ROADMAP 2050

A PRACTICAL GUIDE TO A PROSPEROUS,
LOW-CARBON EUROPE

POLICY RECOMMENDATIONS

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A Practical guide to a prosperous, low-carbon Europe

PREFACE

In July 2009, the leaders of the European Union and the G8 announced an objective to reduce greenhouse gas emissions by at least 80% below 1990 levels by 2050. In October 2009 the European Council set the appropriate abatement objective for Europe and other developed economies at 80-95% below 1990 levels by 2050. In support of this objective, the European Climate Foundation (ECF) initiated a study to establish a fact base behind this goal and derive the implications for European industry, particularly in the electricity sector. The result is *Roadmap 2050: a practical guide to a prosperous, low-carbon Europe*, a discussion of the feasibility and challenges of realizing an 80% GHG reduction objective for Europe, including urgent policy imperatives over the coming five years. The scientific basis and the political process behind the setting of that objective are not discussed.

This is the second of three volumes. Volume 1 is a technical and economic assessment of a set of decarbonisation pathways. This volume addresses the policy and regulatory implications arising from the analysis and Volume 3 will address the broader implications for society. ECF strongly recommends that further work be carried out that will help stakeholders understand the required change in more detail, including the different ways in which various regions would experience the transformation.

Roadmap 2050 breaks new ground by outlining plausible ways to achieve an 80% reduction target from a broad European perspective, based on the best available facts elicited from industry players and academia and developed by a team of recognized experts rigorously applying established industry standards.

This study is funded by ECF, which itself is funded solely by private philanthropic organizations[1]. ECF does not have financial ties to EU political bodies, nor to business. Representatives of the European Commission and its services have provided strong encouragement for the development of this undertaking and have given welcome guidance regarding the objectives and the approach. Along with representatives of other EU institutions, notably the European Parliament and Council of Ministers, the European Commission has been consulted periodically throughout the course of the project. In addition, a wide range of companies, consultancy firms, research centres and NGOs have counseled ECF in the preparation of this report. These organizations can be found in the acknowledgements section.

1. ECF's funding sources are fully disclosed on its website, www.europeanclimate.org

ACKNOWLEDGEMENTS

The mission of Roadmap 2050 is to provide a practical, independent and objective analysis of pathways to achieve a low-carbon economy in Europe, in line with the energy security, environmental and economic goals of the European Union. The Roadmap 2050 project is an initiative of the European Climate Foundation (ECF) and has been developed by a consortium of experts funded by ECF.

The work on the three volumes of the Roadmap 2050 project has been undertaken by:

- Volume 1 - Technical and Economic Analysis: McKinsey & Company; KEMA; The Energy Futures Lab at Imperial College London; Oxford Economics and ECF
- Volume 2 - Policy Report: E3G; The Energy Research Centre of the Netherlands (ECN), The Regulatory Assistance Project (RAP), and ECF
- Volume 3 - Graphic Narrative: The Office for Metropolitan Architecture and ECF

This "Volume 2 – Policy Report" draws upon ECN's research paper *A zero-carbon European power system in 2050: proposals for a policy package*, by P.A. Boot and B. van Bree, which was commissioned by ECF as part of the *Roadmap 2050* project and served as a valuable source of extensive policy insight in the preparation of this report. This report follows ECN's paper in many respects but in other respects charts a somewhat different course, informed by the Volume 1 analysis and by a broad consultation process. ECN's paper can be accessed as an online appendix to this report at the project web site noted below.

In addition, a wide range of companies, consultancy firms, research centres and NGOs have provided various forms of assistance during the preparation of this report. These organisations have provided valuable counsel that we have tried faithfully to reflect in this analysis, however their willingness to consult and to be consulted in the course of this work should not be taken to mean that each of them agrees with all of its assumptions or conclusions.

ECF is the sole author of the Roadmap 2050 report, is solely responsible for its content and will act as a guardian of the content. The materials can be freely used to advance discussion on decarbonisation of the power sector and the broader economy. The report is made available to any and all audiences via a Creative Commons license. For details of the terms and conditions, please see www.roadmap2050.eu/cc

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For more information on Roadmap 2050:
www.roadmap2050.eu

European Climate Foundation:
www.europeanclimate.org

EXECUTIVE SUMMARY

This report seeks to initiate a critical policy debate across Europe relating to the future of energy markets. The analysis contained in Volume 1 has highlighted significant new insights and opportunities to decarbonise the economy at the same time as maintaining security of supply and promoting economic recovery, prosperity and energy price stability. However, the existing policy and regulatory framework does not allow us to fully grasp these opportunities within the necessary timeframes.

We do not argue here for a radical overhaul of existing arrangements; the single energy market agenda and the comprehensive climate policy package that have been pursued across Europe over the last decade set the right basic framework going forward. However, there is emerging consensus on the part of governments, regulators and industry that important additions are required to align these arrangements more effectively with the objective of a fully decarbonised and fully reliable energy sector by 2050. Moreover, there are many practical examples across Europe and beyond where beneficial policy developments are being successfully implemented within a market framework. Therefore, there are reasons to be optimistic that a targeted agenda of policy reform is both politically and practically achievable.

Volume 1 has identified a series of important outcomes that will set Europe on the path to reduce greenhouse gas emissions by at least 80% below 1990 levels by 2050.[2] Key findings are:

1. Full decarbonisation of the power sector[3] by 2050 is a prerequisite

2. Fully decarbonising electricity whilst maintaining the current standard of service reliability is technically feasible across a surprisingly wide range of pathways

3. There is no significant difference across the range of pathways tested in the overall cost of electricity delivered to customers

4. Every pathway relies on achieving and sustaining a much more aggressive rate of improvement in energy efficiency than what has been achieved in recent years

5. The key to these outcomes resides in networks: greater integration across national and regional electricity markets, combined with investment in fully smart local grids

6. Technology to do this exists today but it must be commercialized more aggressively; it is highly capital-intensive and the long-term business case must be much clearer

The most cost-effective pathways to achieve this objective depend critically in the shorter term on the deployment of more aggressive energy efficiency measures and, particularly post 2020, on a large-scale switch of heat and transport sectors to the use of decarbonised electricity. There are a number of important policy challenges relating to the transport and heating sectors that will reduce energy consumption and position Europe for a steep rate of fuel switch after 2020. However, the key focus of the analysis has been the power sector and, therefore, this report has focussed on policies relating to the decarbonisation of electricity. Volume 1 sought to investigate the feasibility of achieving these abatement objectives based on the further development and deployment of commercial and late-stage technologies whilst recognising the potential benefits of technological breakthroughs. Therefore, the important policy agenda relating to the promotion of innovation has only been considered in respect of the commercialisation of existing and emerging technologies. Finally, this report does not consider international aspects of energy policy, such as the importation of electricity from outside of

2. This is the minimum level of abatement consistent with the European Heads of State declaration dated 29/30 October 2009 that a reduction of 80-95% below 1990 levels by 2050 is required to meet climate commitments.
3. Vol. 1 considered a reduction of 95% or more in power sector emissions to be in effect full decarbonization

Europe, although it is recognised that this could form a significant element of the European policy agenda.

Existing policies to reduce energy demand are manifestly failing to meet existing policy aspirations, let alone lay the foundations for the sustained ongoing improvements that are required. This policy failure is creating a direct economic cost, foregoing the opportunities to stimulate economic recovery through creating new markets and jobs and increasing the extent of the decarbonisation challenge that would need to be delivered through other means. A comprehensive package of measures at both European Union (EU) and Member State levels is required to remove pervasive and persistent market barriers.

Decarbonisation of the power sector requires policy mechanisms to ensure that high carbon generation sources are replaced by low/zero carbon resources as soon as prudent security of supply considerations allow. The analysis presented in Volume 1 points to new ways of thinking about networks that expand the range of options for addressing security of supply, thereby enabling policy makers to commit more aggressively to a timetable for this transition. This in turn requires the commercialisation of a variety of low carbon generation options, such as offshore wind, solar PV and carbon capture and storage (CCS). The transition also requires stable, long term financial incentives and a market framework that provides the business case for timely disinvestment and retirement of high carbon assets and investment in sufficient replacement low/zero carbon assets.

Volume 1 highlights the importance of network developments in reducing the costs and risks of decarbonisation. Increased interconnection between existing energy systems and improved co-ordination of resource planning across Member States can yield enormous direct benefits for the operation of the single market and improved security of supply, in addition to securing the option for a reliable, zero-carbon generation mix involving high proportions of renewable energy sources within the 2050 horizon. Demand response is also very significant in reducing the overall costs of a decarbonised power system and this, in turn, requires smart grid technology to be piloted as quickly as possible to enable rapid deployment across Europe over the next 10-15 years. In short, networks hold the key to enabling renewable resources – large-scale and distributed – to meet Europe's demand for energy as reliably and affordably as more traditional sources, in turn creating for the EU a wider range of energy and climate options.

This report sets out a series of potential policy responses to these challenges. It highlights where action is required at the EU level and where it is most appropriate to be progressed within Member States or regions. The objective of these proposals is to 'kick-start' the conversation amongst policy makers, regulators, investors and other stakeholders that is required if we are to deliver changes that are robust and timely.

Key areas for the EU to progress are:

- Action to convert the non-binding 2020 efficiency goal into a firm requirement to deliver the target, whilst allowing Member States flexibility in how to do so

- The need to update the EU ETS to meet current 2050 greenhouse gas reduction goals, alongside additional, complementary measures that reinforce incentives to invest in low/zero carbon resources, rule out investment in long-lived high-carbon generation and overcome market barriers to energy efficiency measures

- A new 'Climate and Resources' framework to create the policy mix that will efficiently deliver the climate targets and address resource constraints across sectors beyond 2020 and out to 2050

- A review of EU budget allocation to ensure appropriate funding is allocated to investments in renewables, CCS, energy efficiency and network infrastructure

- Expansion of the ACER/ENTSO-E mandates to develop a strategic interconnection plan out to 2050 and to ensure it facilitates full decarbonization and the optimisation of resources across Member States

Key areas for Member States to progress are:

- Adopt aggressive targets and strategies for the deployment of energy efficiency measures that will double to triple the current rate of overall energy efficiency improvement

- Consider the need for deployment targets beyond 2020 for key renewables generation technologies such as off-shore wind, solar PV; consider parallel deployment strategies for carbon capture and storage, especially in heavy industry

- Initiate a review of wholesale market arrangements to ensure that incentives promote investments in energy efficiency and other demand-side resources[4], system balancing and low carbon generation sources in addition to supporting efficient cross border trading

- Explore regional alignments with neighbouring Member States around strategic low-carbon resource development, networks planning and execution, and wholesale market design and operation

- A review of the mandate of the network regulators within the framework of the internal energy market to create a robust investment framework that enables the upgrade and roll-out of smart infrastructures at transmission and distribution levels.

- Establish a timetable for implementing fully smart power networks, maximising opportunities for demand response and distributed generation

- Review spatial and environmental planning laws to ensure they are fit for purpose

- Ensure that sources of funding, financial institutions and risk allocation are appropriately aligned to ensure that the new low carbon infrastructure can be readily and cost-effectively financed.

The benefits of action are significant and the costs of delay are considerable. The proposals contained in this report therefore demand the urgent attention of policy makers. We believe that, with appropriate stakeholder engagement, they can be readily developed into a package of reforms that is both politically acceptable and practically deliverable.

