Modelling and Analyses in R&D Priority-Setting and Innovation

Workshop Summary

23-24 April 2014
IEA Experts' Group on R&D Priority Setting and Evaluation
Paris, France

International Energy Agency

The International Energy Agency (IEA), an autonomous agency, was established in November 1974. Its mandate is two-fold: to promote energy security amongst its member countries through collective response to physical disruptions in oil supply and to advise member countries on sound energy policy.

The IEA carries out a comprehensive program of energy co-operation among 28 advanced economies,[1] each of which is obliged to hold oil stocks equivalent to 90 days of its net imports.

The Agency aims to:

- Secure member countries' access to reliable and ample supplies of all forms of energy – in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context, particularly in terms of reducing greenhouse gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organizations, and other stakeholders.

IEA Experts' Group on R&D Priority Setting and Evaluation

Research, development and deployment of innovative technologies is crucial to meeting future energy challenges. The capacity of countries to apply sound tools in developing effective national research and development (R&D) strategies and programs is becoming increasingly important. The Experts' Group on R&D Priority Setting and Evaluation (EGRD) was established by the IEA Committee on Energy Research and Technology (CERT) to promote development and refinement of analytical approaches to energy technology analysis, R&D priority setting, and assessment of benefits from R&D activities.

Senior experts engaged in national and international R&D efforts collaborate on topical issues through international workshops, information exchange, networking, and outreach. Nineteen countries and the European Commission participate in the current program of work. The results and recommendations provide a global perspective on national R&D efforts that aim to support the CERT and feed into analysis of the IEA Secretariat.

For information specific to this workshop, including the agenda, background information, and presentations, see http://www.iea.org/workshop/modelling-and-analyses-in-rd-priority-setting-and-innovation.html. For information on further EGRD activities, see www.iea.org/aboutus/standinggroupsandcommittees/egrd/.

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[1] Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Republic of Korea, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States; the European Commission also participates in the work of the IEA.

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Executive Summary

Reducing global GHG emissions is a huge challenge for all countries demanding various political and financial measures for all stakeholders. To develop a low carbon economy requires a long time period and the use of novel and innovative technologies that are still in the research phase. With regard to R&D policy a special attention is paid to the OECD countries due to their high technological standards and research capacities. But do we invest R&D money right? Will the technologies be developed fast enough to meet GHG targets without a high loss of wealth globally?

The main topic of the workshop is how to priorities energy R&D and related innovation funding in order to develop a low carbon economy. To optimize the process of prioritization the workshop looked into innovative approaches modeling the energy system and its transformation as well as the R&D and innovation process. National and international examples were presented and discussed. Indicators for innovation were examined and provided for discussion. Beside the process of prioritization for public R&D budgets best practice examples from private industry and research institutes were also included into the agenda.

As a starting point for discussion existing indicators for innovation were presented giving contradictory statements. Looking at annual growth rate of low carbon technology patenting, we see an enormous increase for all technologies, esp. for wind and PV. Analyzing the energy R&D expenditure rates for OECD countries, we see a diverse picture. Even though R&D budgets for some areas are decreased or increased in most countries, some technologies like nuclear fission show a strong increase in some countries and a strong decrease in other countries. When it comes to the indicator “tracing clean energy progress” we see that only renewable power is “on track”, whereas some crucial technologies like CCS or energy efficient buildings lack behind.

Modelling the energy system as well as the transformation process of the energy system is accompanied with high uncertainty as novel technologies, innovative devices and new organizational structures have to be integrated. The longer the time period is, the higher the degree of uncertainty. Some fundamental insights from this work is that the transformation of the energy system requires high capital investments as low carbon technologies in general are capital intensive, like wind or CCS. Furthermore the transformation is as much depending on technologies as on system design and addressing least innovative sectors.

When it comes to R&D priorities that facilitate the transformation of the energy system, studies show that investments in storage and renewables as well as vehicles deliver a higher marginal return than nuclear or fossil. This supports a shift of budgets towards low emission technologies to reach a cost optimal transformation path. One important R&D priority for low carbon technologies is to lower the investments costs for these technologies as they are considerably higher than for conventional technologies.

Models show that reducing cost is not only a task for R&D but also for innovation policy. It is very difficult to model “technology learning” based on R&D or higher market penetration (learning curve) but to improve the effectiveness of R&D a simultaneous deployment of low carbon technology is needed. Through public investment in R&D and complementary market regulation, private R&D money can be attracted and strengthen the process of technological learning.

As models rely on previous trends novel technologies and tipping points are difficult to indicate. To model discontinuities in the energy system models can be supported by expert assessment. Due to some inherent weaknesses of this method (e.g. excessive optimism) expert judgment on exogenous trends can be used to assure quality of modelling.

Modelling plays a role in many national and international R&D programs as well as for private companies. The aim of these modelling activities for public authorities is to identify priorities for R&D derived from the specific target (e.g. GHG reduction target) the program is developed for. Long term energy demand scenarios are also taken into account as well as technology roadmaps to set targets for the program and to allocate money to specific technologies. The design of R&D programs for public authorities as well as private companies is following good practice meaning external/internal evaluation of proposal and regular evaluations of the program itself. Even though the outcome of R&D investments is a priori fundamentally uncertain, the decision is based on a much more rational foundation than expert judgment or stakeholder involvement only. Several technics have been developed to reduce uncertainty in modelling like learning curves, expert elicitation or interactive decision-making. In most cases a mix of different approaches is used. Furthermore the diversification of R&D portfolio helps to reduce the risk for R&D investments.

Public R&D strategies do not only influence public funds, but also private investments in R&D. First of all many public funds are looking for private co-funding on program or project level and second private investments decisions are often based on similar assumptions taking into account public decisions. Even more relevant to private R&D budgets are energy strategies and market developments. The german “Energiewende” meaning the restructuring of the electricity market with the shutdown of nuclear plants and the massive investments in renewable energy (esp. wind and PV) led to a high uncertainty of utilities and increased not only R&D investments of suppliers for these technologies but also for utilities as the uncertainty about the future market increased substantially. From 2003 to 2013 the R&D budget of 13 major European utilities almost doubled. The focus for utilities moved from energy technologies to system approach and customer related research as the deregulation of the electricity market in Europe increased competition and reduced the timespan for planning in the utility sector.

Several approaches were presented and discussed to evaluate the innovation process from R&D to market penetration of a technology. Via innovation scoreboard or an innovation sensor novel approaches were developed to measure and rank the innovation capacity of countries. Based on existing statistics and complemented by new data at the country level an indicator system would be useful to rank the (clean) energy innovation capacity. Energy Innovation Indices should include

- RD&D investments
- “innovative quality” of deployment subsidies
- Country capacity for innovation
- Taxes and trade metrics
- Public institutions

Beside the indicators mentioned above other factors that influencing the innovation potential like human capital or scientific publications can be taken into account. Some indicators from the (clean) energy innovation index should also be integrated into general innovation indices to raise the awareness for this topic.

The present state of the art is an adequate stimulator for discussion but is still not developed enough to be implemented. It is recommended to develop a conceptual framework that can build the theoretical basis for further developments. Indicators that can best describe the relevant dimension should be discussed with all relevant stakeholders as some of these indicators are not available at the moment, but have to be developed at national level based on an international agreement resp. standard. If possible the index should also include data from private companies and other areas that are indirectly influencing the energy innovation capacity like human capital.

The need for transformation of the energy system to meet GHG targets, the appearance of new technologies (e.g. electric cars) and changing investment patterns in the electricity market (from nuclear/fossil to renewables) as well as changes in the market regulations increase the uncertainty about the future energy system. Therefore the modeling of energy systems and the prioritization of R&D budgets is becoming highly relevant and risky at the same time. Improving models for R&D priority setting on the one hand and developing indicator systems for the assessment of energy innovations systems on the other hand is recommended at national and international level. Due to the enormous challenge in the energy sector and integrated approach of R&D priority setting and innovation policy is recommended. By a coordinated innovation policy private investments in public RD&D priorities can also be attracted and the feasibility of a transformation process towards a low carbon society at low costs can increase considerably.

Background

Rationale

Research, development, and deployment of innovative technologies are crucial to meeting future energy challenges. The capacity of countries to apply sound tools in developing effective national research and development (R&D) strategies and programs is becoming increasingly important, especially against the background of uncertainties regarding future energy systems.

Current Activities

The IEA Experts' Group on R&D Priority-Setting and Evaluation (EGRD) was established by the IEA Committee on Energy Research and Technology (CERT) to promote development and refinement of analytical approaches to energy technology analysis, R&D priority setting, and assessment of benefits from R&D activities. Senior experts engaged in national and international R&D efforts collaborate on topical issues through international workshops, information exchange, networking and outreach. Nineteen countries and the European Commission participate in the current program of work.

Introduction

The main topic of the workshop was how governments could improve the process of prioritizing energy R&D and related innovation funding in order to develop a low carbon economy before 2080. The workshop took into account previous work of the Experts' Group on R&D Priority-Setting and Evaluation at the national and international levels. Models, concepts and new approaches that supplement the outcome of previous workshops had been introduced and discussed. The process of prioritizing R&D budgets was analyzed as part of a more comprehensive approach to reviewing the innovation process, in general, towards a future energy system.

The workshop took cutting-edge models on priority-setting as starting point, but also discussed the practical use of the models in countries, clusters of countries, or cooperative regional entities, with major research budgets. It also sought information on the practical use of Public Private Partnerships (PPP) and on private sector priority-setting practices of large energy-related multinationals investing in R&D and industrial research organizations. During the workshop participants discussed how R&D investments contribute to bringing new technologies into the market, what infrastructure in a broad sense will accelerate the transition of the energy system, what methods and tools are used by public and private stakeholders, and how they can be improved.

The outcome to the workshop will contribute to IEA's development of Energy Technology Perspectives 2015, support IEA's country analyses on the topic of RD&D, and inform IEA member and partner countries on how to improve their own national R&D priority-setting.

Questions that were addressed during the workshop included:

- What tools and models are in use today to prioritize funding in R&D and innovation?
- Are there new approaches that improve the link between R&D and innovation?
- Which data and indicators are used to measure success in R&D funding and innovation?
- What information is taken into account by public and private stakeholders?
- What technologies are identified as crucial for the successful and timely transformation toward a low carbon global economy?
- How can the process of transformation be accelerated?

Report structure

The report provides summaries of the presentations delivered by representatives of selected countries, institutions and companies, respectively. The presentations cover the following areas and topics:

- Modeling of the Transformation of the Energy System;
- States of the art in modelling the R&D and innovation process;
- National and international examples for modelling innovation and R&D priority setting;
- Indicators for Innovation: Energy Innovation Scoreboard;
- Process of prioritization of R&D budgets in the private sector.

Information on discussion and conclusions follow the presentation summaries. Appendixes to the report provide a list of acronyms, workshop speakers, the meeting agenda, and some useful references. All the figures in this report are taken from the presenters' slides.

Modelling of the Transformation of the Energy System

Input on How the Transformation of the Energy System can be modelled

Luis Munuera, Energy Technology Policy Division, IEA

- Link to presentation slides: http://www.iea.org/media/workshops/2014/egrdmodellingandanalyses/1_Munuera.pdf

Energy innovation comprises processes that take an idea for a new energy technology, device, organizational or market structure to the market. In context with the transformation of the energy system the global decommissioning curve has to be taken into consideration as well as the fact that related investment is mainly being characterized by long lifetime and high upfront capital demand. Decisions have to take into account a long time horizon with uncertain or unknown conditions referring to a variety of aspects such as technology development, market conditions, climate impacts, long-term energy prices, economic development, climate policies and operational aspects (e.g. variable renewables, electrification).

The IEA's long-term energy planning model is based on TIMES, a framework developed within the Energy Technology Systems Analysis Program (ETSAP). The ETSAP has been in operation since 1976. It is a consortium of member country teams and additionally invited teams; two workshops per year are being conducted. ETSAP provides a common, comparable and combinable methodology and is being used by more than 150 institutions in 63 countries. The ETP modelling framework is shown in Figure 1. Referring to the supply-side the least-cost optimization model is based on TIMES methodology whereas the end-use sectors (industry, buildings, transport) simulation models are spreadsheet-based. Within the modelling framework the world is being divided into 28 to 40 regions depending on the sector.

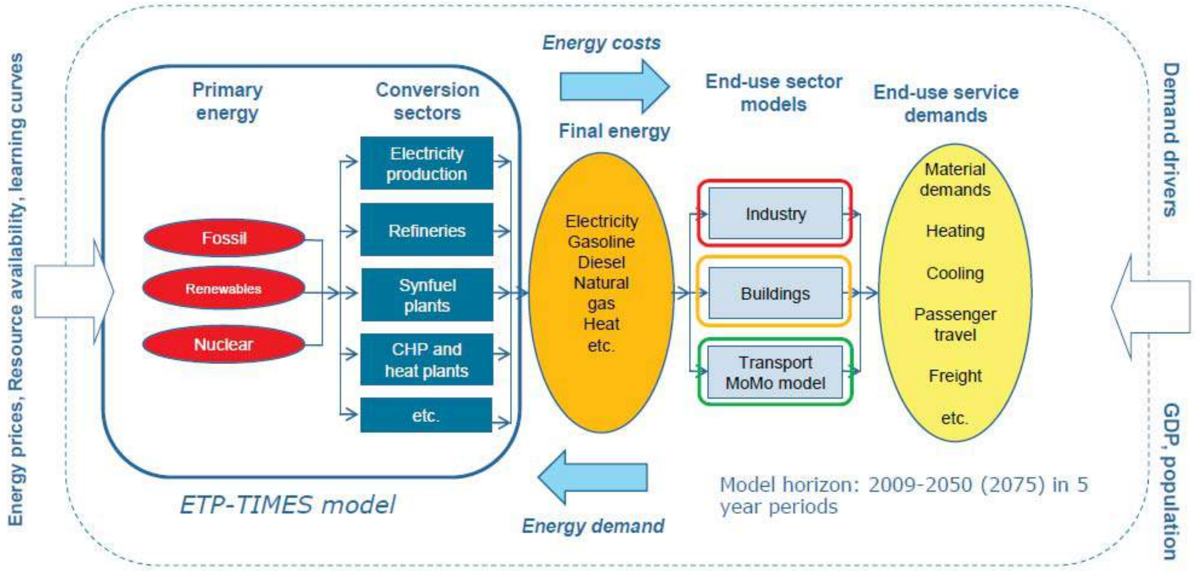


Figure 1: ETP Modelling Framework

In context with modelling the innovation system it has to be taken into account that it's difficult to measure both input and output. Therefore there is no straightforward way of measuring effectiveness of

RDD&D. Measuring is mainly based on learning curves, expert elicitation, factor decomposition, “looking at the past” and on mixed approaches.

In context with global developments there is a choice of three futures:

- The 2°C Scenario: a vision of a sustainable energy system of reduced Greenhouse Gas and CO_2 emissions;
- The 4°C Scenario: reflecting pledges by countries to cut emissions and boost energy efficiency;
- The 6°C Scenario: where the world is heading under current policy with potentially devastating results.

To achieve the 2DS, energy-related CO_2 emissions must be halved until 2050. This requires a massive acceleration of the deployment of low-carbon power technologies over the next four decades. It is common sense that clean energy pays off, but the question is: how to allocate resources efficiently?

The development of energy related RD&D can be assessed by making use of chosen indicators. For example the share of energy related RD&D in overall OECD RD&D budgets has gradually been decreasing since the 1980s whereas the annual growth rate of low carbon technology patenting has increased, mainly for wind power and photovoltaics. The current level of investment in R&D is – depending on the technology – 3 to 6 times lower than required in order to achieve the 2DS scenario.

There are a number of challenges or barriers to be addressed in this context. First, there is high capital investment, esp. for low carbon technologies such as CCS. Another challenge is that transformation is required in some of the least innovative sectors. Furthermore changing the energy system needs to innovate within an existing infrastructure. In a low carbon world innovation is as much about technology as it is about system design, usage and markets. To achieve considerable changes, innovation has to be delivered at scale. Private sector is key on the one hand; on the other hand there is a lack of information esp. regarding level and type of R&D investment, the question where benefits of innovation are accrued and the process of prioritization. Finally, there is the difficulty to characterize the impact of market-pull policies on technology development.

States of the art in modelling the R&D and innovation process

Principles and Innovative Methods for Public R&D Decision-Making

Gabe Chan, Harvard University

Link to presentation slides:
http://www.iea.org/media/workshops/2014/egrdmodellingandanalyses/2_ChanandAnadon.pdf

In context with public R&D decision making it has to be taken into consideration that there is a broadening portfolio of technologies, interacting in new and more complex ways. Furthermore it can be observed that decision making is often shaped by individual technology-focused program offices. At the same time governments have called for more analytical approaches to R&D decision-making (e.g. US NRC, OMB).

