MVV Mannheim-Wallstadt residential demonstration: initially 30kW of PV, home owners involved in demand management on this ecological housing estate.
JAPAN	The Amori Project in Hachinohe: 100kW of renewable sources, 510 kW of diesel generation, a 100kW battery bank, integrating 7 city buildings.
JAPAN	The Aichi Project near Central Japan Airport City: 2 MC fuel cells, 4 PA fuel cells, and an SO fuel cell. 500kW NAS battery. The system has a planned islanding mode.
JAPAN <i>Other projects of note</i>	The Kyoto project at Kyotango The Sendai project
CANADA	The British Columbia Boston Bar system: a planned islanding system during substation maintenance periods. 8MW small hydro generation, demand control.

7.3 Observations

In many countries there is evidence of smart metering activity and indeed there may be confusion in the minds of some that smart metering is synonymous with smart grids, whereas smart metering is but one element of the Smart Grid concept. It is however an important element, particularly because it develops the concept of a two-way interface with customers.

"network developments are lagging"

Where smart metering is being progressed the developments are much broader than the meters alone. There have to be associated communications infrastructures and business transaction support processes.

There is a noticeably smaller set of demonstrations that have been identified for networks. It might be judged that network developments are lagging and that they risk becoming the brake on developments. This is consistent with the comments previously concerning barriers and the reluctance of network companies to engage actively.

"political interest is rising"

Political interest in Smart Grids would appear to be rising as their key enabling role becomes evident to policy makers (notably with regards to achieving environmental and security of supply goals). In Europe for example, a recent high profile contributor has been Jeremy Rifkin²⁶ who is an advisor to the EU president on energy policy. He makes reference to a *Third Industrial Revolution* and is a high profile advocate for intelligent utility networks (ie Smart Grids). His vision for the future also embraces hydrogen infrastructure.

7.4 Policy Considerations

To assist policy debate, the table below identifies key issues and makes recommendations for action.

Chapter 7: Status of World Wide Developments Policy Considerations

◆ **7/1** When research projects are being considered for public funding in The Netherlands, more weight might usefully be attached to areas of the Smart Grid concept that appear to be lagging other developments, notably on networks. (This observation is common to many member states and impacts adversely on progress along the critical path.)

- > **Proposed action: government should consider whether its research funding mechanisms might be adapted to encourage greater attention to lagging areas of Smart Grid network development, e.g. in the successors of programmes like IOP EMVT and EOS ‘Opwekking en Netten’ (Electricity Generation and Grids). Furthermore, the government could consider encouraging the cooperation of researchers, specialists and engineers to strengthen the base of research and development for Smart Grids in The Netherlands.**

◆ **7/2** In view of the thinking emerging in Brussels, it might be timely to raise the political profile of Smart Grids to capitalise on EU themes such as energy policy and the third industrial revolution.

- > **Proposed action: government should further consider the profile of this area of work in view of its strategic importance in contributing to environmental and supply security goals. Increasing attention from the EU Commission makes this opportune. As a modest step, publication and dissemination of this report might be helpful to further this goal.**

Chapter 8 The Dutch Position

8.1 Opportunities and Risks

"a strong track record and a platform for growth"

The Netherlands has a track record of proactive engagement in energy matters and an increasingly respected profile on the wider European and international scene. This can be a strong platform for growth.

The challenges of environment, supply security and related issues, have been under active examination for some time and there have been papers and reports produced by the Energy Transition Task Force and by a range of institutions, companies, and individuals²⁷. There has also been active support also from the Ministry (EZ).

The Netherlands has also taken a lead role in international thinking, for example the EU Technology Platform SmartGrids (where Mr P Nabuurs of KEMA is the chairman of the group) and engaged actively with other bodies such as the Assembly of European Regions AER²⁸ and Eurelectric and CIGRE²⁹, to mention but a selection. Internationally KEMA is a member of the GridwiseTM alliance in the USA and partner in the DOE-study for the Gridwise Architecture.

It is timely for The Netherlands to consider its own position in regard to Smart Grids and its positioning in relation to Europe and beyond. In addition to making real the direct benefits of Smart Grids, there is strong potential for export and international leadership.

Considering the position of the Netherlands, the following opportunities and risks can be identified.