4 . Including demand response and distributed (on-site) generation

POLICY RECOMMENDATIONS

The EU Must Take Action To

Dramatically Accelerate Energy Efficiency

- Action to convert the non-binding 2020 efficiency goal into a requirement to deliver the target whilst allowing Member States flexibility on how this should be achieved
- Revise the Energy Services Directive to support a tripling of the energy efficiency policy impact, which is required to achieve the 2020 energy savings goal
- Strengthen the Eco-Design of Energy Using Products Directive with mandatory minimum energy performance requirements based on 'best available technology' on the global market and a sufficient updating process ('frontrunner approach')
- Full implementation of the Energy Performance of Buildings Directive to ensure that all new buildings meet zero net energy requirements by 2020
- Progress legislation that will establish the framework for efficiently delivering climate objectives allocating limited resources beyond 2020 and out to 2050

Deliver Combination Of Instruments To Drive Power Sector Decarbonisation

- Develop complementary measures to the EU ETS which safeguard the long-term transition of the power sector and maintain a non-distorted carbon price signal
- Review EU ETS reduction targets to ensure they are consistent with delivery of 2050 emissions targets
- Request Member States to come forward with long term targets for deployment of key renewable generation technologies and adopt parallel measures for CCS
- Introduce new provisions requiring Member States to identify a long term planning generation and demand-side resource mix out to 2050 that is consistent with decarbonisation objectives and can underpin strategic network development

Realise The Potential Of The European Grid To Reduce The Costs And Risks Of Decarbonisation

- Expand the ACER/ENTSO-E mandate to:
  - Assimilate Member State and regional long term forecasts of generation and demand-side resources to meet projected power requirements
  - Use this baseline to develop a strategic interconnection plan based on minimising resource costs of decarbonisation across Europe
  - Provide feedback to Member States on opportunities for additional interconnection to reduce the costs of meeting decarbonisation objectives while maintaining power system reliability and long term security of supply
- Build on the existing institutional arrangements to ensure appropriate regulation and system operation in a more interconnected European power network

Ensure The Transition Can Be Financed

- Review the allocation of funds to low carbon generation, energy efficiency and network investments as part of the overall review of the EU budget
- Ensure that funding is available from the EU budget to demonstrate critical low-carbon technologies across all relevant regions along with appropriate instruments to allocate these funds
- Ensure sufficient financing is in place to take forward the strategic network investments through a combination of regulatory mechanisms and seed funding
- Provide necessary funding through the SET Plan as required to drive a range of smart grid pilot projects across Europe

Member States Must Take Action To

Ensure Energy Efficiency Assumes And Retains Top Priority

- Establish an aggressive mandatory annual and cumulative targets to retrofit buildings with deep efficiency improvements
- Establish a network of trusted and customer focussed delivery agents to provide a one-stop-shop for building assessments and retrofits
- Strengthen performance standards for existing buildings at Member State and/or local level

Drive The Commercialisation Of Key Renewable And CCS Technologies

- Consider the need for longer term deployment targets for key renewable generation technologies and whether these need to be co-ordinated at EU level
- Introduce regulations to ensure that new fossil-fired generation (gas and coal) can and will be retrofitted with CCS technology; expand support for demonstration projects and early deployment

Implement Measures That Will Deliver A Unified And Low Carbon European Power Market

- Undertake a review of market framework and regulations to ensure it:
  - Delivers sufficient certainty of revenue to drive long term investments in low carbon demand-side resources and generation and system balancing technologies, both during the commercialisation stage and thereafter
  - Provides clear signals for the disinvestment in and retirement of high carbon technologies
  - Facilitates efficient utilization of system balancing resources within and between regions and, where appropriate, the full integration of markets
- Use the review of market frameworks to ensure that energy efficiency and demand response investments can compete on equal footing with supply and network investments, e.g., in the valuation of capacity and the provision of balancing services to the Transmission System Operators (TSOs)
- Consider market design improvements, including relevant experience with market mechanisms in other regions, that recognize the capital intensity of renewables and CCS and address the persistence of competition from high-carbon assets
- Ensure that the wholesale market framework and internal infrastructure will enable investors to take advantage of the import/export opportunities afforded by the strategic interconnection plan
- Mandate network regulators within the framework of the internal energy market, and building on the Third Energy Package, to create a robust investment framework enabling the necessary upgrade and roll-out of smart infrastructures at the transmission and distribution level
- Establish a timetable for implementing fully smart power networks, maximizing opportunities for demand response and distributed renewable generation

Ensure Necessary Infrastructure Can Be Built

- Review spatial and environmental planning laws to ensure they are fit for purpose, including explicitly setting decarbonisation as a criterion
- Evaluate and inventory feasible CO_2 storage capacity, adopt framework for allocating capacity rights across sectors and develop an appropriate mechanism for the regulation of CO_2 network infrastructure

Ensure The Transition Can Be Financed

- Explore new sources of funding to leverage sufficient private capital investments in energy efficiency, renewables, CCS and network infrastructure, including carbon auction revenues, network system charges and new retail savings products
- Develop incentive measures and a stable and sufficient source of funding to underpin delivery of energy efficiency targets
- Establish building retrofit financing schemes for householders and small businesses
- Ensure mandates to regulators support a business case for private sector financing of the required networks investments
- Consider whether new institutions need to be created to focus on financing low carbon investments
- Assess where and how government may wish to underwrite key risks to reduce the overall financing costs, though such transfers of risk from private companies to the public should be considered as a last resort and where no good alternatives exist

POLICY CONTEXT

The last ten years has been a period of intense activity in the field of European energy policy. The liberalisation agenda has triggered monumental changes in industry structure and ownership and has created a new basis for competition and regulation in power and gas markets. This process has involved three legislative packages at EU level, with the last of these coming into force as recently as 2009, along with a whole series of regulations and statutes being implemented within Member States. In addition to this revolution in the market framework, the energy industry and policy makers have had to come to terms with the extent of the climate change challenge and the implications this has for the way energy is produced and consumed going forward. New policies, such as the European Emissions Trading Scheme (EU ETS), have now been implemented and these have led industry to discard old investment plans and consider new technologies and approaches going forward. In particular, the EU has agreed challenging targets for energy efficiency, deployment of renewable energy sources and the reduction in greenhouse gas emissions[5] by 2020 and meeting these targets is the focus of much ongoing policy effort within Member States. Meanwhile, the requirement to preserve security of energy supplies has given rise to its own challenges and concerns relating to the reliability of imports have lead both the EU and Member States to further review the policy framework.

This intense period of change has inevitably created a sense of policy fatigue and it is important that policy makers avoid further reforms unless there is a strong case that they are necessary to ensure delivery of energy policy objectives. The policy trinity to ensure security of supply, reduce greenhouse gas emissions to levels which avoid damaging climate change and promote prosperity through competitive energy markets and affordable energy prices is well understood and the basic market framework now in place provides a good platform from which to achieve these goals. However, we are beginning to tread on uncharted territory and it is inevitable that we will learn more about the challenges we face and the success of existing policy measures in tackling these challenges. Further reforms and new instruments will therefore inevitably be required; the recently adopted Lisbon Treaty creates an EU competence on energy that opens up new opportunities for a harmonised, ambitious and strategic energy policy. Nevertheless, if we are to ensure ongoing delivery against policy objectives it is essential that new policies work within the existing framework, support all three energy policy objectives where possible and involve an implementation path that is short and credible.

This report has been written in light of the policy context outlined above and does not argue lightly for policy reform. The analysis contained in Volume 1 provides new insights into Europe's future energy challenges and opportunities, particularly as a result of exploring the implications of a reduction of at least 80% in EU greenhouse gas emissions below 1990 levels by 2050[6]. This report concludes that there are significant areas in which the current policy and legislative framework needs to be improved if Europe is to address those challenges in time to meet the 2050 objective.

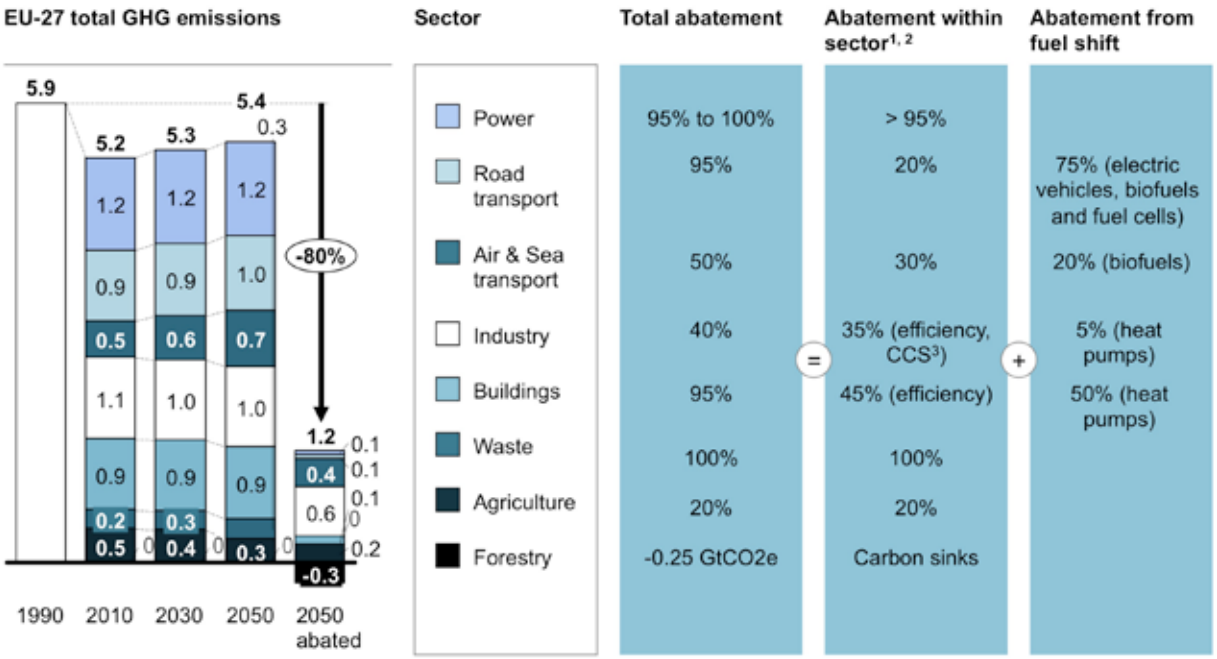
The analysis presented in Volume 1 is an energy system study and it demonstrates that all major emitting sectors will need to be transformed by 2050 if the objective is to be met. Exhibit 1 illustrates the emission abatement potential in each sector and the underlying levels of fuel shift involved. This shows that the most cost effective pathways require particular focus on the deployment of energy efficiency measures and, particularly after 2020, a large-scale switch of heat and transport sectors to the use of increasingly decarbonised electricity. Exhibit 2 shows the extent of the reduction in power demand that is required through improved energy efficiency and how, over time, this is broadly reversed by an equivalent increase arising through the electrification of other sectors. There are

5. The impact of the recession means that the target to reduce CO_2 emissions by 20% is no longer as challenging as first envisaged and there are strong arguments that the target can now be increased to 30% at acceptable economic cost.
6. This is the objective recently adopted by EU Heads of State - see *Presidency Conclusions – Brussels, 29/30 October 2009,* page 3, pp II.7; the actual conclusion documented was for a reduction of 80-95% below 1990 levels by 2050.