The motivation for developing decision-making principles is driven

- by the technical and organizational complexity of the problem which comprises uncertainty in the returns to R&D,
- by technology and market interactions as well as
- by the need for transparency and buy-in.

Four decision making principles are being proposed:

1. Technology improvement benefits prospectively quantified with a full account of uncertainty;
2. Social benefits evaluated in a common framework;
3. Flexible to changing assumptions;
4. Feasible transparency.

Based on these principles, a method consisting of three components has been developed. This comprises expert elicitation of technology cost conditional on public R&D levels and allocations (1), benefit estimation in an economic model (MARKAL) with Monte Carlo simulation (2) and optimization of R&D portfolios based on greatest expected benefits (3). Expert elicitations have been conducted in 7 technology areas, but 6 are comparable for this analysis: (1) utility-scale energy storage, (2) bioenergy, (3) advanced vehicles, (4) fossil energy, (5) nuclear energy, (6) solar photovoltaic technologies.

In context with evaluating the method it can be stated that joint uncertainty is being quantified conditional on R&D in a common framework over a 20-40 year time horizon. Aggregate social benefits are being estimated in a single economic model yielding consistent evaluation metrics across R&D areas. Flexibility to changing assumptions is ensured through importance sampling, flexibility to policy changes through scenario analysis. External experts' names and affiliations are being published. Results are anonymized and published on the internet.

The results of the optimization of R&D portfolios (see Figure 2) show that the rate of decreasing marginal returns implies that there are R&D budget allocations above $15 billion for which net economic surplus exceeds R&D cost.

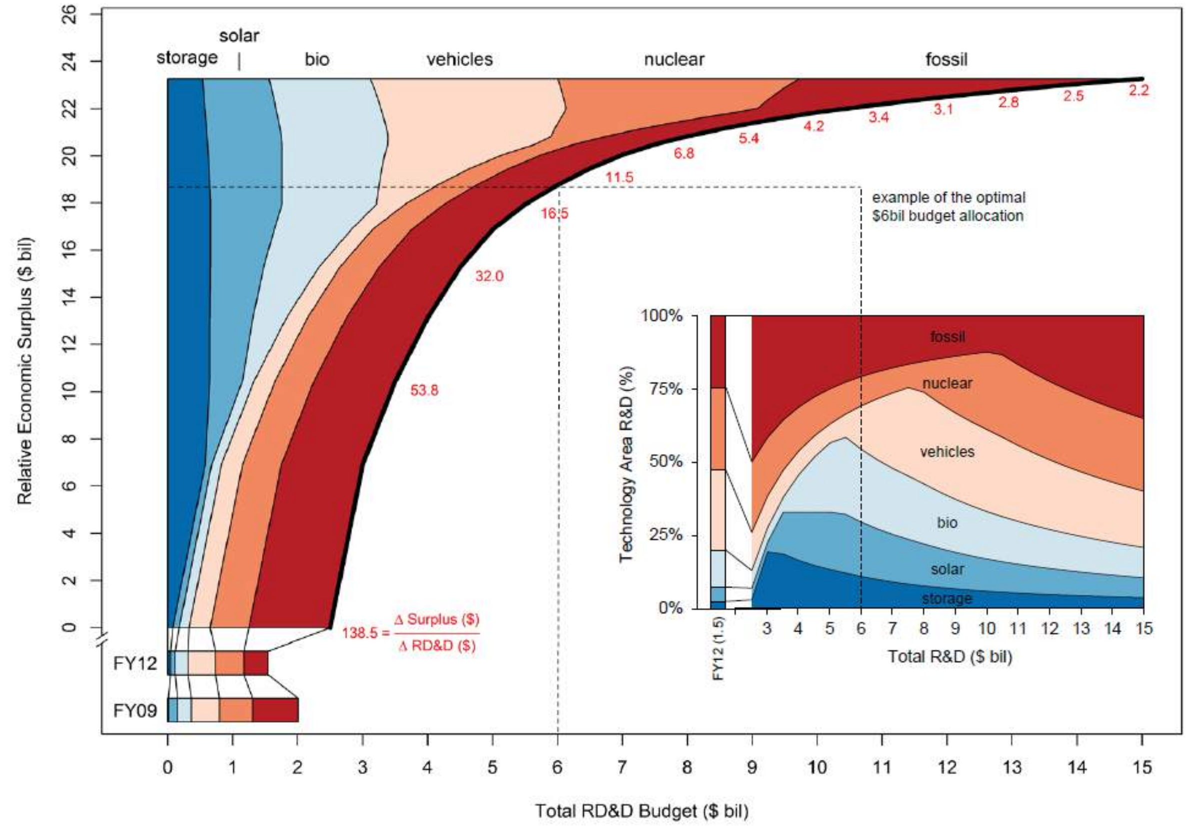


Figure 2: Optimizing R&D Portfolios

The prioritization of investments based on marginal returns delivers the following order: (1) energy storage, (2) solar PV, (3) bioenergy, (4) vehicles, (5) nuclear, (6) fossil. It should be noted that the current R&D allocation differs substantially from the allocation that optimizes net economic surplus.

The JRC-EU-TIMES modelling platform; inputs to prioritisation for energy research and innovation

Alessandra Sgobbi, EC, DG JRC

Link to presentation slides:
http://www.iea.org/media/workshops/2014/egrdmodellingandanalyses/3_Sgobbi.pdf

Technology innovation plays a central role in EU policies and strategies: tools to support prioritizing R&D investment decisions are therefore critical. The JRC-EU-TIMES model is one of the instruments that can be used today to support such prioritization processes, representing the energy system of EU28 and neighboring countries. Main target of the JRC-EU-TIMES modeling platform is the identification of key factors that accelerate innovation.

A critical assumption in energy system models used for policy and priority setting is that R&D and innovation measures lead to changes in technological deployment and affect learning. In the JRC-EU-TIMES model, the benefits of research and innovation measures can be assessed through three main approaches: expert based judgment, stochastic modelling, and endogenous technology learning. Results from the three methodological approaches are presented in turn.

For sharing technical and economical characteristics of energy technologies between JRC technology experts and JRC modellers, the Energy Technology Data Base ETDB (see overview in Figure 3) has been set up. Technology reference data are being used as input for modeling at aggregated and detailed levels. The scenario outputs serve as boundary conditions for detailed modeling.

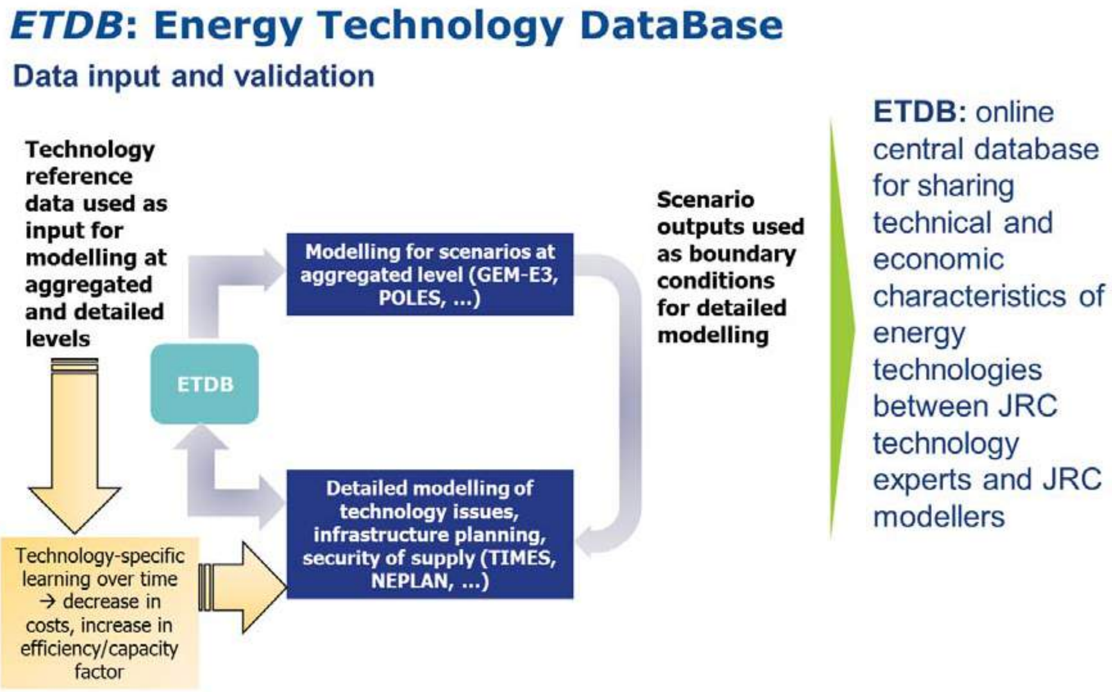


Figure 3: Energy Technology Data Base ETDB

When reflecting on R&D and innovation priorities in an energy system perspective while ensuring the least cost path to decarbonisation, it can be observed that the costs to a low carbon transition do not differ substantially from the business as usual: 0.15 % of GDP in 2030 and 1.65 % of GDP in 2050, respectively. However, it is the composition of the costs that changes substantially, moving towards higher investment in innovative equipment and lower fuel expenditures. Therefore lowering the cost of meeting GHG reduction targets requires research and innovation to focus on decreasing investment cost of low carbon technologies. Uncertainty on the effects of R&D and innovation calls for simultaneous efforts on reducing costs and improving technological efficiencies.

The role of cost and efficiency in influencing the competitiveness and the large scale deployment of key technologies in an energy system perspective needs to be assessed systematically. While technological cost is an important barrier to deployment, research and innovation should also address technological efficiencies, which is critical in determining earlier deployment and market penetration of fringe low-carbon technologies. Additionally, uncertainty around the impact of research and innovation highlights the importance of sensitivity analysis to derive robust results through modeling.

Emission reduction of the magnitude required involves the simultaneous deployment of several low carbon technologies. In order to exploit synergies in context with improving the effectiveness of R&D and innovation common actions targeting more than one technology can be prioritised to obtain double dividends. Furthermore, it has to be considered that innovation is inherently uncertain, and not treating it as such may lead to underestimation of benefits and thus sub-optimal research and innovation efforts – e.g. R&D expenditures in one technology field may lead to benefits in others as well. Not taking this into consideration, the referring benefits will be underestimated. Because of breakthroughs, the impact of research and innovation on energy system cost may be non-linear.

Modelling with endogenous technology learning can be instrumental in setting research and innovation priorities and their timing. Furthermore it energy system modelling can support the identification of crucial technologies. In this context it is important to consider the effects of targeted research and innovation efforts in an energy system perspective including synergies and competition.

Summarizing should be noted that technology learning does exist and has a significant impact, but there is not one single way to extrapolate it or model it. Therefore there is a continued need for assessing impact of research and innovation policies on energy systems. This comprises the need to explore differentiated impacts of research and innovation beyond technology costs. Furthermore policies for research and innovation on the one hand and support to deployment on the other have to be complementary. Due to uncertainty sensitivity analysis around learning factors is needed crucially.

Two- and single-factor learning curves and other methodologies for modelling learning by doing and learning by researching

Dr. Robert Gross, Centre for Environmental Policy, Imperial College, London

Link to presentation slides:
http://www.iea.org/media/workshops/2014/egrdmodellingandanalyses/4_Gross.pdf

In context with forecasting future costs of energy technologies chosen methods and approaches are being applied as e.g. experience curves or engineering assessment.

Experience curves are grounded in empirical observations that learning and cost reductions do happen. On the one hand they can help identify the level of investment and deployment required to drive down costs but on the other hand experience curves are susceptible to uncertainties over selection of the correct starting point, learning and deployment rates. A specific concern refers to the use of proxy values from similar technologies. Furthermore they may be more applicable to some technology characteristics than to others (modular vs. large-scale) and, of course, experience curves can be overwhelmed by other factors. System boundaries in context with technology systems are an important point as the results might be different depending on what is being taken into consideration when assessing a system.

Engineering assessment (and expert elicitation, stakeholder workshops, etc.) can inform detailed parametric models and don’t need to rely on previous trends. They can allow for discontinuities, but on the other hand expert opinions can differ, may suffer manipulation or excessive optimism and are still difficult to get right for emerging technologies. The range of LCOE estimates for chosen technologies, in year-mean and UK specific forecasts can be seen in Figure 4.

Case studies on capital expenditures or LCOE, respectively, are available for the following energy technologies: Nuclear, Combined Cycle Gas Turbine (CCGT), Coal and Gas-fired Carbon Capture & Storage (CCS), Onshore Wind, Offshore Wind and Solar Photovoltaics (PV).

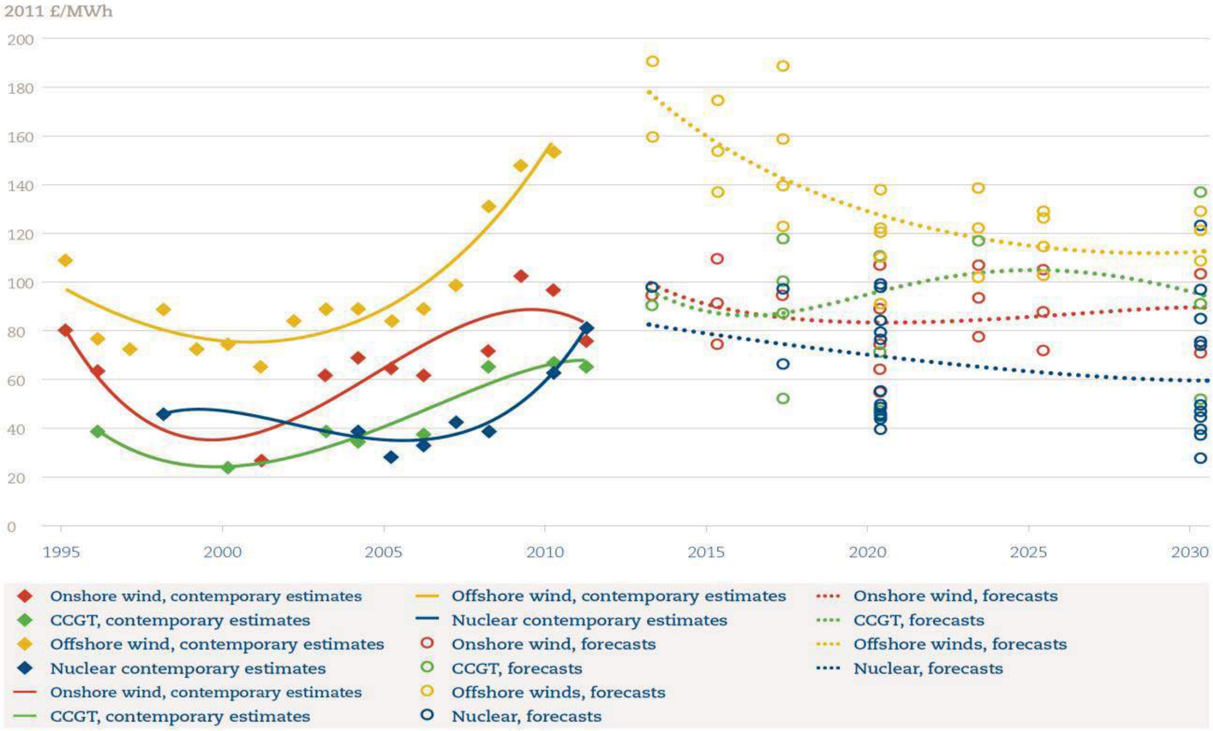


Figure 4: Range of LCOE estimates for chosen technologies, in year-mean and UK specific forecasts

Past experience shows both exogenous ‘sideswipes’ (e.g. commodity or fuel prices increases, cost of finance, unfavourable currency movements) and endogenous factors can override learning effects and economies of scale – some examples for endogenous factors: increased safety or environmental requirements, lack of competition renewable energy components, supply chain constraints, greater depth and distance, increased O&M, disappointing reliability (= reduced availability = poor load factors).

It has to be considered that experience curve uncertainties and appraisal optimism can be overwhelmed by other factors and exogenous shocks. There is a need for reliable and disaggregated data and sufficient volumes and time periods. Furthermore the uncertainties explicitly have to be acknowledged and it has to be recognised that learning effects are an inherently stochastic process.

There is clear empirical evidence that the cost of electricity generation can fall through time and as deployment rises and learning happens. However, learning is not inevitable and quality of projection is a product of data, assumptions, judgment, etc. Learning can be overwhelmed by other factors; there is the temptation to focus on the potential for cost reductions risks ignoring other relevant issues such as supply chain constraints. The initial roll-out of a technology may result in short-term bottlenecks, ‘teething trouble’ and other issues; short term costs may rise before they can fall.