Opportunities	Risks
<ul style="list-style-type: none"> • NL has strong intellectual capability and skills. • NL has a track record for innovation. • There is a strong grid network and high quality of supply performance from which to build. • Marine and wind resources are available with considerable potential. • There are electricity storage possibilities. • There are CO₂ storage possibilities. • There are established stakeholder co-ordination mechanisms. • NL has international influence and active engagement, particularly in Europe but also more globally. • NL has research and laboratory facilities of world standard. • It is anticipated that gas will remain available for the medium term. 	<ul style="list-style-type: none"> • Interconnections to neighbours may result in adverse grid interactions. • Densely populated so special care needed when seeking new energy infrastructure. • Too little too late; for example if there is inadequate clarity of vision or incentives for change. • Inconsistent policy priorities would cause loss of confidence. • If incentives are not of sufficient duration it may be problematic to secure market funding. • Progress will stall if any unintended barriers to innovation in commercial and regulatory frameworks are not addressed or take a long time to resolve. • Progress will stall if technology push is not matched by industrial pull. Noting Europe-wide experience, should there be an absence of active engagement of Dutch network companies, particularly in demonstration projects, this would become a critical path factor.

8.2 Practical Steps

Attachment 1 provides a schedule that outlines Smart Grid applications. It is ordered in three bands to show

- i) Technology that is available now
- ii) Technology that is judged to be near to market
- iii) Technology that requires Research and Development

The applications shown are also grouped by the categories of user or operator across the sector. Specific proposals can be developed from the ideas shown to add to those already being considered in The Netherlands. In each case the details would require to be assessed on a location by location basis with the companies and other stakeholders concerned.

8.3 Policy Considerations

To assist policy debate, the table below identifies key issues and makes recommendations for action.

Chapter 8: The Dutch Position Policy Considerations

- ◆ **8/1 Considering wider European experience, it can be anticipated that the timescale required for addressing barriers to innovation and Smart grids deployment will not be short.**
 - > **Proposed action: the government should satisfy itself that barriers in regulatory and commercial frameworks are identified and that an action plan is put in place to address them. Unambiguous ownership should be agreed for each item. The Smart Grids Transition Platform may be of considerable assistance here.**

Continued/...

◆ **8/2** Active engagement by the key players will be necessary to achieve Smart grids deployment. Removal of barriers is an essential first step but may be insufficient on its own to promote new behaviours. This is particularly the case where there may be an element of risk and uncertainty. No business takes on avoidable risk unless it anticipates commensurate reward.

- > **Proposed action: the action recommended in 8/1 should have a second element that identifies such situations and, working with relevant stakeholders, considers whether incentives might be introduced that would reward successful entrepreneurship and risk management. Government and regulators should be invited to take forward ideas for incentives and develop them for inclusion in legal and regulatory frameworks.**

◆ **8/3** This chapter identifies that The Netherlands is well placed to lead on Smart Grid demonstrations. There is potential for significant commercial opportunity here, given the slow rate of deployment elsewhere and the interest in proven Smart Grid solutions both in Europe and internationally.

- > **Proposed action: to capitalise on the strong position that The Netherlands could establish, the government should invite the new Transition platform to make recommendations that address deployment. It will be important to not only engage the network companies, but also large and small scale manufacturers.**

◆ **8/4** Skills shortfalls are judged to be a high risk issue for the electricity sector in view of changing demographics and the likely poaching from other sectors and other countries.

- > **Proposed action: government should consider whether helpful lessons might be learned from best practices in other countries, including for example the Power Academy and new Research Academy in the UK.**

Chapter 9

Conclusions

This paper has identified some risks, many opportunities and high potential benefits to The Netherlands of a transition to Smart Grids.

The overall message is exciting and optimistic; it represents a fundamental change from classical grids to new architectures with new concepts. It heralds new benefits for all in the stakeholder chain from governments through to end electricity users at home and in businesses.

However, there is a challenge here. It is evident from across Europe and beyond that the transition path for grid networks may not be a smooth one. Yet, with anticipation of the problem areas and a commitment to address them in a timely way, this report identifies no insurmountable factors.

Indeed, not only is The Netherlands well placed to adopt Smart Grids but it also has the opportunity to seize the lead and have a unique export potential with markets across Europe and around the world.