EXHIBIT 1

Effort required across sectors to meet 80% reduction target

$GtCO_2e$ per year



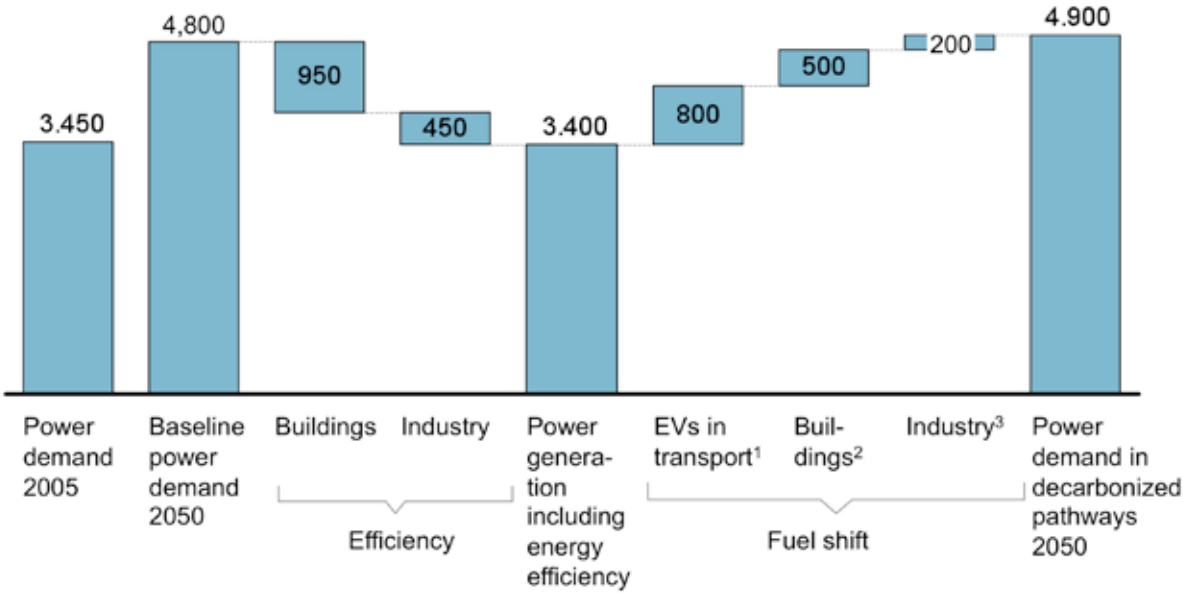
1 Abatement estimates within sector up to 2030 based on the McKinsey Global GHG Abatement Cost Curve
2 Large efficiency improvements are already included in the baseline based on the IEA WEO 2009 (up to 2030), especially for industry
3 CCS applied to 50% of large industry (cement, chemistry, iron and steel, petroleum and gas); not applied to other smaller industries

SOURCE: McKinsey Global GHG Abatement Cost Curve; IEA WEO 2009; US EPA; EEA; Team analysis

EXHIBIT 2

Changes in 2050 power demand arising from energy efficiency and fuel shift

EU-27, Norway and Switzerland power demand, TWh per year



1 Electrification of 100% LDVs and MDVs (partially plug-in hybrids); HDVs remain emitting ~10% while switching largely to biofuel or hydrogen fuel cells
2 90% of remaining primary energy demand converted to electricity (heating/cooling from heat pumps, assumed 4 times as efficient as primary fuel)
3 10% of remaining primary energy demand for combustion converted to electricity (heating from heat pumps, assumed 2.5 times as efficient as primary fuel)

a number of important policy challenges relating to the transport and heating sectors that will reduce energy consumption and promote the fuel switch to electricity. However, the key focus of the analysis has been the power sector and, therefore, this report has focussed on policies relating to the energy efficiency agenda[7] and the decarbonisation of electricity. In addition, the Volume 1 analysis has only deployed technologies that are commercial, or in late-stage development, whilst recognising the potentially significant benefits of future technological breakthroughs. Therefore, the important policy agenda relating to the promotion of innovation has only been considered in the context of the commercialisation of existing and emerging technologies. Finally, the Volume 1 analysis sought to investigate in detail the feasibility of decarbonisation without reliance on importation of electricity from outside of Europe but also recognises the potential benefits – in reduced costs of decarbonisation, in neighbourhood security and others – of importing from neighbouring regions like North Africa. Because it involves broader issues of international diplomacy, foreign policy and development policy that are beyond the competency of the project team, the policy agenda involved in developing such opportunities is not addressed in this report.

The following sections outline the key outcomes that the policy framework must deliver and where current policies are inadequate. A series of potential policy remedies are proposed, highlighting where action is required at the EU level and where it is most appropriate to be progressed within Member States or regions. There are many stakeholders who rightfully expect to be involved in the ongoing policy process and, even though we believe that the proposals should command wide support across the affected constituencies, the recommendations are put forward in the spirit of starting the dialogue necessary to lead to robust policy making. However, the costs of delayed action are also highlighted and it is important that this policy agenda is tackled with an appropriate sense of urgency.

7. Energy efficiency is a broader topic than merely the power sector. However, the necessity of the large-scale fuel shift to electrification in buildings and transport means that the feasibility of decarbonisation of the power supply is heavily affected by efficiency developments in these sectors.

FOCUS ON OUTCOMES

Energy efficiency[8] is the lowest cost and most immediately accessible way to reduce carbon emissions and it reduces the extent to which abatement must be delivered through other means; the construction of ~440 mid-sized coal plants could be avoided and at lower cost. Volume 1 shows that without the gains assumed beyond those included in the baseline, the zero-carbon supply challenge is one-third larger, with all of the supply solutions to meet that incremental demand being more costly than the foregone efficiency measures.

Efficiency directly reduces energy costs, improves security of supply and has the potential to create wide-scale business opportunities and significant numbers of new, local jobs in Europe – it must, therefore, remain the highest priority for policy makers. The analysis in Volume 1 assumes that the EU target to reduce primary energy consumption by 20% by 2020 will be delivered and that this then sets the foundations for continuing to deliver 1-2% gains each year (over and above the 1-2% annual improvements assumed in the baseline) out to 2050. These outcomes provide a benchmark ambition for policy makers and it is vital they are adopted as a critical objective going forward.

The technologies currently exist, or are in the latter stages of development, that would enable electricity to be generated virtually without any carbon emissions[9]. The scenarios in Volume 1 indicate that it is possible to proceed relatively rapidly in decarbonising power generation (by around two-thirds over the next two decades) whilst maintaining at least current reliability standards. This, in turn, delivers important near term reductions in carbon emissions and creates a number of new and low cost options to decarbonise the transport and heat sectors, thereby establishing the foundation for delivering the 2050 abatement objective. It is therefore important to set the early decarbonisation of power generation as a priority policy ambition.

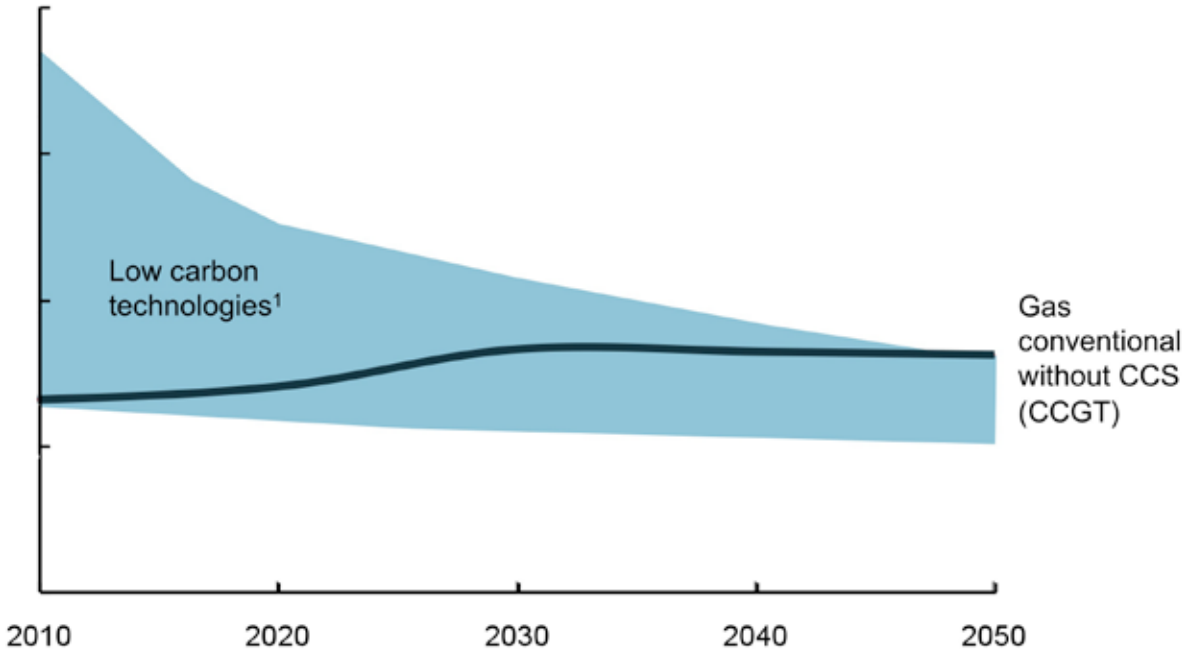
To this end, immature low/zero carbon technologies, such as solar PV, offshore wind and carbon capture and storage, will continue to require targeted support to drive early deployment. By stimulating secure, long-term commercial opportunities for investors in these technologies, policy makers harness the competitive power of companies operating throughout the supply chain to increase production capacity, gain valuable commercial experience, drive down costs and improve performance.[10] Exhibit 3 illustrates the projected cost reductions for low carbon technologies based on information gleaned from a technical review of the current prospects for these technologies conducted with a broad group of industry experts. Once support for commercialisation of the new technologies is gradually phased out, the business case for new investment will increasingly rely on market demand for new, low/zero carbon generating capacity, demand that can only come from load growth and/or retirement of existing plant. Even once the significant potential for cost reduction in these technologies has been realised, it is unlikely that they will be able to compete head to head with relatively small investments to life-extend depreciated unabated high-carbon generators. It is therefore crucial that investment in life-extension of existing high-carbon plants (without retrofitting of full abatement measures) is ruled out along with investment in new unabated high-carbon emitting plants, which would occupy valuable market space for decades to come, as soon as prudent security of supply considerations allow. A combination of market forces (including carbon pricing under the EU ETS) and complementary regulation[11] is necessary to ensure that this transition occurs.

8. Energy efficiency refers to the installation of more energy efficient equipment (e.g., motors, appliances, lighting, heating and air conditioning systems) or using more efficient processes/systems to achieve a continuous and permanent reduction in energy use without reducing the quality of service. Unless otherwise indicated, we use the term "energy efficiency" to refer to these types of end-use efficiency improvements in homes and businesses.
9. It is recognised that residual carbon emissions are likely to remain in the power sector for the foreseeable future, particularly arising from carbon capture and storage plant or open cycle gas plant providing back up for intermittent renewable generation. In the analysis, the power sector is predicted to emit 25 - 80 Mt annually by 2050, which is a reduction of between 94% and 98% over 1990 levels.
10. This assumes that the programs are designed to create sustained competitive pressure on suppliers to do so.
11. An example of complementary regulation that sits alongside a cap and trade system to ensure that emissions from fossil-fuelled power generation (are abated) is given in the appendix A to this document.