Some of the uncertainties revealed by the case studies mentioned above are exogenous, inherently unpredictable and may exhibit high volatility. The question is how to handle these uncertainties. Some of the endogenous cost drivers are more ‘known’ and lend themselves more readily to future projection.

However, this has to be done carefully. Furthermore technology specifics are paramount to cost reduction prospects. E.g. it has to be differentiated between small, mass produced and modular. And finally, communication of uncertainty is key. In recent analyses a trend towards improved ‘appraisal realism’ can be observed.

National and international examples for modelling innovation and R&D priority setting

USA: R&D Investment Decision-Making – Program Analysis and Evaluation

Dr. Robert Marlay on behalf of Shane Kosinski, Deputy Director, Advanced Research Projects Agency for Energy, U.S. DOE

Link to presentation slides:
http://www.iea.org/media/workshops/2014/egrdmodellingandanalyses/5_MarlayonARPAEv6.pdf

The Advanced Research Projects Agency - Energy (ARPA-E) identifies transformational energy technologies with high-potential and high-impact and catalyzes development with unique team formation and funding. ARPA-E focuses on energy technologies that can be meaningfully advanced with a small investment over a defined period of time in areas that are not funded elsewhere due to high technical and financial uncertainty. It furthermore provides awardees with technical assistance and marketing context, strategies and information to help projects succeed. ARPA-E provides a unique bridge from basic science to early stage technology and hands off promising concepts to others for commercialization or more R&D.

An ARPA-E project shows a credible path to market as well as large commercial application. Regarding to transformation, an ARPA-E project challenges what is possible, disrupts existing learning curves and leaps beyond today's technologies. ARPA-E projects translate science into breakthrough technology. The team has to be translation oriented, cross-disciplinary skilled and being comprised of best-in-class people.

The ARPA-E Program framing questions were adapted from the DARPA Heilmeier questions. They include the following questions:

- What is the problem to be solved? Is the problem stated clearly so it is easily understood?
- If successful, how will the proposed program impact one or more of ARPA-E's mission areas: reducing imported energy, enhancing energy efficiency, and reducing energy related emissions?
- What are the program goals and how will progress towards those goals be measured?
- What is the current state of research and development in this area and how is the proposed program a transformative and disruptive approach relative to the current state?
- Why is now the right time to solve this problem?
- What research communities need to be brought together to create project teams to address the program goals?
- How does the program complement research and development efforts in other Department of Energy programs, other federal agencies, and the private sector?
- What happens at the conclusion of the program? How will be the program transition? Who will be the early adopters? What are the barriers to commercialization and how might these problems be overcome?

The underlying technology acceleration model is shown in Figure 5:

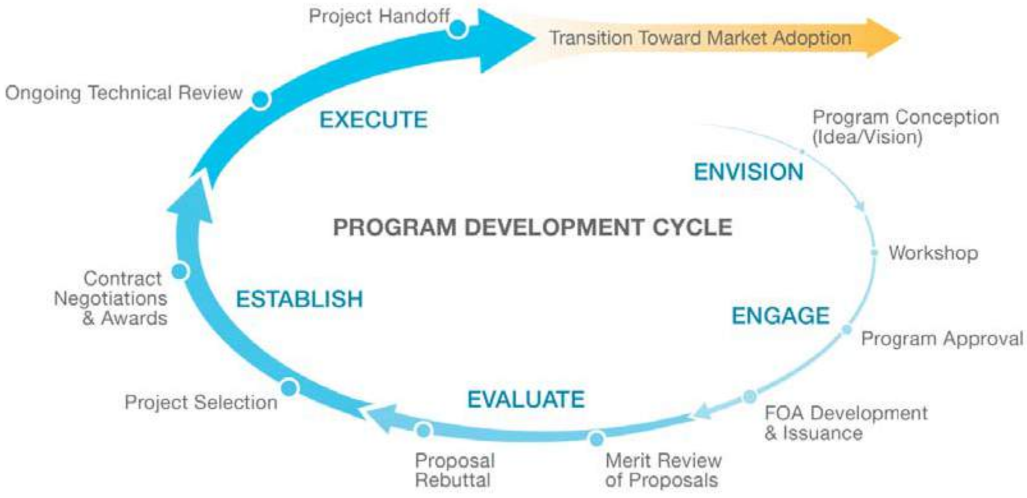


Figure 5: Technology acceleration model

Current focused programs refer to transportation energy technologies, stationary energy technologies and to crosscutting technologies. Furthermore there are three open funding solicitations.

Starting point is the setting of performance metrics informed by probable (expected) value and cost for the respective program. Next step is the solicitation of ideas to meet program objectives. Open (unstructured) solicitations (free ideas) are also used. In average 10 - 12 ideas are chosen with an average award of roughly US-$2 to US-$3 M over 3 years each. Clearly defined technical and commercial milestones that awardees are required to meet throughout the life of a project are being set.

Progress is being reviewed quarterly; technical assistance is provided as needed. When a project is not achieving the goals of the program, ARPA-E works with the awardee to rectify the issue or, in cases where the issue cannot be corrected, ARPA-E discontinues funding for the project. The principle behind is "fail fast, take what you know and move to the next step".

ARPA-E has in-house legal, procurement, and contracting staff co-located with the program directors to provide direct access and timely communication. Final element of the ARPA-E model is the Technology-to-Market program.

Regarding measuring ARPA-E’s success three groups of criteria are being applied: moving technology to market (1), breakthrough achievements (2) and operational excellence (3). The criteria group “moving technology to market” comprises the following sub-criteria: partnerships with other government agencies, licensing/acquisition by an established firm (hand-off), licensing/acquisition resulting in a spinoff, private-sector funding, growth of existing company (e.g. organic growth). “Breakthrough achievements” are characterized by invention disclosures and patent filings, patents issued and publications. In context with the criteria group “operational excellence” expedited program development and project selection are crucial as well as aggressive performance metrics and regular progress reviews.

UK: Priorities setting for RD&D

Dr. Chris Heaton, Energy Technologies Institute / DECC, ETI

Link to presentation slides:
http://www.iea.org/media/workshops/2014/egrdmodellingandanalyses/6_HEATON.pdf

The Energy Technologies Institute (ETI) is a public-private partnership between global industries and UK Government delivering targeted development, demonstration and de-risking of new technologies for affordable and secure energy. The ETI invests in projects at three levels: knowledge building projects, technology development projects and technology demonstration projects.

A central part of ETI's energy system analysis is ESME, a peer-reviewed national energy system design tool (see overview in Figure 6). It comprises least cost optimisation, is policy neutral and includes information on deployment and utilisation of more than 250 technologies. Another characteristic is the probabilistic treatment of key uncertainties. Pathway and supply chain constraints until 2050 are part of the analysis, too. ESME is the key tool in context with deciding in which areas ETI makes its investments.

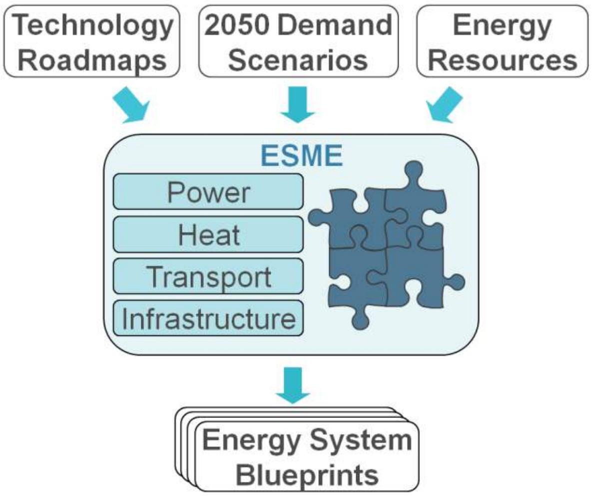


Figure 6: Energy System Design Tool ESME

ESME is in use by ETI, its members and partners. ETI Members are developing own versions for specific countries of interest. Academic research projects are ongoing; ESME software licence is available to academics. ESME is serving as a platform for consolidating knowledge across technology areas. A detailed overview on ETI projects and models informing ESME is shown in Figure 7.

Types of debate that ESME is used to inform are listed following:

- What might be 'no regret' technology choices and pathways to 2050?
- What is the total system cost of meeting the energy targets?
- What are the opportunity costs of individual technologies?
- What are the key constraints, e.g. resources, supply constraints?
- How might accelerating the development of a technology impact the solution?
- How might uncertainty in resource prices and availability influence system design choices?
- Where should new generating capacity optimally be located?
- How might policies and consumer choices influence technology development?

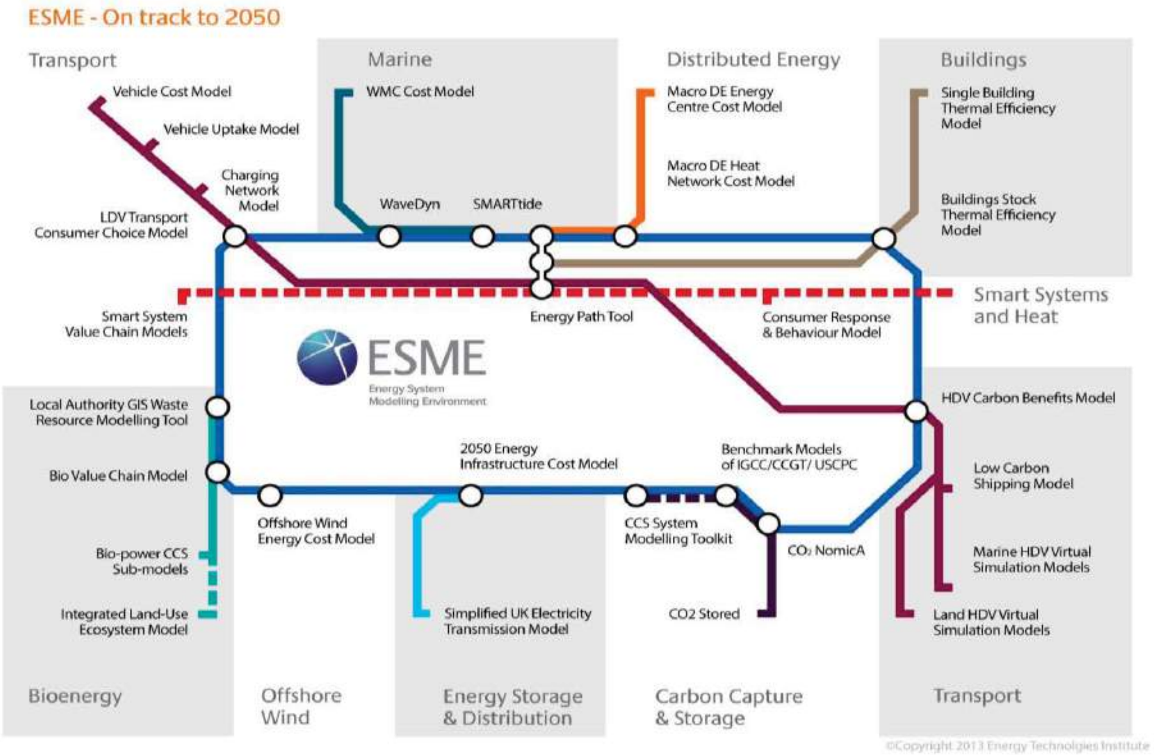


Figure 7: ETI projects and models informing ESME

Japan: R&D Investments in Japan's New Energy and Climate Technology Strategy

Dr. Atsushi Kurosawa, Director, Global Environment Program, The Institute of Applied Energy

Link to presentation slides:
http://www.iea.org/media/workshops/2014/egrdmodellingandanalyses/7_Kurosawa_rev3_web.pdf

The Japanese Cabinet made the decision to define the revised 'Basic Energy Plan' on April 11th 2014 as a result of long political and public debate after Great East Japan Disaster of March 11th 2011. The contents comprise an agenda referring to Japanese energy supply and demand, the definition of a fundamental policy, sector policies and targets in context with strategic technology development as well as information regarding public involvement.

The Cabinet Office of the Council for Science and Technology Policy elaborated the New Low Carbon Technology Plan. This plan includes the identification of innovative technologies that should be developed in the short- to medium-term and medium- to long-term. It furthermore specifies challenges and includes a roadmap for promoting technology development. Policy measures required for international promotion and dissemination of innovative technologies are part of the New Low Carbon

Technology Plan as well. It’s seeking to promote the development of Japan’s prominent environmental technologies and contribute to achieving the goal of halving global greenhouse gas emissions.

One of the key messages is that it is essential to develop and disseminate innovative technologies in order to achieve both economic development and significant reductions in GHG emissions. The Plan addresses 37 technology areas comprising technologies in the field of energy supply and energy demand as well as regarding distribution and integration technologies. In context with R&D promotion the enhancement of collaboration among industry, academia and government is considered as crucial. A government initiative in context with high-risk and high return innovation is part of the plan, too. Global diffusion measures for innovative technologies are being addressed as well.

Chosen examples for technology areas addressed are listed following:

- High-efficiency coal-fired power generation;
- Next-generation automobiles (HVs/ PHVs/ EVs/ clean diesel etc.);
- Next-generation automobiles (fuel cell motor vehicles);
- High-efficiency heat pumps;
- Environmentally-aware iron manufacturing process;
- Hydrogen production, transport, storage (transport/storage);
- Fuel Cells.

For each technology there is stated an outline of the respective technology, a technology roadmap until 2050 and trends and challenges in Japan’s technology development as well as international trends.

R&D priorities have to be considered differentiated by time horizon, socioeconomic conditions and technology area and technology readiness level as well as in the context of the national energy resource potential. Furthermore it is considered as useful to check consistency among energy technology roadmaps. And finally, there is still the challenge to show R&D impacts of cost reduction, performance improvement and other technological estimates in the long run.

China: Clean Energy Priority-Setting in China

Dr. Xuxuan Xie, Energy Research Institute, National Development and Reform Commission, P.R. China

(Presentation slides not available)

Renewable energy is the new field of economic growth in the P.R. of China. An empirical study has shown that continued rapid growth of the Chinese economy is the driver of energy consumption growth. In 2010 GDP was 7.6 times of the GDP in 1978 when the reform and opening-up policy was adopted. The respective relation for energy consumption is 2.55. Having a look at the beginning of the 21st century, one finds that GDP in 2012 was 3.2 times of the GDP in 2000 and energy consumption in 2012 was 2.5 times of the respective value in 2000.

In the frame of the CNREC Study (2013/2014) three scenarios in context with the penetration of renewable energy until 2050 were developed: Reference, RE Max and RE Optimised. Within the reference scenario existing policies are maintained and the trend is continued. For the RE Max scenario it is assumed that renewable energy deployment is driven by an ambitious CO_2 cap and only constrained by availability of RE resources, geographical constraints (mountains, rivers, buildings, military) and integration issues. The assumption for the RE Optimised scenario is that renewable energy deployment should be ambitious as well as economic reasonable using economic drivers. Figure 8 shows an overview of the CREAM-CGE model applied in this context.