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Attachment 1

Concrete steps towards Smart Grids (i)

Level 1 Technology is Available Now	Level 2 Technology is Near to Market	Level 3 Research & Development is needed
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SMALL USERS			
	DEMAND	METERING	GENERATION
Level 1	<ul style="list-style-type: none"> ➤ Responsive demand control of white goods, air-conditioning, and heating. 	<ul style="list-style-type: none"> ➤ Smart Meters, basic functionality ➤ Demand displays 	<ul style="list-style-type: none"> ➤ ROCOF etc ac interfaces ➤ Converter dc interfaces ➤ Micro-generation with export capability
Level 2	<ul style="list-style-type: none"> ➤ Energy efficiency innovations ➤ Modelling of intelligent user devices in large numbers 	<ul style="list-style-type: none"> ➤ Interactive customers ➤ Smart Meters, advanced functionality 	<ul style="list-style-type: none"> ➤ Community level Micro-generation management ➤ Modelling of large numbers of inverter devices ➤ Micro storage devices
Level 3	<ul style="list-style-type: none"> ➤ Virtual Power Plant utilising electric vehicles in large numbers for storage and demand control 	<ul style="list-style-type: none"> ➤ Distributed ICT and Settlement systems ➤ Smart Meters, full gateway ➤ Islanding capabilities to enhance security of supply 	<ul style="list-style-type: none"> ➤ VPP Virtual Power Plant for mini and micro generation

Concrete steps towards Smart Grids (ii)

Level 1 Technology is Available Now	Level 2 Technology is Near to Market	Level 3 Research & Development is needed
-------------------------------------	--------------------------------------	--

	DISTRIBUTION		TRANSMISSION	
	Network Assets	Network Operations	Network Assets	Network Operations
Level 1	<ul style="list-style-type: none"> ➤ Condition Monitoring real time ➤ Fault prediction ➤ New network voltage control for DER feeders 	<ul style="list-style-type: none"> ➤ Dynamic plant ratings ➤ Monitoring of RES devices and their characteristics and trend data 	<ul style="list-style-type: none"> ➤ Condition Monitoring in real time ➤ Flow control devices 	<ul style="list-style-type: none"> ➤ Dynamic ratings ➤ WAM wide area monitoring for security and stability
Level 2	<ul style="list-style-type: none"> ➤ Power flow control devices ➤ Fault Level Limiters ➤ Active distribution networks ➤ Distribution power electronics 	<ul style="list-style-type: none"> ➤ Quality of supply enhancement ➤ Waveform enhancement ➤ Storage for peak smoothing and investment deferral ➤ DMS to EMS ➤ Modelling of mass DER devices on networks ➤ Stability of these devices: assessment and controls 	<ul style="list-style-type: none"> ➤ Fault Level Limiters ➤ Off-shore connections ➤ Off-shore substations ➤ Investment decision tools ➤ Carbon-costed asset management ➤ New protection principles 	<ul style="list-style-type: none"> ➤ Storage for balancing and other ancillary services ➤ Pan-EU emergency co-ordination ➤ New control processes to model, predict and manage intermittent sources
Level 3	<ul style="list-style-type: none"> ➤ Fully Active Distribution networks ➤ Modelling tools ➤ Stability control ➤ Cyber security protection 	<ul style="list-style-type: none"> ➤ Self-healing grids ➤ Islanded operation capability ➤ Variable G to T flows through D networks ➤ Integration of dispersed control intelligence 	<ul style="list-style-type: none"> ➤ Off-shore grids and interconnection ➤ Integration of H2 transmission 	<ul style="list-style-type: none"> ➤ Self-healing grids ➤ Balancing Services from aggregated DER ➤ Pan-EU interoperability

Concrete steps towards Smart Grids (iii)

Level 1 Technology is Available Now	Level 2 Technology is Near to Market	Level 3 Research & Development is needed
-------------------------------------	--------------------------------------	--