EXHIBIT 3

Low carbon technology costs decrease versus gas plant costs increase

LCoE evolution of gas conventional compared to low carbon technologies, € per MWh (real terms)
Example based on the 60% RES / 20% nuclear / 20% CCS pathway, Iberia



1 Technologies included: Coal CCS, Nuclear, Wind onshore and offshore, Solar PV, Solar CSP and biomass dedicated

Perhaps the most significant new insights in Volume 1 relate to the role of network infrastructure in facilitating the decarbonisation of the power sector and achieving this outcome with enhanced security of supply and reduced costs and technology risk. In particular, increased levels of inter-regional network connection and co-ordination in the use of resources between regions appears to be hugely beneficial. Volume I shows that the total investment required to access this benefit is small relative to total investment in the power sector; the incremental investment required over and above the baseline is smaller yet. Whilst the proposed expansion in transmission will undoubtedly present a social, regulatory and political challenge, the impact on the cost of electricity to consumers is, nevertheless, relatively small; the benefits, on the other hand, are dramatic. In every decarbonisation pathway studied, expansion of inter-regional interconnections reduces curtailment of all resources to negligible levels, thus avoiding redundant investment in much costlier zero-carbon supply resources. Moreover, a more interconnected European power network creates the option for high levels of renewable energy to be accommodated on the system securely and cost effectively. By enabling the sharing of resources across regions much less back-up capacity is required to meet high reliability standards. For example, Exhibit 4 shows the extent of the additional storage capacity that would be required within regions to support 80% renewable generation if the interconnection capacity is reduced by 50%. At the same time, the analysis concludes that member state energy self-reliance within the EU-27 is largely unchanged or slightly improved; 8 of the 9 regions studied generated over 90% as much electricity as they consumed, similar to current rates.

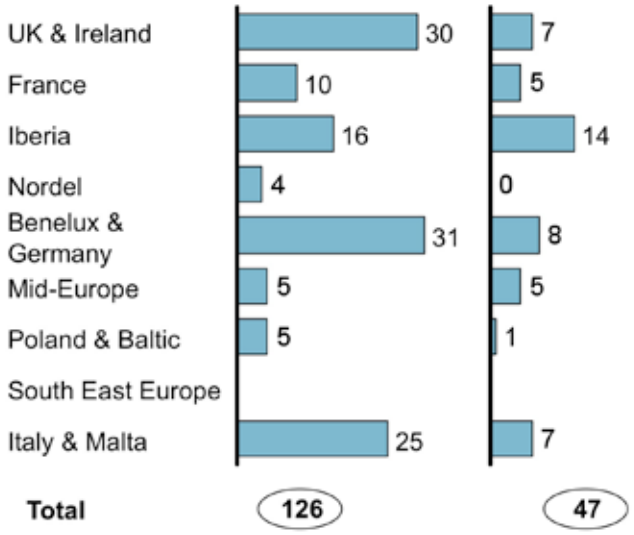
EXHIBIT 4

Additional investment in storage required to support 80% renewables where transmission capacity is reduced by 50%

Effects of halving transmission capacity[1]

- **Curtailment of renewables** increases from 3 to 15-20%. Especially solar energy from Iberia cannot be used optimally
- **Curtailment leads to insufficient generation**
- **Mitigating options include**
  - Adding storage capacity (as described to the right)
  - Adding/changing the generation capacity mix or moving it to other regions

Resulting storage requirements per region[2]



1 Assuming a 50% reduction in capacity for transmission
2 Excluding existing capacity (less than 10% of required capacity)

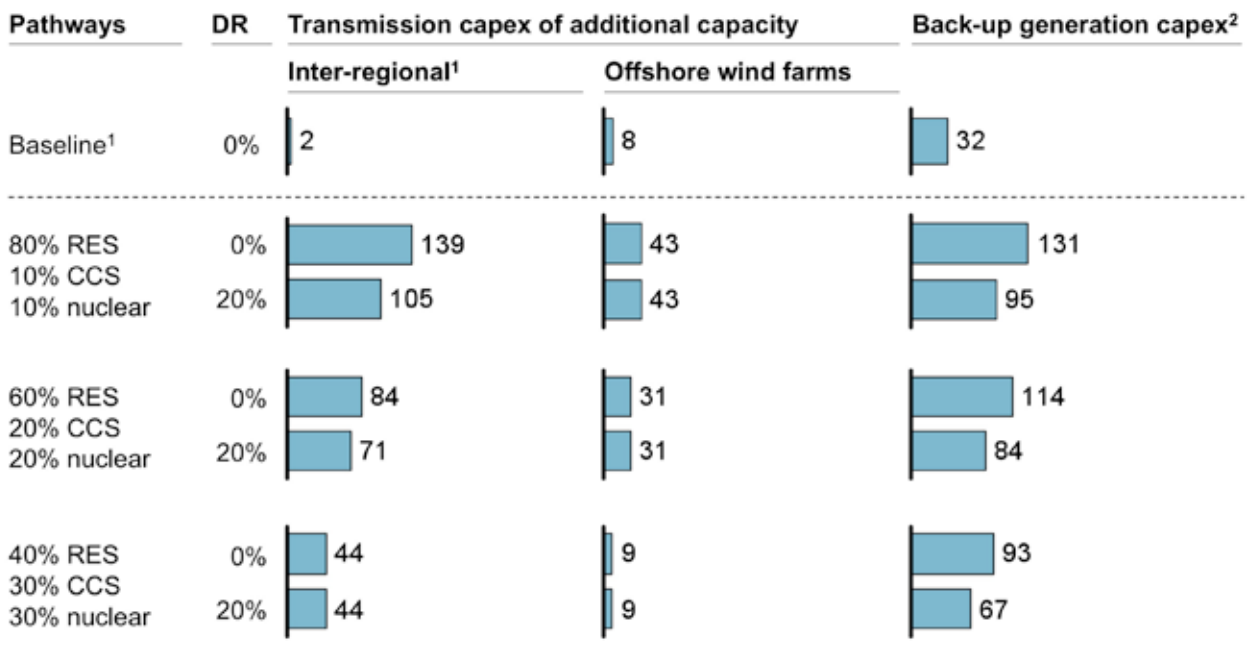
Volume 1 not only shows how to securely accommodate large proportions of renewable generation but that the overall cost of delivering a decarbonised power sector by 2050 is broadly equivalent for a number of credible mixes of generation technology. Therefore none of the future generation mixes considered in Volume 1 can be excluded on the basis of cost or system security. Given the feasibility and urgency of decarbonising the power sector as demonstrated in Volume 1, a prudent energy policy should ensure that all the technology options remain open. Policy makers must therefore bring forward an infrastructure policy package designed to deliver a trans-European grid architecture capable of accommodating the highest penetration of renewable production consistent with affordable and reliable energy supplies. This is a 'no regrets' policy option and entirely consistent with the ambition to create a single internal power market.

Volume 1 has also demonstrated the value of demand response[12] in reducing costs and improving system security. Exhibit 5 shows how 20% demand response capability reduces transmission, back-up generation and balancing costs for a variety of generation technology mixes. These benefits can only be fully realised with sufficient control, instrumentation and communication equipment both within premises and on local power distribution networks – the so-called smart grid concept. The analysis has therefore reinforced the role of smart grids, together with smart policies and retail tariffs, in enabling a secure and cost effective decarbonised power system and this should remain a key focus for policy makers.

EXHIBIT 5

Savings in Transmission and Generation costs through demand response

Cumulative capex from 2010 to 2050, € billion (real terms)



1 Based on an average transmission mix with 73% AC and 27% HVDC (comparable to the Tradewind report) at a cost of € 1,000 MW per km
2 The cost of additional capacity is assumed to be 350,000 € per MW based on OCGTs, but could be any equivalent

This report considers the ability of the existing policy framework to deliver the necessary outcomes in the areas of energy efficiency, the switch from high carbon to low carbon generation and power network infrastructure and sets out suggested policy remedies to address the deficiencies identified.

12. 'Demand Response' refers to an increase or decrease in a customer's electricity demand in response to despatch instructions or price signals communicated to customers' premises. It does not refer to a reduction in the energy delivered in a day but to a change in the time in which it is consumed.

POLICY DISCUSSIONS

Energy efficiency

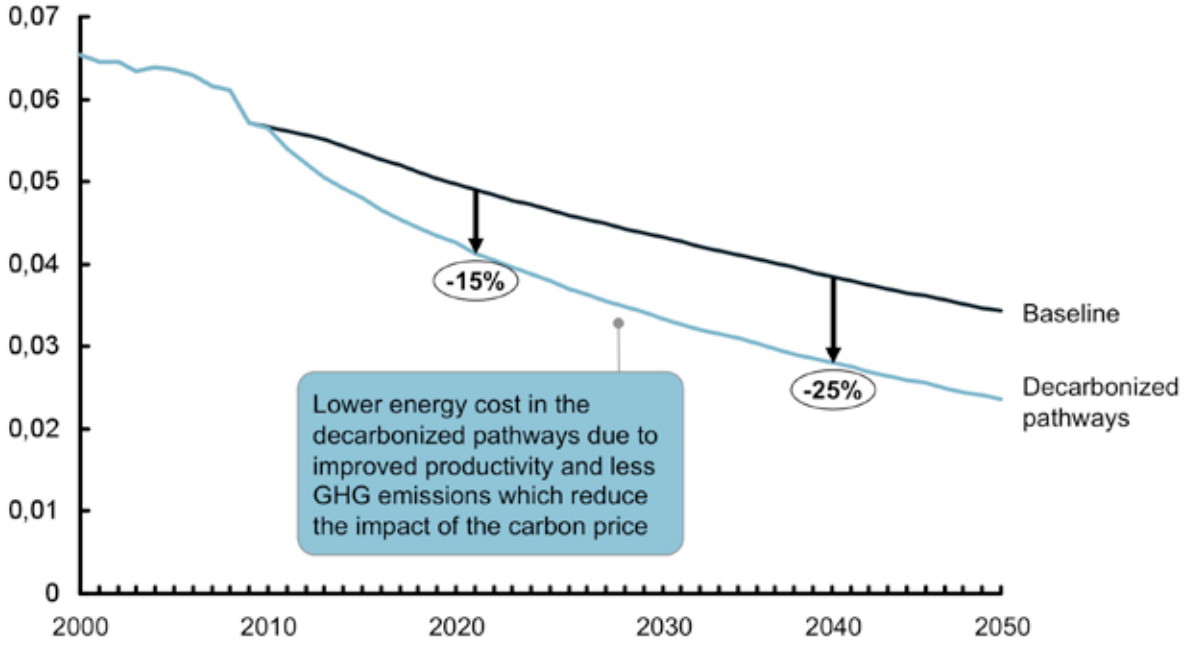
In March 2007, the European Council endorsed a policy to save 20% of primary energy consumption by 2020 against projected consumption and this remains the central plank of European legislation relating to energy efficiency. Member States have been tasked with developing and implementing action plans aimed at achieving this objective. However, despite the widely distributed savings opportunities and other social benefits of energy efficiency, the focus and effort deployed by Member States has been patchy.

A recent study by Ecofys and Fraunhofer[13] concludes that the impact of energy savings policies will need to increase by a factor of nearly three times in order to reach the 20% energy savings target. Failure to do so would cost an estimated €70bn per year in unrealised potential savings to European energy consumers, net of investment costs. This study also identifies a number of reasons for this underperformance. There are numerous, well-documented market barriers to the deployment of cost-effective end-use efficiency measures in homes and businesses alike. Existing governmental efforts to overcome these barriers

EXHIBIT 6

Energy cost decreases in the baseline, but even more so in the decarbonized pathways

Energy cost per unit of GDP output, € (real terms)



Note: Energy prices are a weighted average of prices faced by consumers weighted by the shares of consumption of different fuels

13. "The Feasibility of Binding Energy Savings Targets in the EU" by Ecofys and Fraunhofer (Part 1: facts and figures, April 1, 2010 unpublished report), co-funded by European Climate Foundation and Regulatory Assistance Project. Full final report (Parts 1 and 2) scheduled to be published in early May 2010.

have had some success, but there are still serious limitations, including:

- Non-binding nature of the 20% target renders it subordinate to the 2020 GHG target;
- The Energy Services Directive targets less than 1/3 of cost-effective savings potential;
- Member State implementation efforts are not consistently robust;
- Major delays in implementing and revising the Energy Performance Directive for Buildings;
- Long transition periods for minimum standards under the Eco-Design Directive; and
- Delays in revisions of outdated labelling schemes.