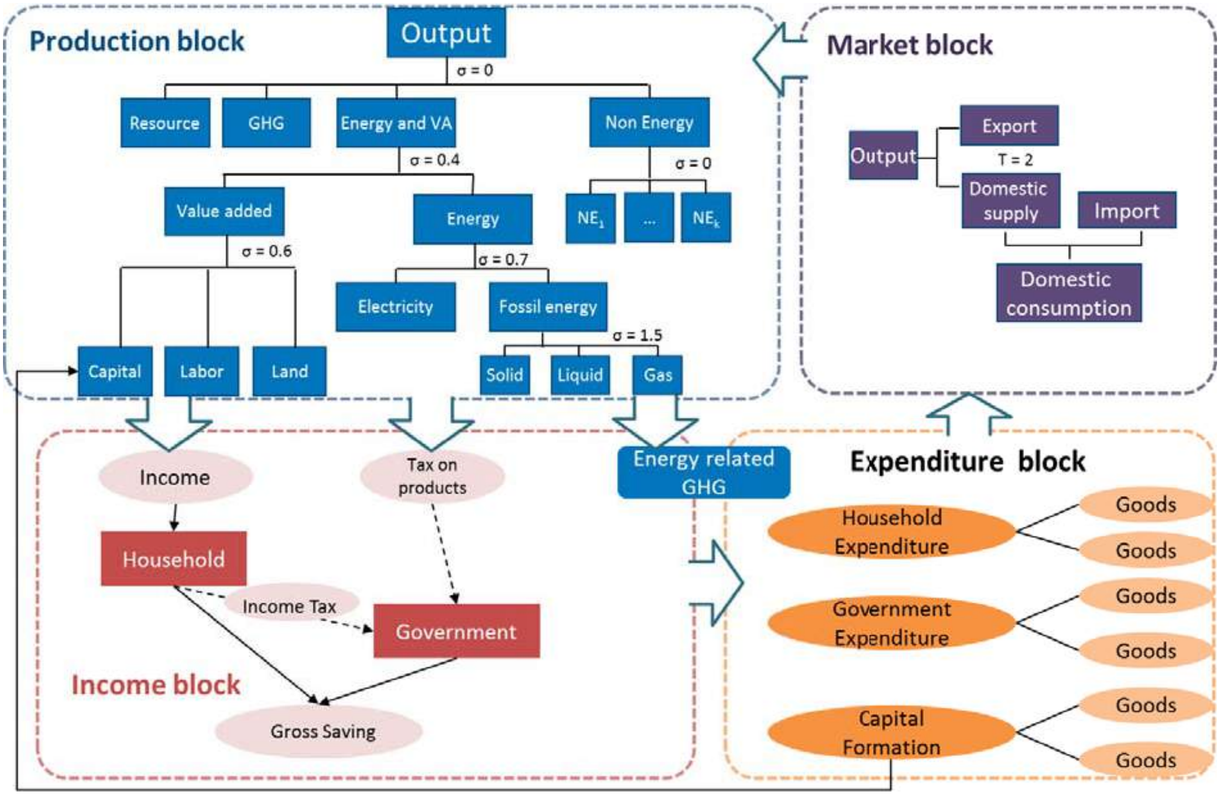


Figure 8: Overview of CREAM-CGE model

Preliminary results are already available for the reference scenario as well as for the scenario RE Max. The preliminary results refer to economic development, power mix, energy mix, added value of renewable energy sectors, job creation, impact on other sectors, impact on macro economy and environmental benefit.

Nordic Energy Technology Perspectives

Benjamin Smith, Senior Adviser, Nordic Energy Research, Norway

Link to presentation slides:
http://www.iea.org/media/workshops/2014/egrdmodellingandanalyses/9_Smith.pdf

In co-operation with Nordic Energy Research IEA has published the report "Nordic Energy Technology Perspectives" (NETP). NETP combines the global comparability of the IEA's assumptions with detailed analysis and applicability for the Nordic Energy System. The report shows how the Nordic countries could achieve their carbon reduction aims in context with energy related emissions. The 2DS (2° scenario) requires a reduction in greenhouse gas emissions until 2050 compared to 1990 by 70 %. The CNS (carbon neutral scenario) sees emissions of the Nordic countries drop by 85 % compared to the 1990 levels with the rest of the world pursuing the 2DS path. In this context for Denmark a share of 100 % renewable energy was assumed in 2050. For Finland the respective share is 50 % and for Iceland it should be in a range between 50 and 70 %. Norway's energy sector will be carbon neutral according to the assumptions, whereas Sweden's won't cause any net emissions.

Scenario development is based on a combination of forecasting (current policies, concrete plans) and back casting (optimal pathways to 2050 goals).

Meeting the goals in context with the CNS means that the share of wind energy in Nordic electricity production will be 25 % in 2050 compared to 3 % in 2010. Coal and natural gas will experience a phase out whereas it is expected that nuclear electricity production will increase. It is assumed that electricity generation will be increased by 40 % until 2050 compared to 2010. This is mainly due to transport electrification, increased use of electricity in context with heat generation as well as in industry.

In context with the extension of wind energy production the installed capacity has to be extended starting at 6 GW in 2010 to 40 GW in 2050. This requires a newly installed capacity of 1 GW p.a. until 2020 and 1.4 GW p.a. after 2020. The extension corresponds to 10.000 newly installed onshore turbines and 3.000 newly installed offshore turbines, respectively. Making an overall cost assessment the CNS would be cheaper compared to the 4DS. This is due to the fact that in CNS earnings in context with electricity exports as well as cost savings in context with fuel savings can be taken into account.

The development of Nordic public RD&D budgets within the period from 1990 to 2010 can be seen in Figure 9.

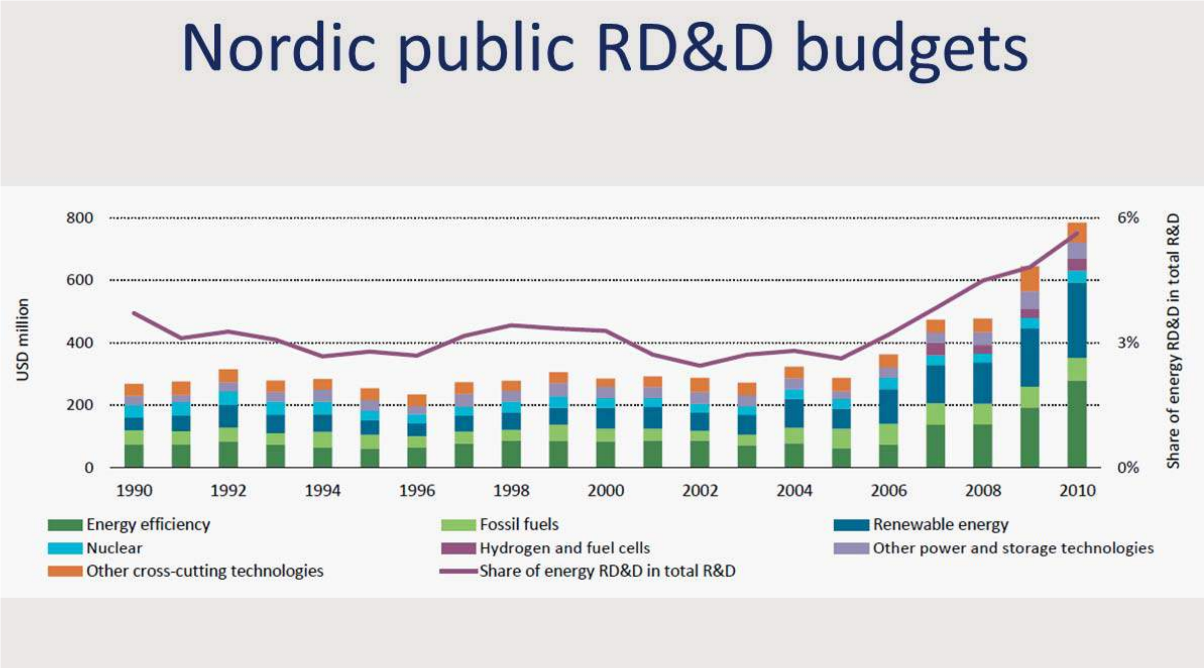


Figure 9: Development of Nordic RD&D budgets 1990 to 2010

From the early 1990ies until 2006 the share of energy RD&D on total R&D was around 3 %. After that year the share experienced an increase achieving nearly 6 % in 2010. In 2010 the respective share amounts to 11 % for Finland, to 6 % for Sweden and to 4 % for Norway, respectively.

Indicators for Innovation: Energy Innovation Scoreboard

Energy Innovation Scoreboard – a pilot framework with a focus on renewables

Dr. Angela Köppl, Claudia Kettner, WIFO

Link to presentation slides:
http://www.iea.org/media/workshops/2014/egrdmodellingandanalyses/10_Kettner_Koppl.pdf

The proposal of an Energy Innovation Scoreboard aims at improving knowledge on energy innovation with a focus on renewables. It shall stimulate discussion on usefulness and feasibility as well as discussion on the choice of indicators, data availability and data gaps. The role of energy R&D for the transformation of the energy system shall be emphasized. Furthermore the monitoring of energy innovation and comparison of energy innovation capabilities of countries shall be enabled. The proposal is embedded in a conceptual framework of the energy system. Internationally comparable databases have to be screened with respect to the availability of data for relevant indicators. Additionally relevant data have to be compiled.

The motivation to propose an Energy Innovation Scoreboard is because scoreboards are highly adequate to cover multidimensional aspects, cover the whole process and enable a comparative assessment of innovation performance. Finally, scoreboard indicators provide a potential basis to condense information to composite indices. In context with the Energy Innovation Scoreboard it has to be considered that indicators included should be thoroughly argued. A structured presentation will be necessary to make broad information manageable. The selection of criteria often will involve stakeholder process.

The Innovation Union Scoreboard (IUS) serves as role model; however, there are various differences. The proposed Energy Innovation Scoreboard is complementary to EU's IUS. It focuses on public energy R&D expenditures; firm level R&D and innovation are not being covered in an early stage. Aim of the EIS is an integrated view of the innovation system, covering enablers and intellectual assets or outputs as key elements of the innovation process. Context indicators and outcome indicators are being used to describe the progress towards a transformation of the energy system. Relevant dimensions of the innovation system are shown in Figure 10. The white boxes represent data or information which still has to be integrated.

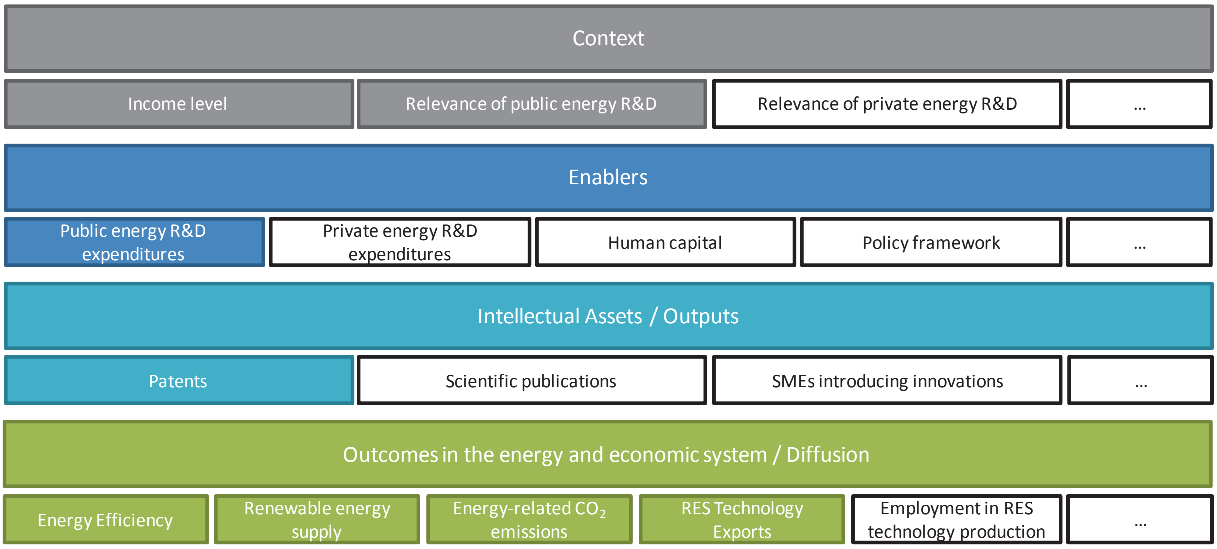


Figure 10: Relevant dimensions of energy innovation

As an exemplary indicator RES patent applications per GDP are shown in Figure 11 for the year 2000 and the year 2010, respectively.

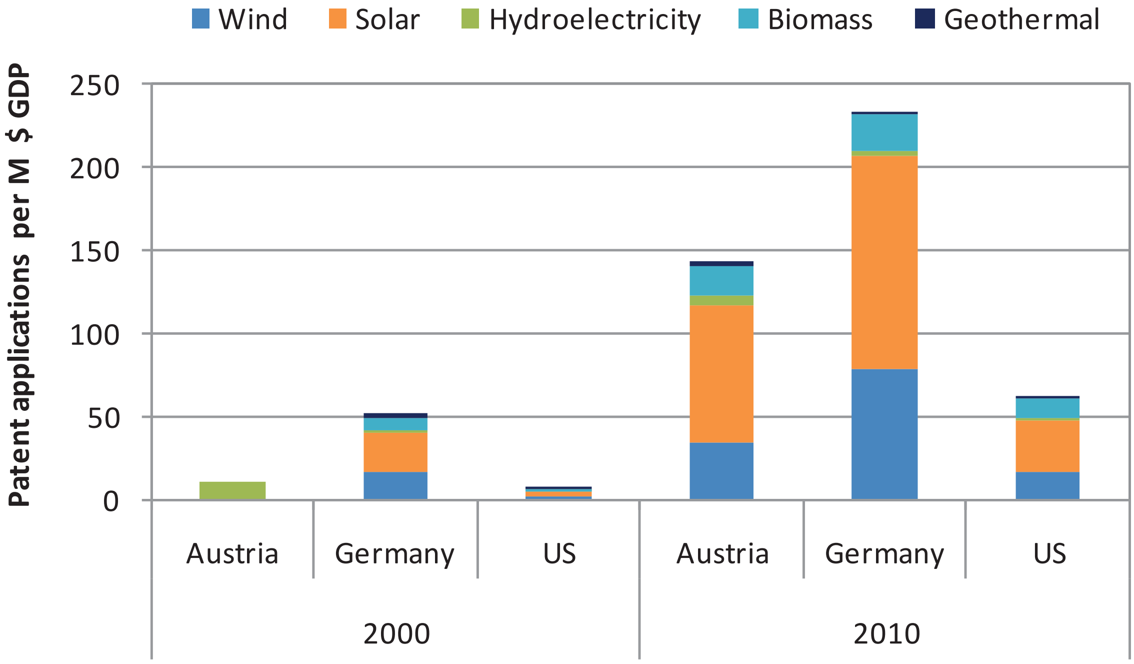


Figure 11: Development of RES patent applications per GDP

In conclusion it can be stated that the Energy Innovation Scoreboard should rest on an agreed conceptual framework. The indicators included have to be thoroughly argued and discussed with stakeholders and finally possible data gaps will have to be filled in.

Netherlands: The Innovation Sensor

Joost Koch, RVO.NL

Link to presentation slides:
http://www.iea.org/media/workshops/2014/egrdmodellingandanalyses/11_Koch.pdf

The Dutch policy on energy innovation aims at realizing both sustainable and economic impact. Indicators in context with sustainable impact comprise sustainable energy production, installed capacity, energy demand reduction and reduction of greenhouse gas emissions. In terms of economic impact the focus is on turnover, export and employment. Energy has been defined as a so called “top sector” in context with Dutch innovation policy; several thematic “top teams” are working on chosen topics. The agenda comprises internationalization, a human resource agenda, demand-driven innovation as well as a portfolio of innovation programs.

The Dutch Innovation Sensor is a kind of dashboard for the portfolio management of innovation programs. It comprises a biennial process of selection of innovation programs which is shown in Figure 12.

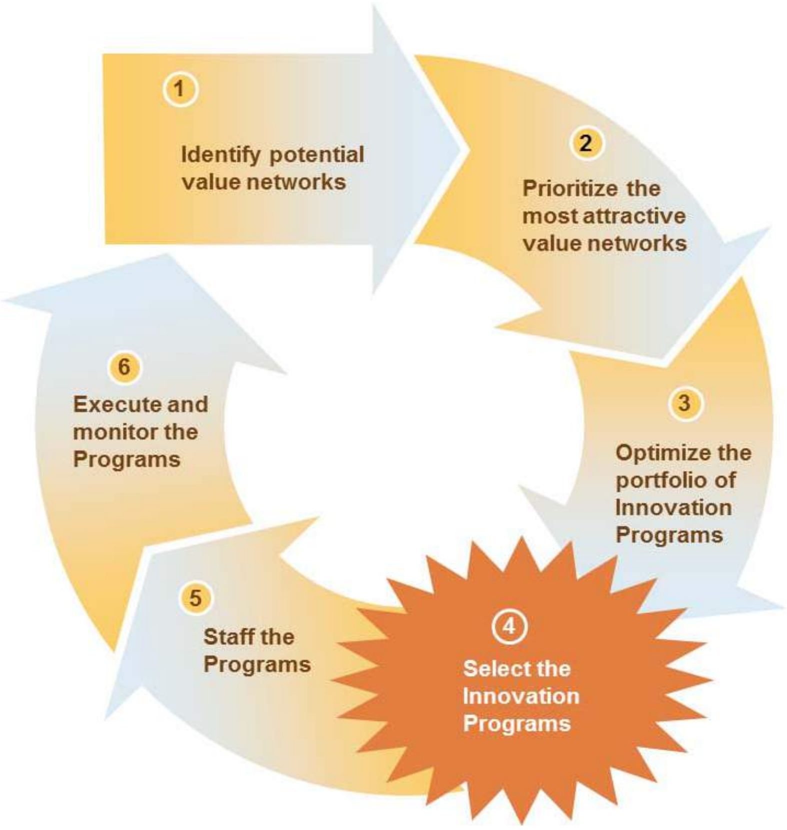


Figure 12: Selection of Innovation Programs

The programs chosen have to contribute to the aims of the National Energy Agreement which comprises targets regarding reduction of final energy consumption, increase of the share of renewables and creation of green jobs. Private partners are appreciated as well as private investment. The phase of the innovation process addressed by a planned program is important in context with the selection of a program, too.