LARGE USERS		
	GENERATION	STORAGE
Level 1	<ul style="list-style-type: none"> ➤ Off-shore substations ➤ Grid-friendly intermittent generation controls 	<ul style="list-style-type: none"> ➤ MW scale battery devices
Level 2	<ul style="list-style-type: none"> ➤ Generation management for constrained networks ➤ Ancillary services from renewable sources ➤ Controls to off-set rapid variability ➤ Integration with storage 	<ul style="list-style-type: none"> ➤ MW scale flow cell devices
Level 3	<ul style="list-style-type: none"> ➤ Hydrogen as an alternative energy vector 	<ul style="list-style-type: none"> ➤ GW scale marine storage ➤ Heat storage and utilisation

Attachment 2

Ofgem Innovation Incentive Mechanisms

Innovation Funding Incentive (IFI)

- A '% of turnover' allowance for technical innovation set at 0.5%
- Equates to €2-3m per company per year cap
- Companies must fund 20% of each project from their own money
- Funding is on a 'use it or lose it' basis
- Compliance with the Good Practice Guide is a requirement
- Ofgem does not approve individual projects
- Annual, open, reporting of activities on Ofgem website
- Ofgem does not off-set any third party funding obtained

Registered Power Zones (RPZ)

- RPZ's are designated parts of a DNO network where innovation is to be used to connect Distributed Generation more efficiently
- Ofgem registers, but does not approve projects
- Ofgem's Hybrid £/kW incentive to connect DG is increased in RPZs, for 5 years, by 3 times the basic level
- Expenditure cap of €0.8m per year per licensee
- Open reporting of RPZ projects on Ofgem's website

Further information is available at:

www.ofgem.gov.uk/Networks/Techn/NetwrkSupp/Innovat/Pages/Innvation.aspx

[http://217.194.217.188/engineering/pdfs/engdocs/ENA_ER_G85_Issue_2_\(5.12.07\).pdf](http://217.194.217.188/engineering/pdfs/engdocs/ENA_ER_G85_Issue_2_(5.12.07).pdf)

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- ⁴ http://ec.europa.eu/energy/electricity/package_2007/index_en.htm
- ⁵ for example see <http://www.euractiv.com/en/energy/interview-third-industrial-revolution-nigh/article-170003>
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- ¹³ ADD REF TO EUTP SRA document
- ¹⁴ This cost/benefit analysis is available at: http://www.ofgem.gov.uk/temp/ofgem/cache/cmsattach/6583_RPZ_IFI_RIA_Final.pdf
- ¹⁵ The European Technology Platform SmartGrids will shortly publish its Strategic Deployment Document (SDD). This will address the steps that the stakeholders believe are needed to make Smart Grids a reality and focuses on issues such as business cases and barriers to resolved, rather than technology issues.
- ¹⁶ SmartGrids, PV, Zero emissions fossil power plant, Hydrogen & Fuel cells, Wind see http://cordis.europa.eu/technology-platforms/home_en.html
- ¹⁷ Council of European Energy Regulators (CEER) The CEER brings together the independent national energy regulators of Europe. www.ceer.eu ERGEG is the European Regulators' Group for Electricity and Gas. It is a body of independent national energy regulatory authorities, which was set up by the European Commission as an Advisory Group to the Commission on energy issues. www.ergreg.org
- ¹⁸ Lisbon Agenda: a dynamic and knowledge driven economy for Europe www.euractiv.com/en/future-eu/lisbon-agenda/article-117510
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- 22 IEA Experience Curves report www.iea.org/textbase/nppdf/free/2000/curve2000.pdf
- 23 An example of wind turbine unit price trends for Europe is quoted in this presentation
<http://www.iea.org/Textbase/work/2003/extool-excetp6/II-neij.pdf>
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- 25 Jeremy Rifkin is president of The Foundation on Economic Trends in Washington, DC and
26 currently an advisor to the President of the European Union, Jose Socrates, Prime Minister
of Portugal, on energy and economic issues. He serves as the senior advisor to the
European Parliament Leadership group on advancing the Third Industrial Revolution and
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End of document

Het DG Energie en Telecommunicatie van. Economische Zaken geeft een reeks Reflecties uit.. De essays in deze reeks geven een reflectie op het beleidsgebied rondom energie en telecommunicatie. De inhoudelijke verantwoordelijkheid ligt bij de schrijvers van de essays. Ze reflecteren niet de mening van het ministerie van EZ, maar zijn een aanzet voor discussie over haar beleid.

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9. Het effect van paradigma verschuivingen

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