Volume 1 has illustrated the direct benefits for all three objectives of energy policy of a successful energy efficiency deployment strategy. There is also increasing evidence of broader economic benefits and job creation arising from industries operating in the energy efficiency supply chain and this can form an important dimension of the rapid and sustainable return to growth and prosperity across Europe. Exhibit 6 illustrates that energy bills in Europe can start to fall as early as 2015 provided that ambitious energy efficiency measures are immediately put in place.

It is estimated[14] that energy savings measures could create 1 million new jobs in the EU by 2020 due to the labour-intensive and localised nature of the work, offsetting possible short-term job losses due to transition costs. The bulk of these jobs would be created in local installation and manufacturing sectors and to a smaller extent in the transport, energy and service sectors.

Europe cannot afford to continue to underperform in this area and this represents a clear area of policy failure. It is essential that policy makers urgently address the need to get back on track to deliver the 20% target by 2020 and set in place the foundations for sustained ongoing improvements thereafter. It will not be easy to achieve this objective. Pervasive and persistent market barriers to end-use energy efficiency exist and will need to be comprehensively removed in order to achieve the large-scale ramp up of efficiency that is required[15]. It is therefore necessary to develop a broad, assertive efficiency policy strategy, which should involve the following key elements:

1. Change the narrative: energy efficiency is a zero-carbon supply-side resource: Large-scale ramp up of cost-effective energy efficiency requires a strategic and concerted effort by policymakers at all levels of government to fundamentally change the narrative surrounding energy supply, transportation and efficiency. The new narrative needs to recognise explicitly in all policies affecting the regulatory and market landscape that energy efficiency represents a low-cost and zero carbon energy system resource that benefits all customers, irrespective of the physical premises where the measures are installed. For example:

   - Explicitly recognise and treat energy efficiency as a priority energy system resource in high level energy strategy and policy documents (e.g., Strategic Energy Reviews, Energy Action Plans, National Renewable Energy Action Plans, other climate & energy legislation);

   - Add features to the market that recognise energy efficiency and other demand-side measures as a zero-carbon system resource, enabling them to compete on a level playing field with supply-side resources (e.g., in capacity market design).

2. Comprehensive approaches: Success today requires drawing on lessons learned from recent European and international experience. Attracting private investment to this market will require multiple policy tools and strategies to remove all of the barriers and create sufficient demand pull for this market to develop: single-barrier approaches or higher prices alone – including the impact of carbon pricing under the EU ETS – will not be successful. Comprehensive approaches will be needed including packages of regulation, audits, financing, incentives and inspections. For example:
   - A package of minimum energy performance requirements, labeling programs and customer

14. Green Paper on Energy Efficiency. EC 2005 http://ec.europa.eu/energy/efficiency/do/2005_06_green_paper_book_en.pdf
15. There is extensive literature detailing these market barriers, including access to information, high first-cost problems, consumers' high discount rates, unpriced externalities, the landlord-tenant problem, and others. See for example American Council for an Energy Efficiency Economy, Quantifying the Effects of Market Failures in the End-Use of Energy, at iii-vi (2007) available at http://www.aceee.org/energy/IEAmarketbarriers.pdf

incentives for appliances and equipment that will drive the uptake of the most efficient appliances at or before normal turnover.

- Energy performance standards for buildings (e.g., requirements at time-of-sale or major remodels to upgrade the efficiency of the building to a pre-specified standard) that are tied to incentive programs and financing tied to the premise, with sufficient lead-time for the building owner to comply with the performance standard.

3. Sufficient and stable public funding: Successful removal of all market barriers requires a stable and sufficient source of public funds to socialize approximately one-fourth[16] of the total investment cost in efficiency. Funding can be derived from a number of potential sources:

- Network use of system charges;
- Recycling revenues collected through the auctioning of carbon allowances into energy efficiency programs;
- Taxation[17] of excessive infra-marginal rents collected by some generators from the higher market clearing prices created by, for example, the EU ETS;
- A new source of market revenues created through a tradable white certificate program (that is also paid by all electricity end-users);
- A financial obligation on all retail energy suppliers that is then passed through to all end-users in retail prices to the extent permitted by the market.

4. Delivery matters: Success requires new ways of delivering energy efficiency services to homes and businesses that are capable of accomplishing the following:

- Creating consumer trust in the 'messenger' and minimising market confusion from multiple energy efficiency brands and conflicting energy savings values;
- Establishing effective quality controls for the information and retrofit installations provided to households;
- Aligning the incentives of the delivery system to ensure that those interacting with households are strongly motivated (and not conflicted) to deliver 'whole house' or deep retrofit treatments on a large scale, e.g., street-by-street;
- Creating new competitive business opportunities along the energy efficiency supply chain to spur innovation and productivity improvements. For example:
  - One-stop-shop delivery by a qualified and capable entity under performance contract with the government
  - Standard contract payments (euro's per "negawatt-hours" delivered through comprehensive retrofits) by fully accredited market actors
  - Local government partnerships with regulated or unregulated suppliers that create a delivery system meeting the criteria above

16. The '25%-75%' public-private investment ratio stems from experience in rolling out energy efficiency programs over the last three decades in residences and businesses. Some applications will require a larger percentage of public funding to leverage private investments (e.g., residential retrofits with solid wall insulation) whereas others will require a lower percentage. This general rule of thumb is also borne out by the incentive levels (relative to total costs) paid out by Efficiency Vermont, an experienced efficiency deliverer in the US under a performance contract with the State. See http://efficiencyvermont.com/stella/filelib/2008_Efficiency_Vermont_Annual_Report.pdf.
17. An ex-ante taxation approach should be preferred to an ex-post 'windfall' approach given the damaging impact this can have for overall investor confidence in the energy markets and, in any case, should only be considered for fully written down capacity which is not relying on energy credit to recover capital costs.

5. Increase high-level political commitment: Success is unlikely without a long-term, consistent political and resource commitment to energy efficiency that is comparable to other low-carbon resources. Voluntary commitments are not sufficient to create a clear market signal well into the future for policy-makers, consumers and investors to take all of the above steps to ramp up energy efficiency to the requisite level.

There is no magic bullet to tackle energy efficiency. A broad range of approaches will need to be deployed and these must be flexibly designed to take advantage of varying local circumstances. However, there are many opportunities for success and many good examples to draw upon (see Appendix A online). The EU must ensure that energy savings remain a high priority for Member States and local regional government and they, in turn, must take ownership of designing and delivering the necessary package of solutions, operating within a broad framework of standards and regulations established at EU level. It is recommended that the following outline policy programme be pursued urgently:

Actions at EU level

- Action to convert the non-binding 2020 efficiency goal into a requirement to deliver the target whilst allowing Member States flexibility on how this should be achieved
- Revise the Energy Services Directive to support a tripling of the energy efficiency policy impact, which is required to achieve the 2020 energy savings goal
- Strengthen the Eco-Design of Energy Using Products Directive with mandatory minimum energy performance requirements based on 'best available technology' on the global market and a sufficient updating process ('frontrunner approach')
- Full implementation of the Energy Performance of Buildings Directive to ensure that all new buildings meet zero net energy requirements by 2020

Actions at the Member States level

- Establish aggressive mandatory annual and cumulative targets to retrofit buildings with deep efficiency improvements
- Develop incentive measures and stable and sufficient sources of funding to underpin delivery of energy reduction targets
- Establish building retrofit financing schemes for householders and small businesses
- Establish a network of trusted and customer focussed delivery agents to provide a one-stop-shop for building assessments and retrofits
- Strengthen performance standards for existing buildings at Member State and/or local level

The European legislative framework for delivering climate targets is defined out to 2020 by the EU ETS Directive and the CO_2 abatement, renewable energy and (non-binding) energy efficiency targets. However, beyond 2020, only the EU ETS Directive remains applicable and there is no legislative framework in place to ensure the necessary economy-wide reductions will be delivered. There is therefore no long term basis against which industry can plan investment in energy efficiency and build the supply chain capability required to ensure the necessary ongoing improvements are delivered. In addition to establishing the basis for long-term investments outside the sectors covered by the EU ETS, a holistic framework is important to ensure that scarce resources, such as sustainable biomass, are used efficiently across sectors and across the period up to 2050. It is therefore necessary for the EU to set in train legislation to ensure the necessary policy mix is implemented.

Action at EU level

- Progress legislation that will establish the framework for efficiently delivering climate objectives allocating limited resources beyond 2020 and out to 2050.

Decarbonisation of power generation

The switch from high carbon to low carbon generation needs to happen as quickly as prudent security of supply considerations will allow. This involves the commercialisation of a variety of emerging low carbon generation options and financial incentives and regulatory frameworks that ensure timely disinvestment and retirement of high carbon assets and investment in sufficient replacement low carbon assets.

A variety of support schemes are in place across Europe to deliver the 2020 target for renewable energy sources and these represent the major vehicle for commercialising these supply technologies. These schemes have demonstrated the benefits of creating a market opportunity for companies operating within the supply chain and how this can drive down costs as quickly and as far as possible. However, this benefit would be increased significantly if a clear market opportunity extended beyond 2020. Currently, challenging renewables growth targets do not extend over these timescales. This is inevitably constraining supply chain investment, particularly for technologies that are currently relatively immature but that Volume 1 illustrates have huge long term potential (especially offshore wind and PV).

This problem is particularly acute in the case of carbon capture and storage (CCS) technologies. While CCS is only one important option for power decarbonisation, it is an essential technology for decarbonisation of heavy industry and can create net sinks for CO_2 alongside biomass combustion. Proposals are currently being progressed at EU and Member State level to fund a number of demonstration projects across Europe. However, there are no mechanisms in place to incentivise follow-on 'commercial' investments. Even once technically proven, such projects would still be associated with significant technology risk and there is little expectation at present on the part of investors that the EU ETS is capable of providing sufficient incentive. In addition, there is a risk that new coal and gas plant may be built that is not capable of being retrofitted with CCS[18]. In consequence, supply chain investment strategies will be limited to creating technology options rather than meeting a long-term market need at lowest cost. Apart from constraining the ability to decarbonise the power sector efficiently, and the ability to decarbonise heavy industry at all, the potential for supply chain investment to create jobs and grow export markets is also being reduced.

It is critical that Member States now take a view on setting longer term targets for the growth in key renewable generation technologies and consider whether this is best taken forward on an individual Member State basis or whether it is more appropriate to be driven at the EU level. Similar questions must be answered for CCS, where the appropriate measures for driving commercialisation more effectively, particularly in heavy industry, are likely to differ. For example specific measures at Member State level might include direct support for demonstration projects; long-term purchase guarantees for designated early commercial projects; socialization of specific risks; or adoption of needed legal and regulatory frameworks. The difference in approach is due to factors specific to CCS including the possibility of exogenous constraints on storage capacity and the fact that differing priorities may be attached to using CCS for applications that lie outside of the power industry. The EU needs to ensure that the budget contains an appropriate level of funding support for the commercialisation of these key technologies.