Figure 13 shows the annual process of monitoring the function of the Dutch energy system regarding the aspect of innovation.

Figure 13: Monitoring of the function of the Dutch energy system

Issues in this context refer to international reputation, role in value chain, to the percentage of SMEs, whether there are enough private resources and finally whether the actors in the Dutch energy system are the "right ones". In context with collaboration within the Dutch energy system changes in network characteristics are being analysed.

Summarizing it can be stated that the Innovation Sensor supports the "Top Team Energy" in context with judging whether they are "doing the right things" (based on expectations of experts) and whether they "do the things right" (based on facts and figures from projects). This shall contribute to an institutional change in order to empower the new economy.

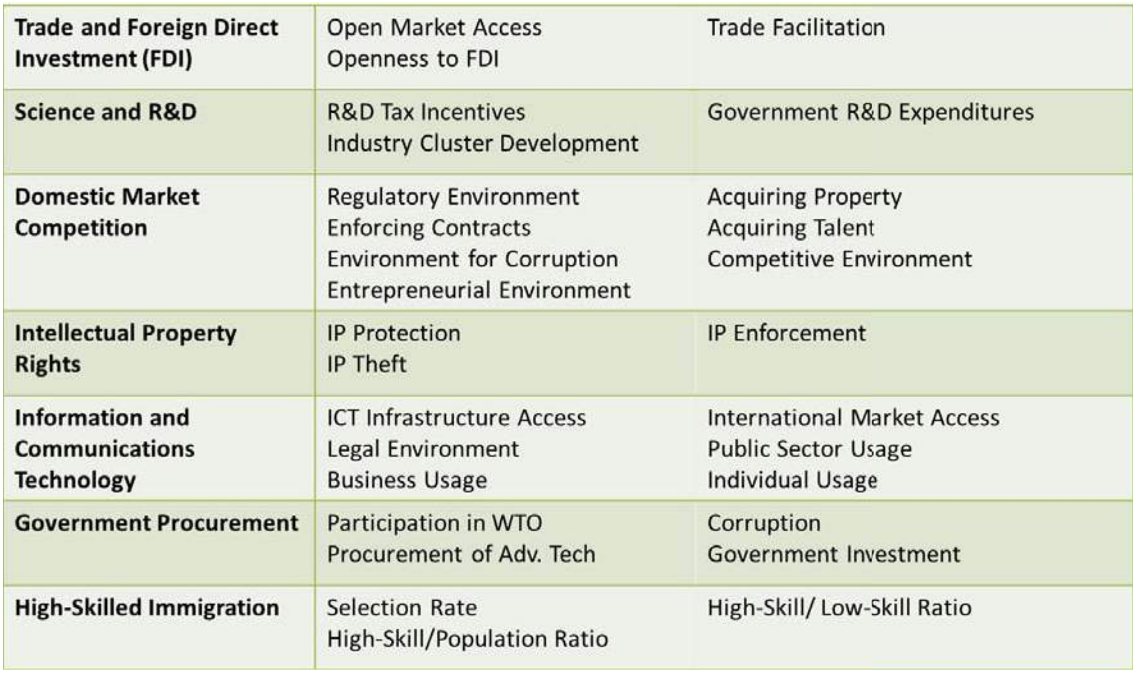
Assessing a Country's Innovation Status and Potential

Matthew Stepp, Executive Director, Centre for Clean Energy Innovation

Link to presentation slides:
http://www.iea.org/media/workshops/2014/egrdmodellingandanalyses/12_Stepp_20140424FINAL.pdf

A country's clean energy and climate policy are often critiqued whether it has any climate strategy vs. it does not; or how much a country says they will cut carbon, but not how. However, each says little about how effective each country's clean energy and climate policies actually are. It can be stated that the underlying policies, innovation capacity, and targeted investments are what will address global climate change. In this context climate policies must impact clean energy innovation and countries must build and maintain strong innovation capacity. The key to the global adoption of low-carbon energy is making it a cheaper alternative than fossil fuels; this requires innovation. In context with assessing a country's innovation status and potential there are – among others – three types of rankings: Ranking a country on innovation policy, on innovation capacity and on innovation competitiveness, respectively.

The ITIF Global Innovation Policy Index was released in 2012 by the Center for Clean Energy Innovation in collaboration with the Kauffman Foundation. The goal is to provide a useful framework of the type of innovation policies countries should promote and implement. The ITIF Global Innovation Policy Index uses 87 indicators to rank 55 countries (including all members of OECD, all members of EU as well as 19 of 21 APEC countries and additionally Argentina, Brazil, India and South Africa). No low-income countries had been included due to a lack of data. Aspects being assessed in context with calculating the ITIF Global Innovation Policy Index are shown in Figure 14.

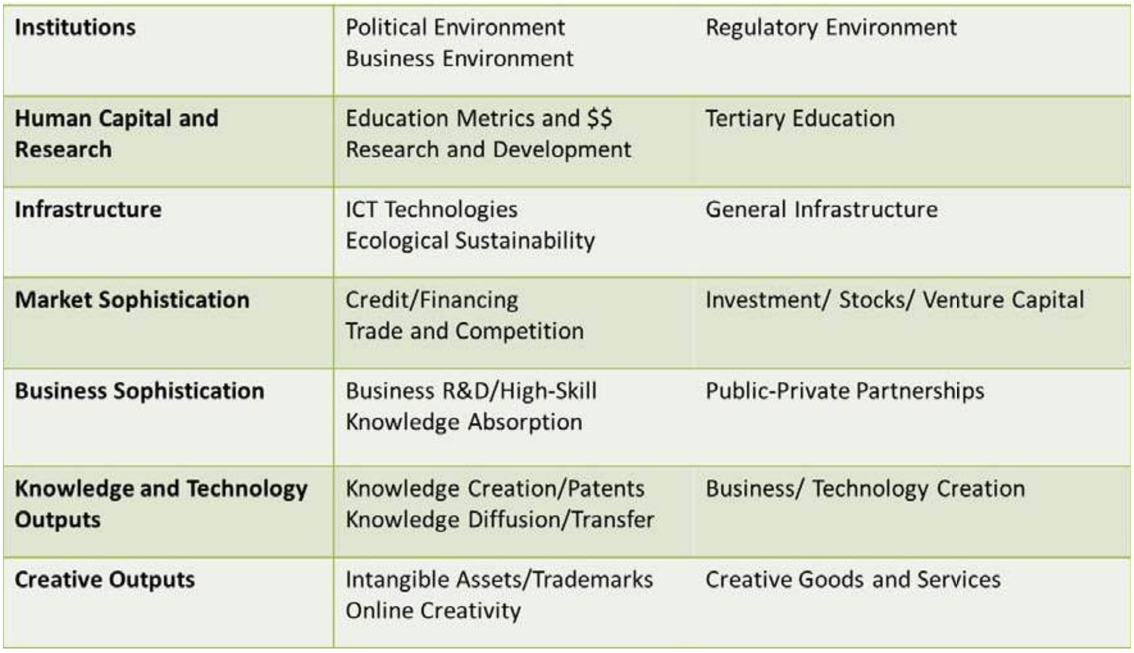


Trade and Foreign Direct Investment (FDI)	Open Market Access Openness to FDI	Trade Facilitation
Science and R&D	R&D Tax Incentives Industry Cluster Development	Government R&D Expenditures
Domestic Market Competition	Regulatory Environment Enforcing Contracts Environment for Corruption Entrepreneurial Environment	Acquiring Property Acquiring Talent Competitive Environment
Intellectual Property Rights	IP Protection IP Theft	IP Enforcement
Information and Communications Technology	ICT Infrastructure Access Legal Environment Business Usage	International Market Access Public Sector Usage Individual Usage
Government Procurement	Participation in WTO Procurement of Adv. Tech	Corruption Government Investment
High-Skilled Immigration	Selection Rate High-Skill/Population Ratio	High-Skill/ Low-Skill Ratio

Figure 14: Aspects being assessed in context with calculating the ITIF Global Innovation Policy Index

Referring to the rating, tiers were calculated as four equidistant ranges between maximum and minimum scores. The countries are listed in alphabetical order within these tiers.

The INSEAD/WIPO Global Innovation Index was released in 2013 by the Center for Clean Energy Innovation in collaboration with Cornell University. The 2013 index represents the 6th edition, it's themed each year. The goal of the INSEAD/WIPO Global Innovation Index is to capture innovation capacity in developed and developing countries. It ranks 142 countries on 84 indicators and uses public as well as private data. Numerical rankings serve to compare year-over-year changes. The rankings are being displayed by region, input, output, total and GDP. The aspects being assessed in the INSEAD/WIPO Global Innovation Index are shown in Figure 15.



Institutions	Political Environment Business Environment	Regulatory Environment
Human Capital and Research	Education Metrics and $$ Research and Development	Tertiary Education
Infrastructure	ICT Technologies Ecological Sustainability	General Infrastructure
Market Sophistication	Credit/Financing Trade and Competition	Investment/ Stocks/ Venture Capital
Business Sophistication	Business R&D/High-Skill Knowledge Absorption	Public-Private Partnerships
Knowledge and Technology Outputs	Knowledge Creation/Patents Knowledge Diffusion/Transfer	Business/ Technology Creation
Creative Outputs	Intangible Assets/Trademarks Online Creativity	Creative Goods and Services

Figure 15: Aspects being assessed in context with calculating the INSEAD/WIPO Global Innovation Index

Several issues in context with innovation rankings can be observed. First, data availability potentially limits broader country rankings, particularly for low-income and emerging countries; second, data availability for specific variables underlying innovation limits ranking robustness. Furthermore there is a need to specify what the innovation ranking is used for: Comparing innovation policies, comparing capacity to innovation or comparing impact of policies on capacity to innovation? Additionally it has to be stated that all indices treat all technologies the same, except ICT and that the impact of institutions is being largely not captured.

As to-date most “energy innovation” rankings focus solely on country RD&D investments or on the level of clean energy patenting, respectively, which are only part of the innovation picture, there can be observed a strong need for a comprehensive “Clean Energy Innovation Index”.

The need refers mainly to two aspects: First, to a new country-level ranking of clean energy innovation policies based on data referring to RD&D investments, “innovative quality” of deployment subsidies, country capacity for innovation, taxes and trade metrics as well as on public institutions (National Labs, etc.). As secondly countries often view climate policy separate from innovation policy, there can be stated a need for inclusion of clean energy innovation in existing global innovation rankings.

Considerations for an 'Innovation Readiness Level' along with the 'Technology and Manufacturing Readiness Level' indicators

Celine Jullien, KiC Inno Energy

Link to presentation slides:
http://www.iea.org/media/workshops/2014/egrdmodellingandanalyses/13_Jullien.pdf

The KiC InnoEnergy[2] approach comprises several components. Starting point is the competence mapping for intra and extra KIC partners per thematic field. This exercise has been done for the period 2000 to 2012. On thematic field level a long term vision of the energy landscape in 2022 has been developed, including interim steps in 2012 and 2017.

Furthermore a strategy and a roadmap had been developed per thematic field, referring to the time period from 2013 to 2017. On portfolio management level a specific assessment process is being applied as well as chosen portfolio management criteria. On project level the IRL tool is being used for monitoring and supporting innovation projects.

For each thematic field priority technologies have been identified using specific criteria. These comprise e.g. time to market (for the technology involved), impact in context with energy cost decrease, increase of operability and decrease of GHG effects as well as foreseeable regulatory impact, required investment to develop the innovations and cross impact in several applications. Finally KiC partners' leadership and competence in the respective topic and technology are of relevance as well as a declared KIC industry interest and commitment.

In context with competence mapping in the field of wind energy around 150.000 patents had been analyzed and roughly 180.000 publications. As a result of a desk research focusing on 800 worldwide players and 100 KIC partners 1.890 collaborations were identified as well as 340 acquisitions or spin-offs and 1.210 products or services, respectively. The segment description for this technology is shown in Figure 16.

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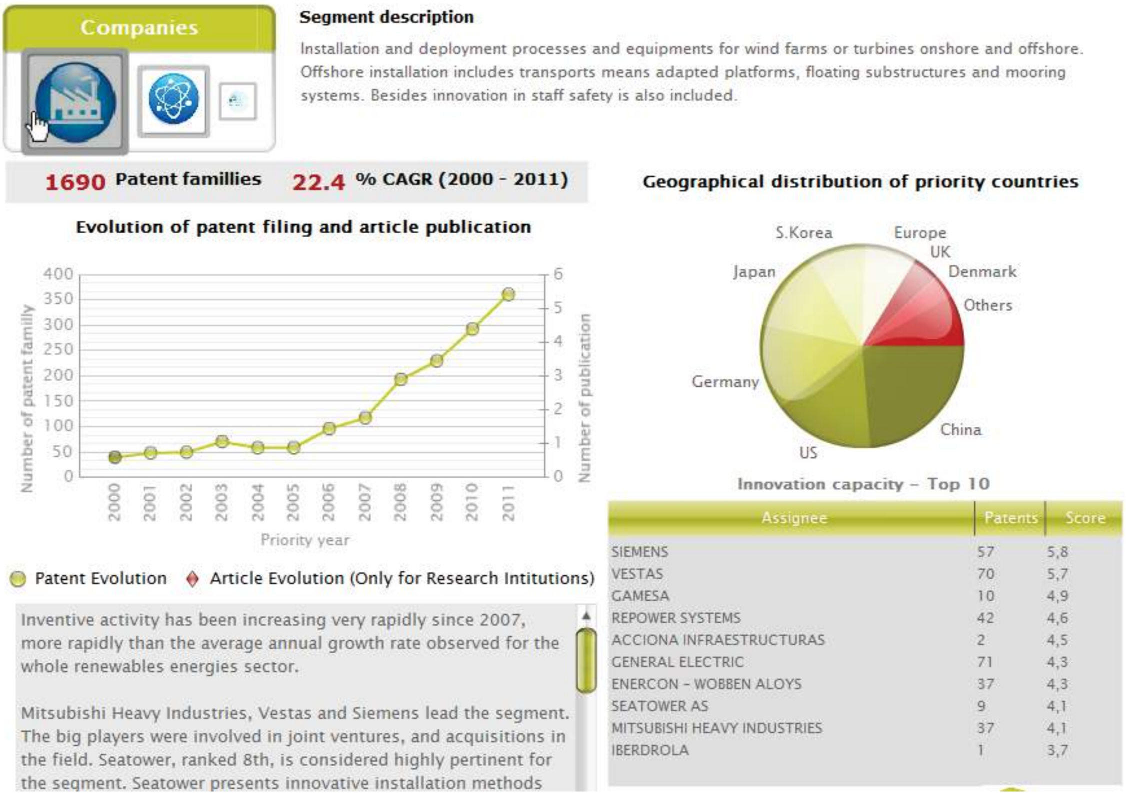
[2] The KiC InnoEnergy consortium consists of 27 shareholders and more than 100 additional partners covering the whole energy mix – companies, research institutes, universities and business schools.



Segment description

Installation and deployment processes and equipments for wind farms or turbines onshore and offshore. Offshore installation includes transports means adapted platforms, floating substructures and mooring systems. Besides innovation in staff safety is also included.

1690 Patent famillies **22.4** % CAGR (2000 - 2011)

Inventive activity has been increasing very rapidly since 2007, more rapidly than the average annual growth rate observed for the whole renewables energies sector.

Mitsubishi Heavy Industries, Vestas and Siemens lead the segment. The big players were involved in joint ventures, and acquisitions in the field. Seatower, ranked 8th, is considered highly pertinent for the segment. Seatower presents innovative installation methods

Innovation capacity – Top 10

Assignee	Patents	Score
SIEMENS	57	5,8
VESTAS	70	5,7
GAMESA	10	4,9
REPOWER SYSTEMS	42	4,6
ACCIONA INFRAESTRUCTURAS	2	4,5
GENERAL ELECTRIC	71	4,3
ENERCON – WOBBEN ALOYS	37	4,3
SEATOWER AS	9	4,1
MITSUBISHI HEAVY INDUSTRIES	37	4,1
IBERDROLA	1	3,7

Figure 16: Segment description for wind energy technology

The assessment criteria in context with the thematic field assessment process are transparent, formalized, communicated and known – see Figure 17.

A1	**BUSINESS DEVELOPMENT**	**6,0**
A1.1	Preliminary product or service definition (problem statement, solution benchmark,...)	2,0
A1.2	Business opportunity assessment (market analysis, competitive analysis, value proposition for customers, ...)	3,0
A1.3	Soundness of IP analysis (background, freedom to operate, protections, etc.)	1,0
A2	**RISK ANALYSIS**	**5,0**
A2.1	Availability of required knowledge in the consortium	2,0
A2.2	Technical barriers identified and mitigation plan	1,5
A2.3	Evaluation of other risks (financial, societal, law, resources, team,...) and mitigation plan	1,5
A3	**FINANCIAL VIABILITY**	**3,0**
A3.1	Project budget vs. market potential and scope of the project	1,0
A3.2	Justification of requested KIC investment	1,0
A3.3	Assessment of plan for KIC investment return	1,0
A4	**OPERATIONAL VIABILITY**	**4,0**
A4.1	Soundness of project plan (milestones, deliverables, availability of resources, etc.)	2,0
A4.2	Soundness of consortium vs. value chain	1,0
A4.3	Quality of project management	1,0
A5	**COMPLIANCE WITH KIC REQUIREMENTS**	**4,0**
A5.1	Integration of students, academics, education organisations	0,5
A5.2	Potential to create business (start-ups, spin-offs, ...)	1,0
A5.3	Compliance with KIC InnoEnergy roadmap	2,0
A5.4	Participation of SMEs	0,5

Figure 17: Assessment criteria in context with the thematic field assessment process

The KIC InnoEnergy IRL tool® allows assessing the innovation potential of a given project considering the maturity of 5 dimensions (see Figure 18):

- the Technology Readiness Level (TRL) measures the maturity of a given technology;
- the IP Readiness Level (IPRL) measures the "freedom to operate" of a given product/service;
- the Market Readiness Level (MRL) measures the maturity of a given need in the market;
- the Consumer Readiness Level (CRL) identifies the level of knowledge about the consumer and to what extent affects the product/service this consumer;
- the Society Readiness Level (SRL) identifies the level of knowledge about the stakeholders' interests and concerns and to what extent affects the product/service the society.

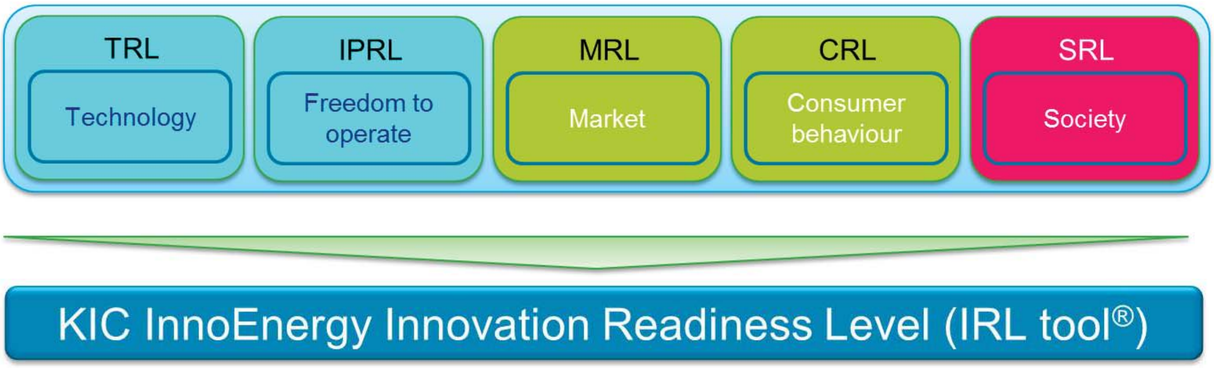


Figure 18: KIC InnoEnergy IRL tool®

Each dimension has different maturity levels and each level has different questions to substantiate each maturity level, respectively. The project manager of a given R&D project fills in the information into the respective form. The committee evaluating the projects evaluates the quality of the answers and assigns a level for each of the five dimensions stated above. The analyses of the dimensions are aggregated in order to evaluate the project as a whole. The analyses of the dimensions are also being used for monitoring the development of a project over time and the results can also be shown for a portfolio of projects.

Process of prioritization of R&D budgets in the private sector

Innovation Action Plan of Eurelectric

Koen Noyens, Energy Policy & Generation Unit, EURELECTRIC

Link to presentation slides:
http://www.iea.org/media/workshops/2014/aprilnuclearworkshop/14_Noyens.pdf

R&D expenditure by large European utilities has nearly doubled over the last decade to over € 1.7 billion in 2012. The respective data for 13 major European utilities for the early 2000s and the early 2010s is shown in **Fout! Verwijzingsbron niet gevonden.**Figure 19.

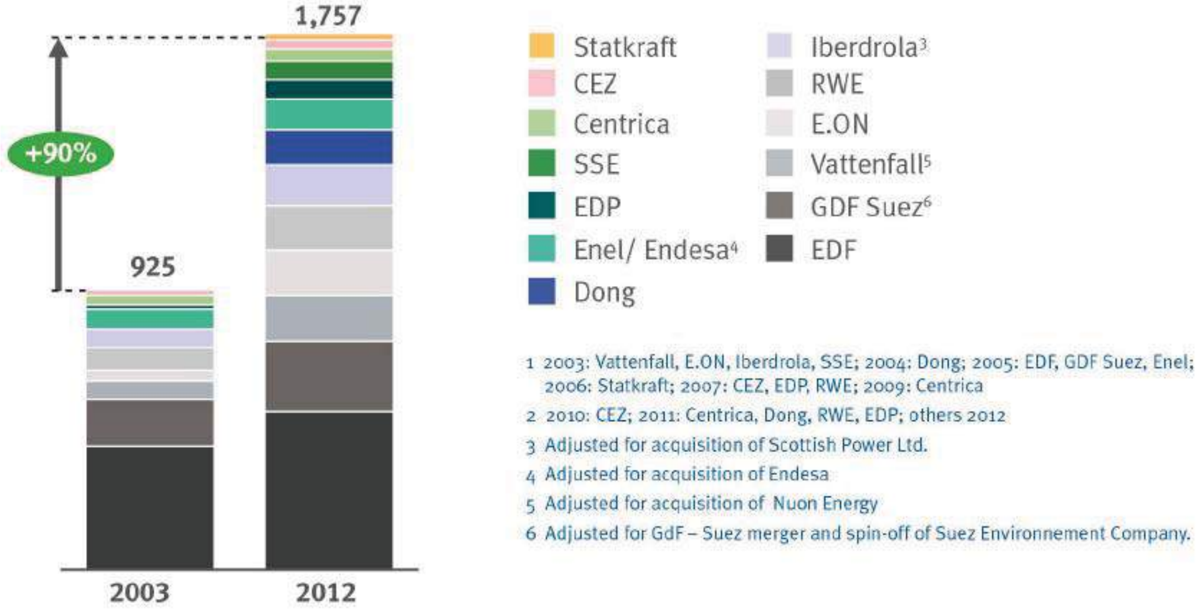


Figure 19: R&D expenditure by 13 major European utilities in early 2000s[1] and early 2010s[2] [in EUR millions]

For European utilities three imperatives stand out in context with innovation: Mastering technologies, getting closer to customers and developing new business models and services.

In context with mastering technologies it can be assumed that the continued development of a large range of technologies will have disruptive impact on the power sector. The imperative "getting closer to customers" has various aspects shown in Figure 20.

Figure 20: Getting closer to customers – various aspects

In context with developing new business models and services the crucial point is how to capture value. It's about moving from sales of commodity to services, i.e., from €/MWh to €/customer. Within the power sector data is easier to capture compared to other sectors and its potential value is rising – e.g. it can be used for tailored new products or services, can enhance customer targeting, enable demand side management and can be used for optimizing operations.

The survey of utility executives and innovation experts showed strongly the need to go beyond R&D. As a result five actions to improve EU enabling of power sector innovation have been suggested:

(1) Adopt a systems approach: Innovation policy has to be a tool of energy policy through an integrated perspective on the overall power system;
(2) Nurture public-private dynamics: Innovation through a competitive, business-friendly, and risk-rewarding market framework is harvesting the low-hanging fruits;
(3) Prioritise demonstration and commercialization: The support mechanisms that take innovation beyond R&D have to be strengthened;
(4) Unlock downstream innovation: the enablers of a 'new downstream' set of services and offerings (competitive markets, smart regulation, and enabling infrastructure) have to be put in place;
(5) Create supportive governance for the innovation union: coordination and governance of both EU-level and Member State support mechanisms have to be improved.

Modelling and Simulation assisted Strategic R&D Programming

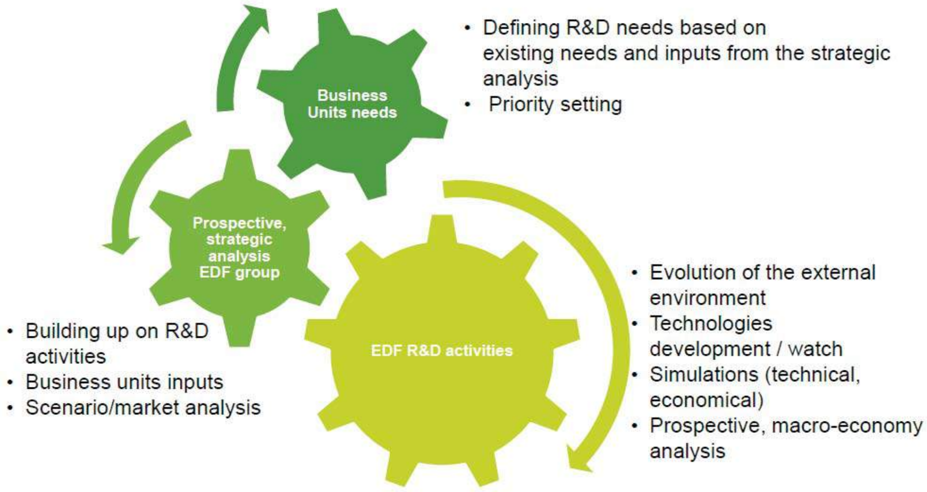
Xavier MAMO, Chef de Département Délégué, EDF – R&D

Link to presentation slides:
http://www.iea.org/media/workshops/2014/aprilnuclearworkshop/15_Mamo.pdf

The R&D department of EDF has formulated three key missions: First, a carbon-free energy mix should be consolidated. This means sustaining the nuclear advantage, developing renewable energies and assessing carbon capture and storage. Second, the electricity system of tomorrow has to be anticipated. In this context the following topics are crucial: development of smart grids, management of network assets and integration of intermittent and distributed power generation. Third, a flexible range of low carbon energy has to be developed. In this context it is intended to help customers to manage their consumption and to develop innovative offers. Furthermore new uses for electricity and energy efficiency services shall be promoted and business models for sustainable cities and mobility shall be developed.

To make progress in context with the key missions EDF has set up an open innovation team. Within a survey 550 start-ups have been detected. In order to transfer innovation to business, it is intended to realize 20 demonstrators per year. According to the objectives formulated there are supposed to be over 40 partnerships or demos in 2015. One of the missions of the innovation network is to promote experimentation and partnerships with the best start-ups. This comprises detecting start-ups, funding innovation, sponsoring innovation related contests as well as creating a network of innovators. Furthermore it is intended to promote internal innovation by strengthening the “intellectual property culture” and integrating it into the business strategy. A promotional network (i.e. businesses / start-ups co-operation) is to be set up in order to back start-ups’ development within the EDF Group as well.

In the EDF Group there is a unique R&D division for all Group businesses: Generation, Energy Management, Customers and Sales, Renewable Energies, Electrical Networks and Information Technology. Defining R&D needs for business units is based on existing needs and inputs from the strategic analyses. Priorities are being set. For the prospective, strategic analysis for the EDF Group information in context with R&D activities, inputs by the business units and scenario analyses as well as market analyses are being used.



- Defining R&D needs based on existing needs and inputs from the strategic analysis
- Priority setting

- Building up on R&D activities
- Business units inputs
- Scenario/market analysis

- Evolution of the external environment
- Technologies development / watch
- Simulations (technical, economical)
- Prospective, macro-economy analysis

Figure 21: EDF Group – R&D

Summarizing it can be stated that EDF's R&D activities are based on information about the external environment, observed technologies developments, technical and economical simulations as well as on prospective macro-economic analysis – see also Figure 21.

Prioritizing Corporate Investments in R&D

Alexander Wilmes, RWE Aktiengesellschaft, Forschung & Entwicklung Konzern / Steuerung

Link to presentation slides:
http://www.iea.org/media/workshops/2014/egrdmodellingandanalyses/16_WilmesWeb.pdf

The R&D portfolio of RWE covers more than 200 projects; around 30 to 50 patents are granted per year. Most R&D projects are developed close to operations in co-operation with suppliers, manufacturers and research institutions. In 2014 RWE was ranked third among Europe's 16 largest energy utilities in the Innovation Index of the European School of Management and Technology (ESMT).

The definition of the "right" corporate R&D portfolio requires strategic/management guidelines as well as suitable processes – an overview is shown in Figure 22:

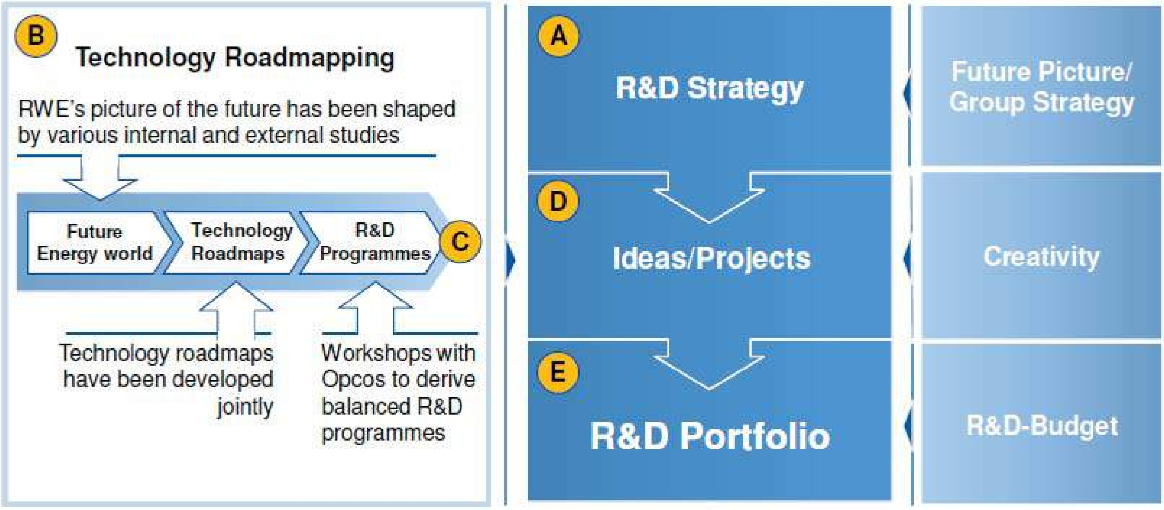


Figure 22: RWE R&D portfolio - strategic/management guidelines and processes

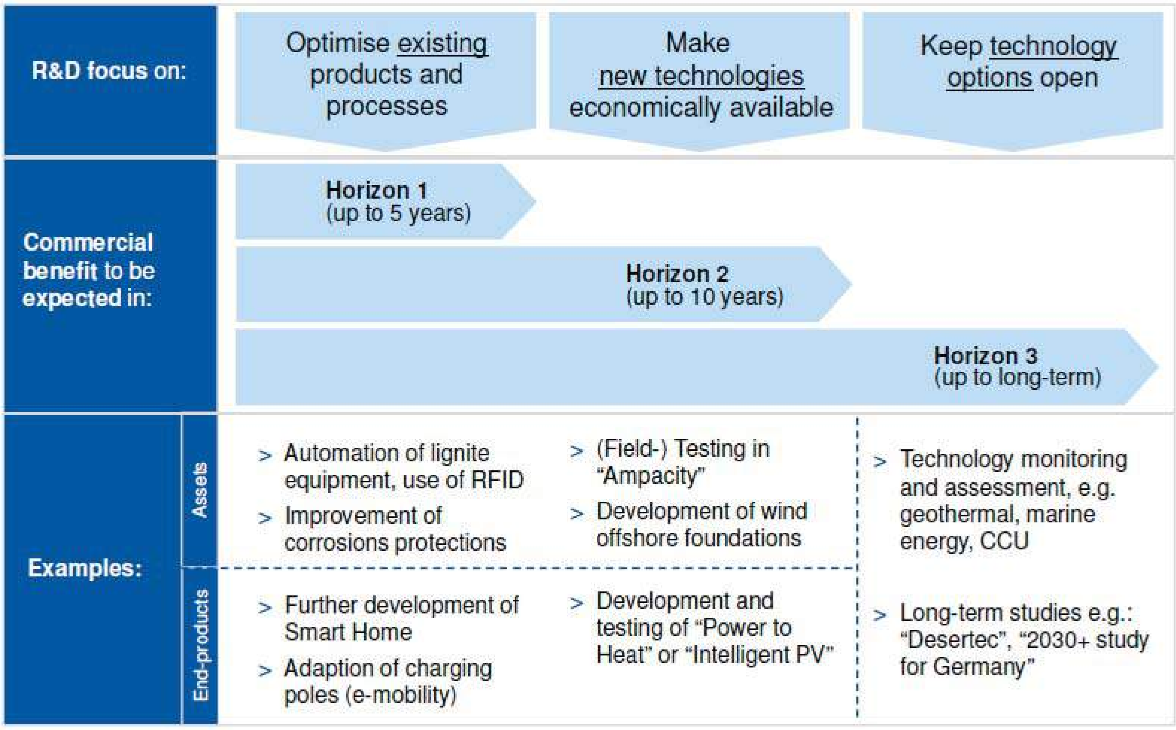
The R&D strategy supports the RWE group-wide strategy; it shall contribute to the target to deliver innovative, value-adding energy and infrastructure products & services to the customers and to assure a high operational performance along the whole value chain.