It is extremely important that the broader market framework is appropriately incentivising sufficient volumes of new generation capacity and ensuring

18. It may be appropriate to retain some unabated CCGT capacity on the system for a period operating a low load factors as the least cost and lowest emission route to provide system balancing services.

that the technologies involved are consistent with achieving decarbonisation goals. Different countries across Europe will need to replace their generation capacity at various times depending on the age and technology mix of the existing generation fleet. For example, Poland is expecting to replace around 50% of total generating capacity before 2020 and the current presumption that much of this replacement capacity will be coal-fired power plant is at odds with the imperative to dramatically reduce carbon emissions. Despite the fact that the latest System Adequacy Forecast from ENTSO-E does not report any tangible concerns going forward for security of supply in Member States, many of the investments assumed in their forecast are far from reaching financial close and there are many circumstances that could prevent these projects from being realised.

Investors contemplating major investment opportunities in power generation face significant uncertainty:

- Market uncertainty: Power stations are long-term investments and the attractiveness of an investment will depend critically on the market opportunity one to two decades into the future (or further in the case of nuclear). Over these timescales there is huge uncertainty over both the market need and the potential market prices. Europe's success in deploying large-scale energy efficiency and alternative generation technologies is far from certain at this time and this will affect investors' assessment of whether there will still be a need for traditional generation to meet system reliability requirements and security of supply in the future[19]. In addition, it seems likely that the characteristics of prices in energy-only markets will change significantly, with more and longer periods of low prices offset by brief but perilous periods of very high prices, as the proportion of low carbon generation increases. Indeed, Denmark, Germany, Spain and Portugal have already experienced periods with zero or negative prices and they are expected to arise in France and Benelux by next year at the latest. This is because technologies such as renewables and nuclear have relatively high capital costs but extremely low variable costs and in an energy-only market it is the latter that will increasingly be setting market price[20]. Extended periods of very low wholesale pricing will place severe strain on the financial condition of generation owners, whilst the brief periods of very high and volatile prices – periods that generation owners will rely upon to recover their investment – have often sparked intense political reactions and, not uncommonly, direct political intervention in the market. Investors are therefore currently expected to believe in future prices that are entirely without historical precedent and, through the eyes of today, can seem implausible. These market uncertainties are in addition to the already significant and more traditional uncertainties associated with commodity prices, technical performance and competitor behaviour.

- Policy uncertainty: Significant involvement in the market by Governments is accepted as inevitable given the intense political interest in energy costs, security of supplies and impacts on the environment and investors see a significant proportion of investments in the market being driven by direct Government or EU interventions (renewables, CCS demonstration projects). However, there is no clear and accepted narrative that explains where these interventions will focus in the future and how long they will last. Indeed, the oft-stated role of the 'market' as central to current energy policy seems entirely at odds with the self-evident investment realities for low carbon technologies. Moreover, it is often asserted that the EU ETS will be the central driving force for decarbonisation of the power sector. However, there is little or no evidence that it is capable of efficiently incentivising significant and long-term low carbon investments at large scale. In part, this arises from the fact that current experience makes investors sceptical that politicians can deliver or safeguard the tight and

19. Indeed, failure in energy efficiency programmes and deployment of low carbon generation could create a large need with significant investment in traditional generation required to maintain system reliability and security of supply. The consequence of this is that the economics of all new and existing capacity improves greatly (at least in the short to medium term) in the circumstances where the transition to a low carbon economy fails. This risks diluting the commercial imperative of incumbent players to promote the transition and reinforces the imperative for a concerted, aggressive set of policy and market drivers for energy efficiency, timely retirement of high-emitting resources and the commercialisation of promising new low-carbon generation technologies by the EU and Member States.
20. Negative prices arise because generators are prepared to 'pay' to generate in order to earn subsidy income.

reducing caps (or resist the temptation to dilute the effectiveness of the caps through generous treatment of external compliance mechanisms) that are required to meet the 2050 emissions objective and prices are therefore heavily discounted by investors making decisions today.

One option that could be explored to address these concerns is the use of market refinements such as forward capacity markets[21] ; a number of other options exist. Any such measure must include (i) treatment of demand side and efficiency as resources on equal footing with new supply and (ii) strong emissions criteria in the valuation methodology.

Recent events in the financial markets have both limited the availability of capital and increased the awareness of risk amongst investors. In light of the uncertainties associated with investments in the power market, it seems inevitable that investors will be wary of making large financial commitments and, where they are prepared to make investments, they will be looking for healthy financial returns[22]. Faced with these considerations, investors may defer investment and/or prefer the lowest capital cost investment options such as CCGTs and life-extension of existing power stations. At a time when massive investment in new infrastructure is needed, including in generation capacity, this has the potential to undermine the necessary transition to low carbon generation, significantly increase the associated costs and potentially threaten security of supply.

Specific market frameworks vary considerably across Europe along with the timing at which major replacement of existing generation assets is required. However, it now seems essential that Member States[23] undertake a review of market frameworks and consider the need to re-balance risk – shifting more risk away from individual investors to electricity customers or an even wider group of stakeholders. In particular, the review will need to consider how to accommodate increasing volumes of energy produced by technologies still in receipt of 'commercialisation support' such as feed-in tariffs that involve a transfer of risk to other market participants. Investors will always face market, policy and investment uncertainties and it is not suggested here that the role of policymakers and regulators is to insulate private investors from risk. Indeed, overall market efficiency and operational performance can be significantly reduced if investors and companies are insulated from risks that they are best placed to manage. This is the key reason, for instance, that commercialisation support mechanisms such as 'feed-in tariffs' will need to be reviewed as the market shares of the relevant technologies become significant. It is therefore important that the EU and Member States provide much clearer and consistent market signals relating to policies affecting resource mix, transmission access and energy pricing to ensure that they are creating a stable, long term framework for investors and that they support a strong business case for investing in zero- and low-carbon resources. Notwithstanding the above, Member States will need to undertake a careful assessment of what portion of development risks (in new renewable and carbon-captured technologies) and infrastructure investments will nonetheless need to be socialised over electricity customers or an even wider group of stakeholders, based on a reasonable balancing of benefits, risks and costs between individual investors and the broader public.

21. Forward capacity markets are explored in depth in the recent paper by the Regulatory Assistance Project, which can be found at: http://www.raponline.org/docs/RAP_Gottstein_Schwartz_ForwardCapacityMarkets_2010_4_2.pdf
22. It is a mistake to assume that investment risks are necessarily unusually high at the moment. The power market will constantly face new technology challenges and opportunities and be affected by developments in global markets that are impossible to predict. Significant investments will be required throughout the coming decades and we cannot rely on future risks declining.
23. Where unified regional markets already exist it is clearly appropriate that the reviews are conducted on a regional basis.

Volume 1 has also highlighted the benefits in optimising resources across regions within Europe (see Power Networks section below) and it is equally important that Member States bear this in mind when considering longer term targets for renewable generation technologies and when reviewing power market arrangements. Significant opportunities may exist to export power or to reduce costs through importing from neighbouring regions. Member States should ensure that these opportunities are maximised by taking a long term strategic view of the potential of certain technologies and by ensuring that market arrangements allow efficient trading between regions, the unification of arrangements into regional markets and, ultimately, a European single market. The single energy market agenda has been pursued by the EU for over a decade but is still far from complete. For example, the Florence Forum has made considerable progress with market coupling initiatives but there has been limited attention paid to the integration of reserves and balancing markets that Volume 1 suggests will be absolutely critical. It is recommended that Member States are required to produce a long term planning generation and demand-side resource mix out to 2050 that is consistent with decarbonisation objectives and can be used to underpin the strategic development of the network. This should not be viewed as a move away from the market and toward central planning since the fuel mix outcomes may end up very different as technology costs evolve. However, it does recognise that the objective of a decarbonised, reliable and affordable power sector relies on the development of resources that may not be developed without a coordinated strategic view. It also recognises that it will be impossible to develop the appropriate pan-European infrastructure without taking a long-term strategic view of the resource mix.

Finally, it is time for a thorough debate over the future role of the EU ETS in driving forward investment in low carbon generation. The EU ETS has proved extremely successful in setting a price for carbon that is now incorporated as an avoidable cost by power plant operators in generation despatch and short term planning decisions. It also provides the basis for greater international collaboration on reducing carbon emissions through linking with other cap and trade schemes and represents a growing source of market revenues that can be used to make investments in energy efficiency, new low carbon technologies and the infrastructure needed to meet the 2050 carbon reduction objective. The EU ETS plays an essential role in addressing the market failure associated with climate externalities and should therefore remain as an important instrument going forward. However, the full decarbonisation of power, which is only one sector within the unitary ETS, has been shown in Volume 1 to be essential to decarbonisation of transport and building heat, sectors not covered by the ETS, such that a 'successful' ETS that does not lead specifically to a fully decarbonised power sector would in reality undermine economy-wide decarbonisation efforts. Furthermore, the power sector is capital-intensive and large investments must be made on the basis of a view of prices over several decades. These timeframes are well beyond the horizon within which the ETS can provide the confidence necessary to drive tens or hundreds of billions of euro of capital investment. Additional, complementary measures are therefore required to ensure that the overall market framework is able to deliver the results that it was originally intended would be delivered by the EU ETS alone. The complementary measures must rule out investment in long-lived high-carbon generation – both in new plant and in the life-extension of existing plant – since these would monopolise critical market space for decades to come, crowding out investment in the similarly long-lived assets capable of producing the low-carbon energy upon which the success of the ETS will depend. The consequence of these measures would be to create a long-term, visible, low-risk market opportunity for new capacity that will encourage investment in mature, capital-intensive, long-lived low/zero carbon generation.

The level of ambition and success of these complementary measures will inevitably impact the carbon price arising from the EU ETS. It is therefore important that careful consideration is given to ensuring that these effects do not destabilise and undermine the carbon price. Mechanisms such as full banking and borrowing of permits across time, adjusting the cap within bands and adjustment of CDM volumes deserve urgent consideration, though each presents difficulties and carries risks. Imposition of limits on the range of the carbon price, though it warrants investigation, may face particular difficulties. CDMs and other offset allowances should be limited in order not to water down the ETS and in order to drive innovation and competitive advantage for the EU.