RWE R&D focuses on three main development targets:

(1) Optimise existing products and processes,
(2) make new technologies economically available and

(3) keep technology options open.

The respective time horizons as well as examples can be seen in Figure 23.



R&D focus on:		Optimise existing products and processes	Make new technologies economically available	Keep technology options open
Commercial benefit to be expected in:		**Horizon 1** (up to 5 years)	**Horizon 2** (up to 10 years)	**Horizon 3** (up to long-term)
Examples:	Assets	> Automation of lignite equipment, use of RFID > Improvement of corrosions protections	> (Field-) Testing in "Ampacity" > Development of wind offshore foundations	> Technology monitoring and assessment, e.g. geothermal, marine energy, CCU
	End-products	> Further development of Smart Home > Adaption of charging poles (e-mobility)	> Development and testing of "Power to Heat" or "Intelligent PV"	> Long-term studies e.g.: "Desertec", "2030+ study for Germany"

Figure 23: RWE R&D: three main development targets

A three step approach was carried out to deliver the mid-term R&D programme portfolio – an overview is shown in Figure 24:

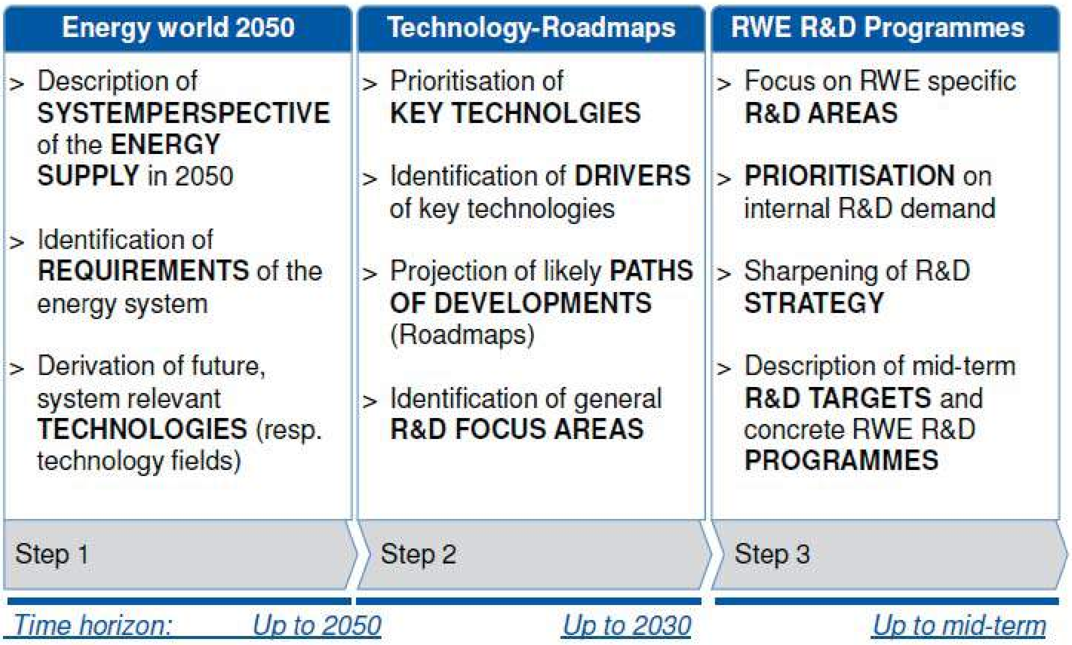


Figure 24: Three step approach to deliver the mid-term R&D programme portfolio

Technology roadmaps have been jointly developed with a consortium of scientific institutes and are now part of an annual update process. The main task of the scientific institutes was to identify and to describe general technologies being relevant for the energy system and corresponding R&D demands. . In a second step the RWE specific view on these general R&D demands was internally assessed, finally coming to a prioritization of the RWE relevant technologies and R&D demands. The consolidated results have been condensed to a set of technology roadmaps and support the definition and shaping of mid-term R&D-programmes.. Each R&D programme contains several targets which have been defined as measurable as possible/ suitable. Thus the R&D programmes build the bridge between the long term strategic guideline and the mid-term R&D portfolio orientation and budget needs.

Furthermore, a systematic process is a prerequisite to successfully turn ideas into valuable “innovations”. An orientation for the main decision steps used at RWE R&D in this context is shown in Figure 25:

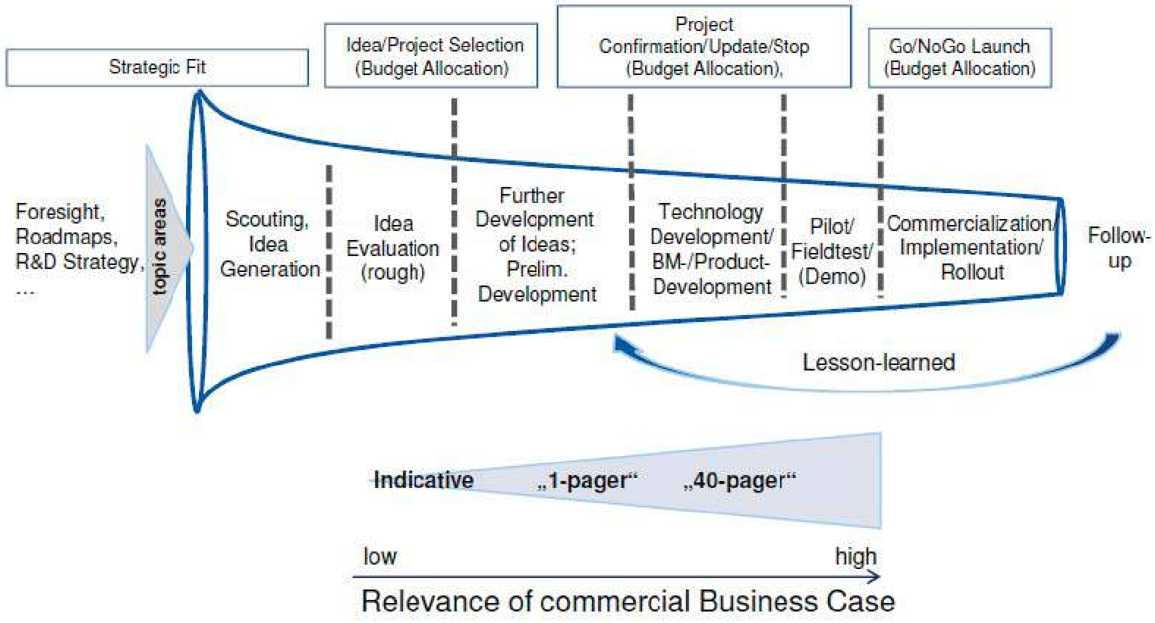


Figure 25: Process of selection of project ideas

All corporate R&D projects must contribute substantially to the companies' R&D value drivers measured through three group-wide KPIs: Know-how gain, reputation (in context of utilising R&D results for external communication) and monetary value. Whereas know-how and reputation are being assessed qualitatively, there is a quantitative assessment of the monetary value (by calculation of a NPV, taking probabilities into account). Besides these group-wide comparable KPIs, additional topic- or business-specific evaluation criteria for R&D projects exist.

Prioritization or ranking of projects, finally, is performed by a RWE R&D management panel, e.g. taking into account strategic developments, content, KPIs and budget restrictions. The current RWE R&D portfolio covers about 200 projects along the entire value chain comprising upstream, power generation, distribution grid/storage as well as energy application/efficiency.

Cost of Energy as R&D Prioritization

Anders Mortensen, Siemens Wind Energy

Link to presentation slides:
http://www.iea.org/media/workshops/2014/aprilnuclearworkshop/17_Mortensen.pdf

A core target of Siemens Wind Energy is the reduction of the levelized costs of energy (LCOE). In order to accelerate cost reduction the "R-evolution" program has been started. Within this program improvements of the Balance of Plant (BOP) costs are addressed, too. These costs refer to foundations, substations, cable supply, and project costs – see Figure 26 for wind energy onshore and offshore project cost split.

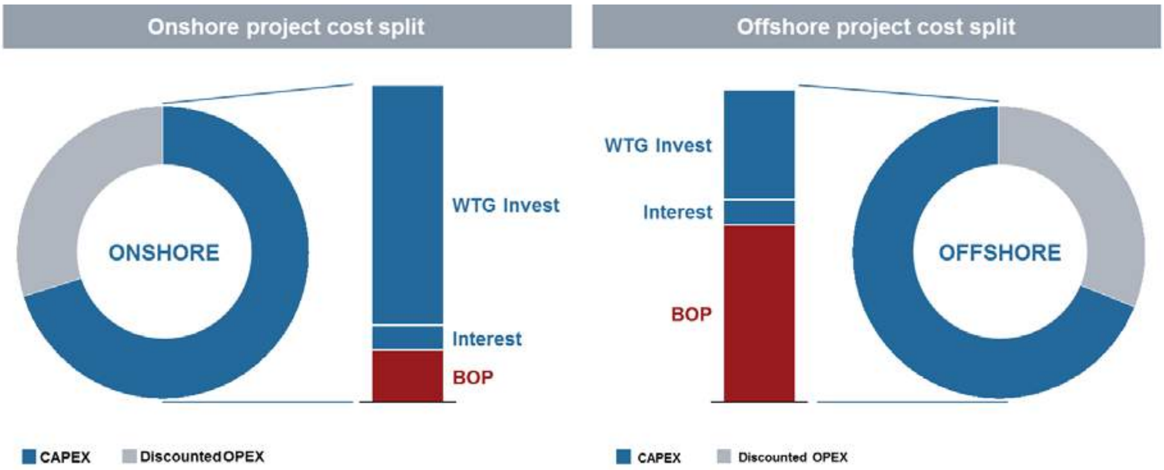


Figure 26: Wind energy: onshore and offshore project cost split

All available levers have to be used in order to reduce the cost of energy produced in order to meet the target. This comprises the reduction of capital expenditures (CAPEX) in context with the windmill (by e.g. lower weight and less components) as well as outside Siemens scope (e.g. offshore foundations, grid access). Higher reliability reduces maintenance requirements and contributes to the reduction of operating costs (OPEX). The lifetime energy output can be increased by higher efficiency and longer life time (see Figure 27).

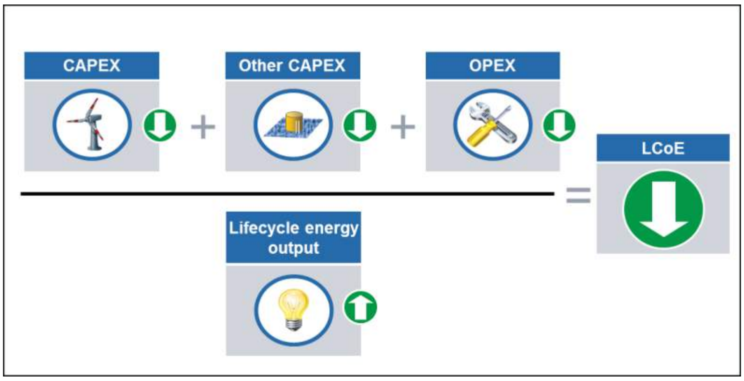


Figure 27: Relevant levers in context with the reduction of levelized costs of energy (LCoE)

Market requirement defines product targets for R&D new product development projects and drives technology development accordingly. Starting point is a business plan focusing on market requirements and costumer business cases – see overview in Figure 28.

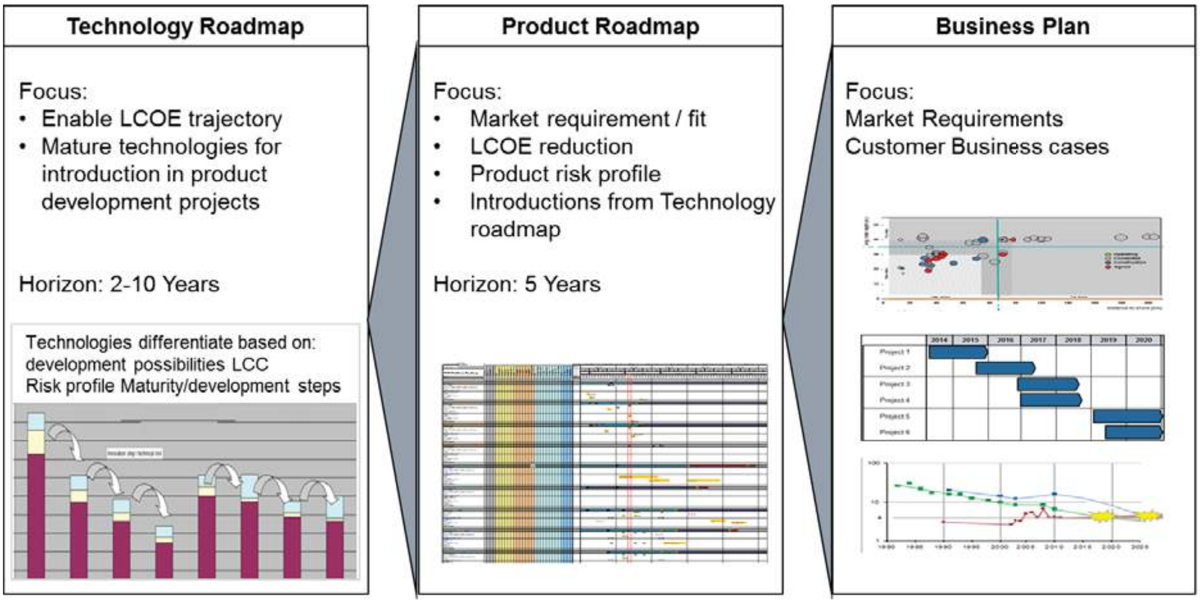


Figure 28: Business plan – product roadmap – technology roadmap

Meeting R&D Needs of Utility Clients

Dr. Geoff Blanford, U.S., Electric Power Research Institute

Link to presentation slides:

http://www.iea.org/media/workshops/2014/aprilnuclearworkshop/18_Blanford.pdf

The mission of the Electric Power Research Institute (EPRI) is advancing safe, reliable, affordable and environmentally responsible electricity for society through global collaboration, thought leadership and science & technology innovation. The members of EPRI represent more than 90 % of generation in the US, as well as public agencies and 40 countries worldwide. The multi-tiered advisory structure of EPRI is shown in Figure 29:

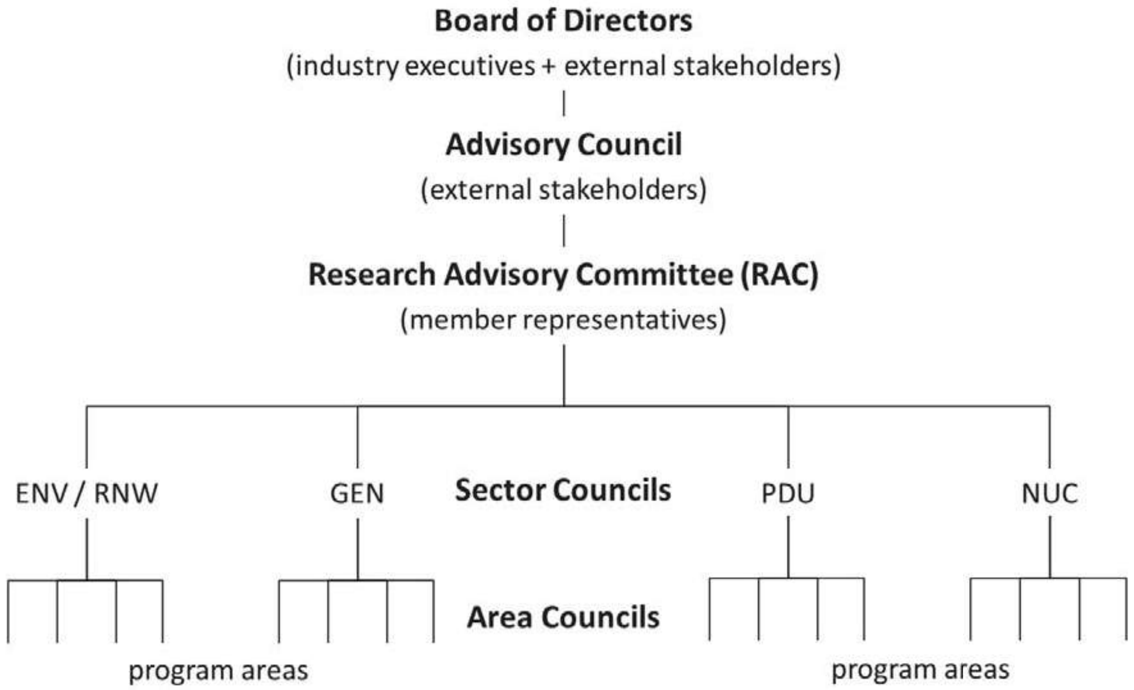


Figure 29: Multi-tiered advisory structure of EPRI

The Research Advisory Committee (RAC) provides guidance on EPRI's technology strategy; it identifies major science and technology needs and priorities of the electricity industry. Furthermore it serves as the integrating advisory group on industry issues for EPRI's four Sector Councils: "Environment", "Generation", "Power Delivery and Utilization" and "Nuclear".