The following issues should therefore be taken forward:

Actions at EU level

- Develop complementary measures to the EU ETS which safeguard the long-term transition of the power sector and maintain a non-distorted price signal
- Review EU ETS reduction targets to ensure they are consistent with delivery of 2050 emissions targets.
- Ensure that funding is available from the EU budget to demonstrate critical low-carbon technologies across all relevant regions along with appropriate instruments to allocate these funds
- Request Member States to come forward with long term targets for deployment of key renewable generation technologies and adopt parallel measures for CCS
- Introduce new provisions requiring Member States to identify a long term planning generation and demand-side resource mix out to 2050 that can be used to underpin strategic network development and is consistent with decarbonisation objectives

Actions at Member States level

- Consider the need for long term deployment targets for key renewable generation technologies and whether these need to be co-ordinated at EU level
- Introduce regulations to ensure that new fossil-fired generation (gas and coal) can and will be retrofitted with CCS technology; expand support for demonstration projects and early deployment
- Undertake a review of market framework to ensure it:
  - Delivers sufficient certainty of revenue to drive long term investments in low carbon demand-side resources and generation and system balancing technologies, both during the commercialisation stage and thereafter
  - Provides clear signals for the disinvestment in and retirement of high carbon technologies
  - Facilitates efficient utilisation of system balancing resources within and between regions and, where appropriate, the full integration of markets
- Use the review of market frameworks to ensure efficiency and demand response investments can compete on equal footing with supply and network investments, e,g,, in the valuation of capacity and the provision of balancing services to the TSOs
- Consider market design improvements, including relevant experience with market mechanisms in other regions, that recognize the capital intensity of renewables and CCS and address the persistence of competition from high-carbon assets

Power networks

Changes in network infrastructure and the way it is operated are critical to meeting the 2050 emissions objective since this will create the option to deliver decarbonisation through a range of generation mixes, including those involving high levels of renewable generation, securely and at affordable costs. In particular it is necessary to:

- Increase interconnections between power systems and optimise the use of resources amongst Member States, and
- Significantly improve demand response through smart grid applications

The process to-date for identifying and deciding on new interconnections has been fully delegated to Member States, although it has necessarily involved the need for bilateral coordination. The prevailing model involves the Transmission System Operator identifying the need for new network investments and, depending on the regulatory arrangements, the investments may be subject to regulatory approval and be included in the regulatory asset base[24]. Investment decisions are therefore taken through a 'bottom-up' assessment of need at a national level (unless additional financing has been sought through the TEN programme or from international donor organisations where specific projects have been approved on the basis of broader market integration or security of supply reasons).

Recently, EU Directive 2009- 72 has required ACER and ENTSO-E to prepare and use a 10-year network development plan. This involves processes for checking consistency between national plans and the potential for ACER to recommend changes. However, these proposals remain deficient in their ability to develop a strategic European grid network or support a single electricity market. In particular

- The EU-wide network development plan is explicitly designated as non-binding
- The network development plan is limited to a period of 10 years and falls far short of the planning horizon required in network development
- Whilst Regulation (EC) 714/2009 refers to economic benefits and security of supply, it fails to include environmental targets and emission reductions as criteria to be considered when assessing proposed investments and investment needs
- Although the EU-wide plan shall include a European view on the networks and generation adequacy, Regulation (EC) 714/2009 explicitly states that it shall be based on national plans, not vice versa.
- New legislation lacks any clear rules/provisions for joint financing of common infrastructure or projects of a wider regional and/or European interest.

According to ENTSO-E figures, 1650km of new interconnectors have been built between 2004 and 2009 with a total capacity of 12.6GW. This rate of build is significantly less than the forecasts contained in the recent 10-year network development plan produced by ENTSO-E which suggests that the construction and upgrading of 42,000km of transmission lines will be required of which nearly half the total investments (18,700km at a cost of €23-28bn) are expected in the next 5 years. Therefore, not only is change needed in the processes used to identify the necessary grid enhancements, but the institutions involved need to be capable of stimulating a significant increase in the rate of interconnection investment.

Efficient planning of a European power network requires a long-term strategic view of the generation and demand characteristics across Member States that extends well beyond 10 years. The majority of Member States do not currently develop a view of their system that is sufficiently long term or definitive to facilitate regional network planning. Moreover, the existing institutions do not have the ability to access such plans or turn these system requirements into a strategic European infrastructure plan, or to ensure that the use of power resources is optimised amongst

24. There are provisions in European legislation (see Regulation EC 714/2009, art. 17) for the option of merchant interconnectors, which may be exempted from third party access rules. However, examples of where this has been applied are extremely rare.

Member States. It is therefore necessary that the EU requires Member States to produce a long term indicative forecast of generation and demand-side[25] resources to meet projected national electricity requirements; the EU should strongly encourage and actively assist Member States to integrate these forecasts on a wider regional basis and this should ideally stretch out to 2050 and therefore be capable of ensuring alignment with the delivery of emissions objectives. It is also necessary that existing institutions (ACER and ENTSO-E) be given the additional mandate to integrate these forecasts and create a strategic infrastructure plan. Importantly, this mandate should involve the ability to share proposals with Member States for how their forecasts might be altered to reduce overall costs for the European energy system as a result of trading and sharing balancing services between countries and regions. An improved regulatory regime should also be developed to fund the infrastructure build and enable the costs to be shared equitably across European consumers who will all benefit from the reduced energy costs and increased system security. Finally, these institutions need to ensure that resources across Europe are utilised efficiently on an operational basis. The system developed in the Nordic regional market for a fully integrated common balancing market and the sharing of reserves could be used as a useful example for how this might be achieved. Other useful examples can be found among the several Independent System Operators (ISO) and Regional Transmission Operators (RTO) that have been organized in parts of North America to operate regionally integrated wholesale electricity markets. Each of them has been structured somewhat differently by regional actors to reflect regional preferences, but they are all chartered and regulated federally against certain minimum but critical criteria. These examples are described in more detail in appendix B online.

In addition to the benefits of a more interconnected European power system, Volume 1 has also highlighted the benefits of significantly improving demand response through smart grid applications at the local distribution network level. Since there is no strong evidence for how long it would take to install the necessary level of instrumentation and communication technology, it is important that deployment is progressed rapidly to ensure that the lack of smart technology does not become a limiting factor in the cost effective decarbonisation of the power sector. The regulatory frameworks, which drive the behaviour of local network operators, do not tend to encourage companies to adopt the new operating practises necessary to develop and deploy smart grid technology. Instead, they tend to incentivise efficient spend of capital programmes and reductions in operational expenditure. The European Commission has recently proposed that funding be allocated through the Strategic Energy Technology (SET) financing plan to support a series of smart grid pilot projects across Europe and it is important that this funding is delivered along with clear deadlines by which the projects must be complete. However, this funding is insufficient to drive the wide-scale deployment of smart grid technologies without strong incentives and targets being set by individual regulators. This, in turn, requires clear direction from Member State governments and it is therefore important that each government establishes an aggressive timetable for the implementation of a fully smart power network and a robust and accountable regulatory framework for approving the necessary investment budgets by the network regulators.

There are also widespread deficiencies in the detailed technical conditions imposed by the Transmission System Operators that make it difficult for demand response to be considered on an equivalent basis to flexible generation. These include the requirement for minimum capacity increments, the need to guarantee 100% delivery and the requirement for real-time communication and monitoring. It is important that these are corrected to accurately reflect the true value of demand response to the system.

Smart grid technology by itself will be insufficient to deliver the potential benefits and an appropriate

25. Including energy efficiency, demand-response and customer on-site distributed generation.

policy and market framework must be in place. For example, the competitive pressures on energy retailers to develop innovative tariffs and products will be key to enabling consumers to manage their usage, choose the most economically efficient energy service offerings and produce the maximum system benefits. The Council of European Energy Regulators (CEER) and European Regulators Group for Electricity and Gas (ERGEG) recognise that 'smart grids and smart energy regulation go hand-in-hand in meeting climate change objectives'[26] and these and other forums should be used to ensure that smart policies are developed alongside the deployment of this new technology.

Finally, the wide-scale rollout of CCS technology is likely to require that governments and regulators facilitate the development of an appropriate infrastructure to ensure cost effective transport and storage of CO_2. In particular, it will be necessary to ensure that sufficient cost-effective storage capacity is available for the highest priority applications and sensitive issues relating to permitting and public acceptance will need to be addressed. In addition, it is likely that cross-border transport of CO_2 will be required and this, in turn, will require the development of an appropriate and, possibly, pan-European framework for CO_2 network regulation.

The analysis contained in Volume 1 highlights the significant opportunities that can arise from developing the potential of the power network infrastructure and this should be a key focus for policy makers. The following actions are proposed:

Actions at EU level

- Expand the ACER/ENTSO-E mandate to:
  - Assimilate Member State long term forecasts of generation and demand-side resources to meet projected power requirements
  - Use this baseline to develop a strategic interconnection plan based on minimising resource costs of decarbonisation across Europe
  - Provide feedback to Member States and regions on opportunities for additional interconnection to reduce the costs of meeting decarbonisation objectives while maintaining power system reliability and long term security of supply
- Build on the existing institutional arrangements to ensure appropriate regulation and system operation in a more interconnected European power network
- Ensure sufficient financing is in place to take forward the strategic infrastructure plan through a combination of regulatory mechanisms and seed funding
- Provide necessary funding through the SET Plan to drive a range of smart grid pilot projects across Europe

Actions at Member States level

- Ensure that wholesale market framework and internal infrastructure will enable investors to take advantage of the import/export opportunities afforded by the strategic interconnection plan
- Mandate network regulators within the framework of the internal energy market, and building on the Third Energy Package, to create a robust investment framework enabling the necessary upgrade and roll-out of smart infrastructures at the transmission and distribution level
- Establish a timetable for implementing fully smart power networks, maximising opportunities for demand response and distributed renewable generation
- Ensure mandates to regulators support a business case for private sector financing of the required networks investments
- Evaluate and inventory feasible CO_2 storage capacity, adopt framework for allocating capacity rights across sectors and develop an appropriate mechanism for the regulation of CO_2 network infrastructure

26. "Smart Grids and smart energy regulation can help implement climate change objectives" a Fact Sheet by the ERGEG and CEER, available at www.energy-regulators.eu. See also "Smart Grid or Smart Policies: Which Comes First?" The Regulatory Assistance Project, July 2009 at www.raponline.org.

KEY ENABLING POLICIES

Volume 1 highlights the extent of the investment required over the coming decade and beyond (see Exhibit 7) and the ability of Europe to deliver this amount of investment represents a major challenge. The sections above have illustrated the importance of creating significant long-term market opportunities and the positive impact this will have on the development of the necessary supply chain capability. However, this in itself is insufficient and there are two additional hurdles that policy makers need to address:

- Permitting: Spatial and environmental planning laws vary across Europe but developers of major infrastructure projects regularly encounter significant delays in winning the necessary approvals. This is a result of processes which are often multi-layered, have poorly defined terms of reference and have no statutory time limits within which a planning decision must be made. These issues are particularly severe for major network projects as a result of the geographical area affected and this therefore represents a major risk to the EU achieving the 2050 emissions objective. As part of the regional strategic infrastructure planning processes discussed elsewhere, it would be valuable to explore the idea of pre-approved planning areas for strategic low-carbon assets, including both high-value resource areas as well as critical transmission corridors. This could draw a wide cross-section of civil society into a cooperative effort to accelerate decarbonisation as an alternative to the often-corrosive process of project-by-project consultation. It is vitally important that Member States ensure that local spatial and environmental planning laws are fit for purpose, ensuring local democracy whilst delivering an appropriate planning decision as promptly as possible.

- Financing: The European economies are emerging from a severe recesssion that took the banking sector to the point of near collapse. This has had major implications for the availability of capital for investments in low-carbon resources and infrastructure projects. Banks are slowly rebuilding their balance sheet strength, which is restricting the availability of debt, whilst equity investors have become more acutely aware of investment risk and are taking a cautious approach. It is likely that the necessary funding will not emerge to meet the investment need described above whilst this situation prevails. This requires concerted action on the part of the EU and Member State governments to leverage a sufficient level of private capital for the low carbon transition with the strategic use of public funds and financing instruments. In particular, it is necessary to:

  - Identify potential new sources of public funding such as carbon auction revenues and network system charges or 'retail savings products' where money is raised directly from individual private investors. The EU also needs to undertake a review of the overall budget with a view to considering whether it is necessary to increase the allocation for investments supporting the transition to a low carbon economy

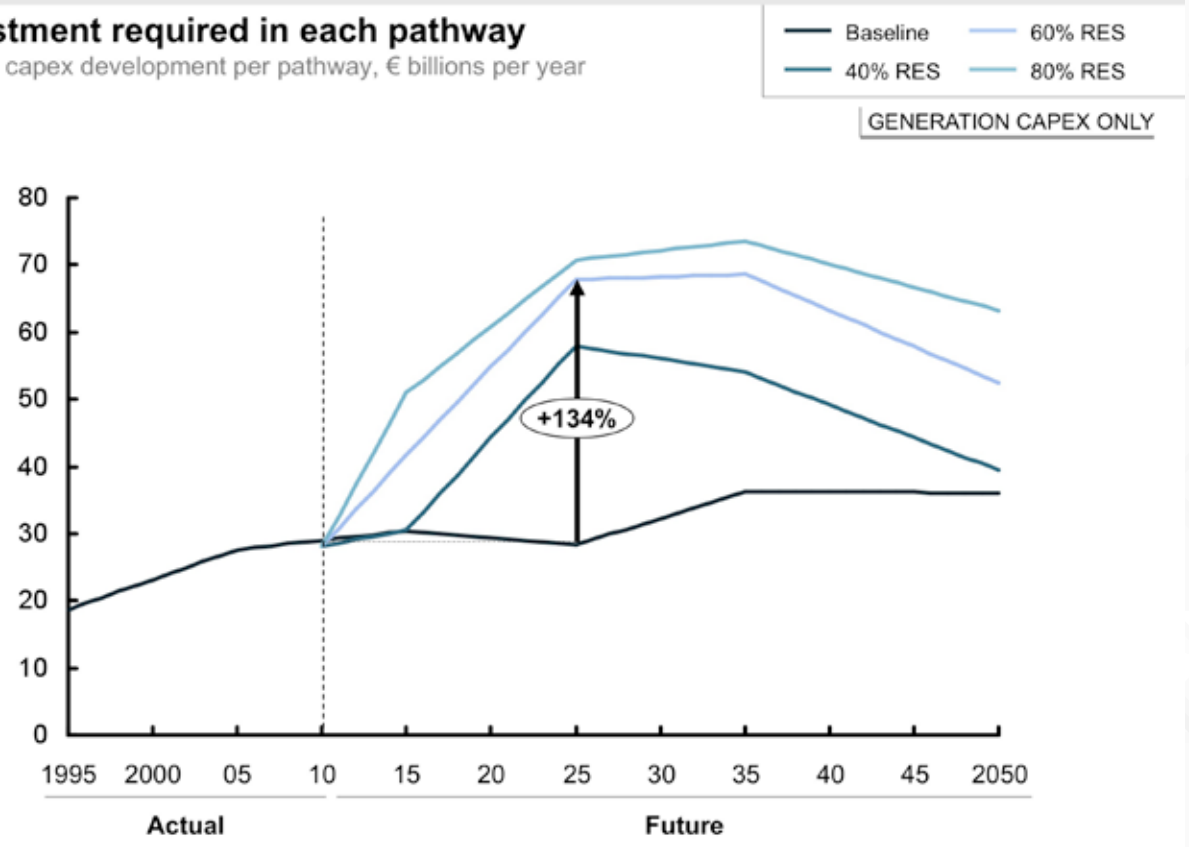
  - Consider whether new institutions might be required that specifically focus on relevant investments and ensure that funds can be rapidly allocated to key infrastructure projects

  - Assess whether Governments and regulators can develop risk-management initiatives or risk pools among private actors, or may wish to underwrite key risks to reduce the overall financing costs for major projects (though risk transfers from investors to taxpayers often obscure associated hazards and hidden costs).

EXHIBIT 7

Investment required in each pathway

Annual capex development per pathway, € billions per year



Policy makers need to urgently address permitting and financing issues and, in particular:

Action at EU level

- Review the allocation of funds to low carbon generation, energy efficiency and network investments as part of the overall review of the EU budget

Actions at Member States level

- Review spatial and environmental planning laws to ensure they are fit for purpose, including explicitly setting decarbonisation as a criterion
- Explore new sources of funding to leverage sufficient private capital investments in energy efficiency, renewables, CCS and network infrastructure, including carbon auction revenues, network system charges and new retail savings products
- Consider whether new institutions need to be created to focus on financing low carbon investments
- Assess where and how government may wish to underwrite key risks to reduce the overall financing costs, though such transfers of risk from private companies to the public should be considered as a last resort, where no good alternatives exist

WAY FORWARD

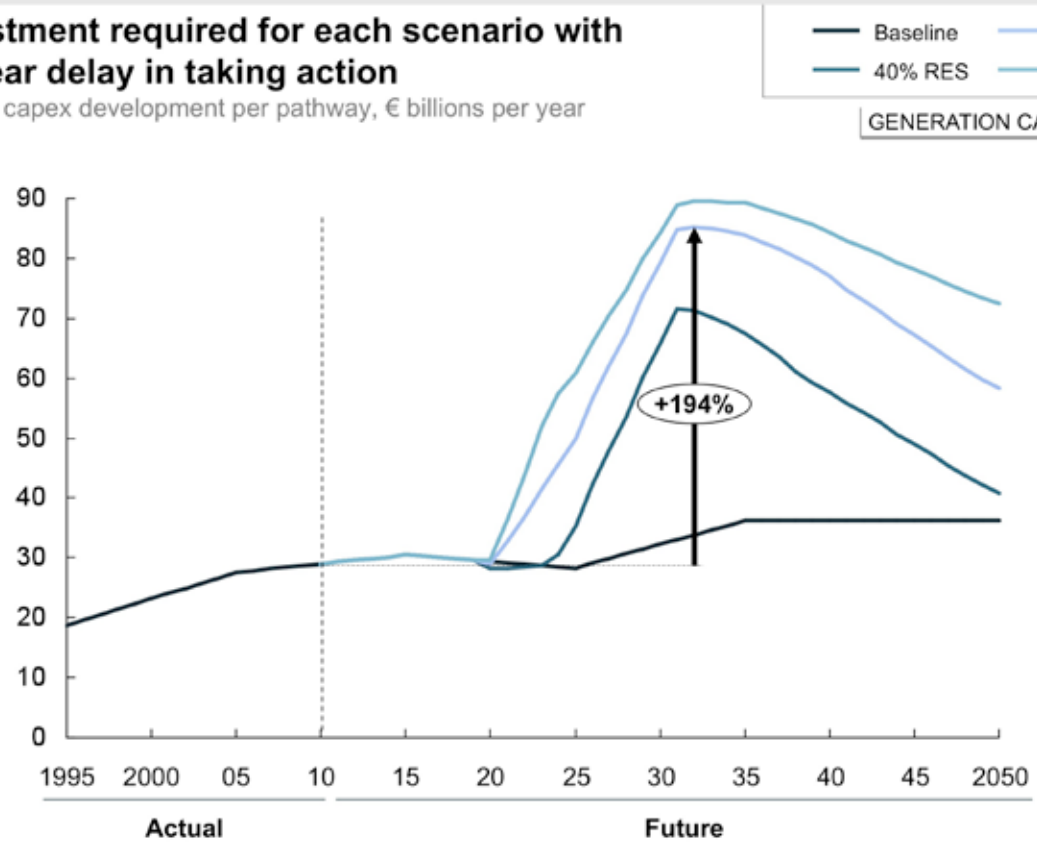
The previous sections highlight that, despite the intense effort in progressing energy policy at national and EU levels over recent years, there is still much to do and it is vital that policy makers retain a sense of urgency in driving this agenda forward. The analysis contained in Volume 1 identifies a series of significant opportunities to improve energy efficiency and drive forward the decarbonisation of the power sector whilst simultaneously improving system security, integrating European energy markets and creating jobs and new growth industries. In particular, an integrated European power network delivers huge benefits in managing technology risk and reducing overall costs associated with decarbonising the power sector. An increase in investment will be required. However, a delay in taking action will be even more costly. The analysis from Volume 1 has calculated that a delay of 10 years will result in a far greater step change in investment during the following decade, placing even greater strain on the ability of supply chains to deliver (see Exhibit 8 compared to Exhibit 7).

Many of the actions will need to be progressed at Member State rather than EU level. This recognises the differing circumstances that prevail across Europe and the fact that policy is now moving towards a delivery phase operating within the high level European energy market framework that has been established over the last decade. However, further actions will also be required at EU level. It is believed that the proposals for EU action outlined in this report should receive general support from Member States

EXHIBIT 8

Investment required for each scenario with 10 year delay in taking action

Annual capex development per pathway, € billions per year



since they relate largely to policies that help Member States reduce underlying resource costs and provide additional funding to help support key demonstration projects and infrastructure. Moreover, one of the key findings of this report is that Member States are already committed to emission reductions that require a more regional or pan-European approach to the power network; failure to widen the scope of market and regulatory coordination is likely to entail a considerable duplication and, possibly, stranding of investment along with significant additional cost.

There is also increasing consensus amongst the broader stakeholder community that further action is now needed to drive forward investments in energy efficiency, low carbon resources and network infrastructure. The proposals contained in this report have been pitched at a level that we hope will be helpful in triggering a focussed and engaged conversation amongst policy makers and stakeholders. Indeed, we have resisted developing our proposals to a greater level of detail since the issues involved are complicated and it is more important that broad sign-on is obtained to the approach before experts develop the detailed solutions. However, we think it is important to note that there are many areas of best practise in energy market policy and regulation across Europe and beyond. The Appendix A online contains a list of examples where effective policy solutions are under development or have been implemented, particularly in the challenging area of delivering energy savings targets. We believe that these examples provide practical help in delivering the policy agenda outlined in the previous sections and it is important that policy makers appreciate that solutions do exist which can be readily implemented and which work.

This paper sets out the key policy challenges associated with improving energy efficiency and decarbonising the power sector in line with delivering the overall 2050 CO_2 reduction objective. The extent of the challenge, and the potential benefits of greater regional and pan-European coordination, demand that policy makers treat these issues with urgency. We have set out a series of policy recommendations that we believe are practical and achievable and will deliver huge benefits for Europe.

The next stage is for these proposals to be taken forward and debated more widely by key stakeholder groups to ensure that robust new policies are ready for implementation as soon as possible.

APPENDICES AVAILABLE ONLINE

A . Examples of policy ‘best practise’

B. Examples of regional transmission operators

Roadmap 2050: a practical guide to a prosperous, low carbon Europe

The mission of Roadmap 2050 is to provide a practical, independent and objective analysis of pathways to achieve a low-carbon economy in Europe, in line with the energy security, environmental and economic goals of the European Union.

The Roadmap 2050 project is an initiative of the European Climate Foundation (ECF) and has been developed by a consortium of experts funded by the ECF.

The work on the three volumes of the Roadmap 2050 project has been undertaken by:

Volume 1: Technical and Economic Analysis
McKinsey & Company; KEMA; The Energy Futures Lab at Imperial College London; Oxford Economics and the ECF

Volume 2: Policy Report
E3G; The Energy Research Centre of the Netherlands (ECN), The Regulatory Assistance Project (RAP) and the ECF

Volume 3: Graphic Narrative
The Office for Metropolitan Architecture and the ECF

In addition, a wide range of companies, consultancy firms, research centres and NGOs have provided various forms of assistance during the preparation of this report. These organisations have provided valuable counsel that we have tried faithfully to reflect in this analysis, however their willingness to consult and to be consulted in the course of this work should not be taken to mean that each of them agrees with all of its assumptions or conclusions.

The ECF is the sole author of the Roadmap 2050 report, is solely responsible for its content and will act as a guardian of the content.

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For more information on Roadmap 2050:
www.roadmap2050.eu

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CO2 REDUCTION