The Advisory Council includes leaders from regulatory, academic, environmental, and scientific organizations, along with the finance and business sectors. It advises EPRI management on trends in political, economic and social issues and ensures research relevance and balance in serving the public interest.

Most allocation decisions occur at the sector/program level. As a starting point the members elect to join specific programs. There are semiannual advisory meetings on the general research direction. Supplemental projects are being carried out in order to address emerging issues. At the same time, EPRI seeks to tailor its program offerings to align with both tactical and strategic member concerns. The Technology Innovation (TI) Program complements bottom-up sectoral programs with a strategic, top-down allocation to cross-cutting and/or early-stage research. Accompanying reviewing of the overall portfolio is being performed by high-level advisors.

The strategic programs within the 2014 Technology Innovation Program can be taken from Figure 30:

Power Generation	Materials
	Nondestructive Evaluation
	Nuclear Fuel Technology
	Renewable Energy and Integration
Power Delivery and Utilization	Distributed Energy Resources & Integration
	Energy Efficiency
	Grid Transformation
	Power Electronics
Environmental	Carbon Capture
	Env. Impacts of the Future Power System
	Near Zero Emissions
	Water Use and Availability
Cross-Cutting R&D	Concrete
	Cyber Security
	Sensors & Operations

Figure 30: 2014 Technology Innovation Program - Strategic Programs

From its inception in 1972 until deregulation in the 1990’s, EPRI’s portfolio was allocated almost entirely top-down. In the current model, members “vote with dollars” for most programming; only around 10 % is being allocated top-down. The decentralized compilation of EPRI’s portfolio is efficient in terms of market needs. On the other hand, it risks missing longer-term issues. For that reason one of the key challenges is, how well the market-based allocation does perform and how top-down allocation can best complement it.

Discussion and Conclusion

Research, development, and deployment of innovative technologies are crucial to meeting future energy challenges. The capacity of countries to apply sound tools in developing effective national research and development (R&D) strategies and programs is becoming increasingly important, especially against the background of uncertainties regarding future energy systems. The IEA Experts' Group on R&D Priority-Setting and Evaluation (EGRD) was established by the IEA Committee on Energy Research and Technology (CERT) to promote development and refinement of analytical approaches to energy technology analysis, R&D priority setting, and assessment of benefits from R&D activities. During the workshop in Paris the considerable progress in this field was demonstrated, especially for the formalization of processes and methods.

Higher uncertainties lead to higher attention for R&D priority setting

The challenges in context with R&D priority setting have considerably increased due to uncertainties regarding the future development of the global energy system. Especially for this reason the formalization of R&D priority setting is crucial. In particular it is important to anticipate and manage future political, economic and technological developments. This has to be part of a target-oriented R&D policy. In this context, models and modelling tools have a critical role to play in supporting decision making processes and accelerate and scaling up R&D to market deployment. Several tools and instruments that can support priority making at different levels already exist: these need to be further improved, including through collaborative networks.

Moreover, given the complexity of the innovation challenge, a suite of instruments and approaches is needed, covering, engineering, economic, social and environmental dimensions of the energy challenge in an integrated manner.

Knowledge and data sharing and benchmarking are critical

There is a high interest in an international benchmarking system in the field of energy research and innovation that could help compare and assess progress. Several examples exist at various levels, such as INSEAD/WIPO Global Innovation Index, the European Union's Innovation Union Scoreboard, the Dutch Innovation Sensor, and WIFO's pilot Energy Innovation Scoreboard, focusing on renewable energy. These could be further improved to address specific policy questions. For instance, covering dimensions related to competitiveness, security as well as energy innovation would provide useful insights to R&D policies. However, the lack of data remains a critical challenge. This refers to availability, completeness and timeliness.

In this context, strengthening collaboration, information and data sharing needs to be encouraged. Data from IEA and other sources, including expert-based technology databases such as the European Commission's ETDB, can be valuable references. Moreover, better and more systematic use of expert knowledge and expert elicitation processes could help fill remaining gaps.

Participants expressed their support and interest in energy innovation scoreboards, even though there is further need to discuss indicators to compare and assess innovation as well as the data availability.

Framework conditions create markets and technologies

Reliable framework conditions are crucial in context of successful priority setting in the field of R&D. This is especially due to the long time periods between R&D decision and launching a new technology on the market.

During the last decade utilities have considerably increased their R&D expenditures. This indicates that utilities reflect the increased uncertainty in context with the future development of the energy system and that they have therefore intensified efforts to increase their competitiveness.

The coordination of R&D priorities between the public and private sectors was not a major subject of debate. However, the need for increased support for demonstration projects was pointed out by industry.

New markets ask for innovative business models

The changes in the electricity sector open up a variety of new business models for regional suppliers and flexible service companies. The large utilities make a range of efforts to serve these markets. To increase their prospects of success, often cooperation is being entered when offering services in the field of energy management, third party financing or in context with decentralized power generation. New market players and service providers in each case can respond flexibly to the needs of customers.

Path Forward

A considerable step forward compared to previous workshops can be observed. The situation has improved as there are a lot of models available which can be used in context with prioritization of R&D investments. The large variety of models goes along with the chance to learn from each other and to develop models further. In this context it might be promising to take the step forward from linear to multi-dimensional models. The focus solely on energy technologies should be enlarged, e.g. by capturing the whole process including demand side aspects like energy services and to integrate social benefits of R&D, too. Moreover, system analyses are increasingly needed to tackle complex issues and jointly address key societal challenges – economic, environmental, and social.

It is crucial to provide appropriate tools for the different tasks and levels regarding R&D priority setting. Referring to indicators there is still a need for improvement in context with data availability. Regarding evaluation of R&D it has to be taken into consideration that R&D in one technology field might also lead to progress in another one. Otherwise the benefit of R&D will be underestimated. Depending on what is being taken into account when assessing a system, the results might be different. This is especially important as there are different drivers for the transition of the energy system in different countries.

The deployment of new technologies depends on a lot of enablers besides of innovation policy, too. Harmonizing energy policy and innovation policy might be helpful in this context. As investment in the transformation of the energy system in most cases will be long-term, it is crucial to offer stable and foreseeable framework conditions to the actors involved. A big challenge in this context is the integration of new technologies into existing infrastructure. As renewable energy investment has a high share of capital expenditures, strong R&D efforts have to be taken in order to reduce the respective investment costs within a short time.

To successfully transform our energy system in a contemporary way, joint efforts will be necessary. This is especially true as there is the need to increase spending on R&D considerably in order to achieve climate change and energy targets.

Appendix A: Acronyms

2DS	2° Scenario
4DS	4° Scenario
6DS	6° Scenario
APEC	Asia-Pacific Economic Cooperation
ARPA-E	Advanced Research Projects Agency - Energy
BOP	Balance of Plant
CAPEX	Capital Expenditures
CCGT	Combined Cycle Gas Turbine
CCS	Carbon Capture and Storage
CERT	Committee on Energy Research and Technology
CNREC	China National Renewable Energy Center
CNS	Carbon Neutral Scenario
CO_2	Carbon Dioxide
CREAM-CGE	China Renewable Energy Analysis Model - Computable General Equilibrium
CRL	Consumer Readiness Level
DARPA	Defense Advanced Research Projects Agency
DOE	U.S. Department of Energy
EDF	Electricité de France
EGRD	Experts' Group on R&D Priority Setting and Evaluation
EPRI	Electric Power Research Institute
ETDB	Energy Technology Data Base
ESME	Energy System Modeling Environment
ESMT	European School of Management and Technology
ETI	Energy Technologies Institute
ETP	Energy Technology Perspectives
ETSAP	Energy Technology Systems Analysis Programme
EV	Electric Vehicle
EU	European Union
GDP	Gross Domestic Product

GHG	Greenhouse Gas
HV	Hybrid Vehicle
ICT	Information and Communication Technology
IEA	International Energy Agency
INSEAD	(INSEAD – The Business School for the World)
IPRL	Intellectual Property Readiness Level
IRL	Innovation Readiness Level
ITIF	The Information Technology & Innovation Foundation
IUS	Innovation Union Scoreboard
JRC	Joint Research Centre
KPI	Key Performance Indicator
LCOE	Levelized Cost of Energy
MRL	Market Readiness Level
MWh	Megawatt hour
NETP	Nordic Energy Technology Perspectives
NPV	Net Present Value
NRC	U.S. Nuclear Regulatory Commission
OECD	Organization for Economic Co-operation and Development
OMB	U.S. Office of Management and Budget
OPEX	Operating Expenditures
PHV	Plug-In Hybrid Vehicle
PV	Photovoltaic
R&D	Research and Development
RAC	Research Advisory Comittee
RD&D	Research, Development and Demonstration
RDD&D	Research, Development, Demonstration and Deployment
RE	Renewable Energy
RES	Renewable Energy Sources
RWE	Rheinisch-Westfälische Elektrizitätswerke
SME	Small and Medium-Sized Enterprise
SRL	Society Readiness Level

TI	Technology Innovation
TIMES	The Integrated MARKAL-EFOM System
TRL	Technology Readiness Level
U.S.	United States
USD	United States Dollars
WIPO	World Intellectual Property Organization

Appendix B: Speakers

Name	Position & Affiliation
Chan, Gabe	Harvard Kennedy School
Blanford, Geoffrey J., PhD	U.S. Electric Power Research Institute
Gross, Dr. Robert	Centre for Environmental Policy, Imperial College, London / UKERC
Heaton, Dr. Chris	Strategy Manager - Modeling, Energy Technologies Institute / DECC, ETI
Jullien, Celine	KiC Inno Energy
Kettner, Claudia	WIFO
Koch, Joost	Senior advisor Quality, Monitoring and Evaluation, RVO.NL
Köppl, Dr. Angela	WIFO
Kool, Rob	Chair EGRD, Manager, NL Agency
Kurosawa, Dr. Atsushi	Director, Global Environment Program, The Institute of Applied Energy
Mamo, Xavier	Chef de Département Délégué, EDF - R&D
Marlay, Dr. Robert	Vice-Chair EGRD, U.S. Department of Energy
Mortensen, Anders	Siemens Wind Energy, E W TE
Munuera, Luis	Energy Technology Policy Division, IEA
Noyens, Koen	Advisor, Energy Policy & Generation Unit, EURELECTRIC
Sgobbi, Alessandra (PhD)	Institute for Energy and Transport, European Commission DG Joint Research Centre
Smith, Benjamin	Senior Adviser, Nordic Energy Research
Stepp, Matthew	Executive Director, Centre for Clean Energy Innovation
Wilmes, Alexander	RWE Aktiengesellschaft, Forschung & Entwicklung Konzern / Steuerung
Xie, Dr. Xuxuan	Energy Research Institute, National Development and Reform Commission, P.R. China

Appendix C: Agenda

AGENDA
Day 1

9:30		Welcome	*Didier Houssin, Director of Sustainable Energy Technology and Policy, IEA*
9:40		Introductions Meeting Objectives	*Rob Kool, Chair EGRD, Netherlands Enterprise Agency*
10:00	1	Input on How the Transformation of the Energy System can be modelled	*Luis Munuera, Energy Technology Policy Division, IEA*
STATE OF THE ART IN MODELLING THE R&D AND INNOVATION PROCESS			
Moderator: Rob Kool			
10:30	2	Principles and Innovative Methods for Public R&D Decision-Making	*Gabe Chan, Harvard Kennedy School*
11:00	3	The JRC-EU-TIMES modelling platform; inputs to prioritisation for energy research and innovation Sgobbi, EC, DG JRC	*Alessandra Sgobbi, EC, DG JRC*
11:30	4	Two- and single-factor learning curves and other methodologies for modelling learning by doing and learning by researching	*Dr. Robert Gross, Centre for Environmental Policy, Imperial College, London*
12:00		Question and Answer-Session	
12:30		Lunch	
NATIONAL AND INTERNATIONAL EXAMPLES FOR MODELLING INNOVATION AND R&D PRIORITY SETTING			
Moderator: Dr. Herbert Greisberger			
13:30	5	USA: R&D Investment Decision-Making – Program Analysis and Evaluation	*Dr. Robert Marlay on behalf of Shane Kosinski, Deputy Director, Advanced Research Projects Agency for Energy, U.S. DOE*
13:50	6	UK: Priorities setting for RD&D	*Dr. Chris Heaton, Energy Technologies Institute / DECC, ETI*
14:20	7	Japan: R&D Investments in Japan's New Energy and Climate Technology Strategy	*Dr. Atsushi Kurosawa, Director, Global Environment Program, The Institute of Applied Energy*
14:50	8	China: Clean Energy Priority-Setting in China	*Dr. Xuxuan Xie, Energy Research Institute, National Development and Reform Commission, P.R. China*
15:20	9	Nordic Energy Technology Perspectives	*Benjamin Smith, Senior Adviser, Nordic Energy Research, Norway*
15:50		Break	

16:20		General discussion – Wrap up	
17:30		Close Day 1	
19:30		Self-Paid Dinner	

AGENDA
Day 2

ENERGY INNOVATION SCOREBOARD			
Moderator: Dr. Robert Marlay			
08:30	10	Energy Innovation Scoreboard – a pilot framework	*Dr. Angela Köppl, Claudia Kettner, WIFO*
09:00	11	Netherlands: The Innovation Sensor	*Joost Koch, RVO.NL*
09:30	12	Assessing a Country's Innovation Status and Potential	*Matthew Stepp, Executive Director, Centre for Clean Energy Innovation*
10:00		Break	
10:30	13	Considerations for an 'Innovation Readiness Level' along with the 'Technology and Manufacturing Readiness Level' indicators	*Celine Jullien, KiC Inno Energy*
PROCESS OF PRIORITIZATION OF R&D BUDGETS IN THE PRIVATE SECTOR			
Moderator: Dr. Stathis Peteves			
11:00	14	Innovation Action Plan of Eurelectric	*Koen Noyens, Energy Policy & Generation Unit EURELECTRIC*
11:30	15	Modelling and Simulation assisted Strategic R&D Programming	*Xavier MAMO, Chef de Département Délégué EDF – R&D*
12:00		Lunch	
13:00	16	Prioritizing Corporate Investments in R&D	*Alexander Wilmes, RWE Aktiengesellschaft Forschung & Entwicklung Konzern / Steuerung*
13:30	17	Cost of Energy as R&D Prioritization	*Anders Mortensen, Siemens Wind Energy*
14:00	18	Meeting R&D Needs of Utility Clients	*Dr. Geoff Blanford, U.S. Electric Power Research Institute*
14:30		Break	

PANEL DISCUSSION AND SUMMARY			
Moderator: Dr. Birte Holst Jørgensen			
15:00		Panel Discussion, followed by Participants Discussion and Round Table	*Participants:* *Dr. Herbert Greisberger, Vice Chair EGRD* *Alicia Mignone, Chair CERT* *Rob Kool, Chair EGRD* *Dr. Robert Marlay , Vice Chair EGRD* *Dr. S.D. Peteves, EC, DG JRC*
16:45		Wrap up of the workshop	
17:00		End of workshop	
19:30		Self-Paid Dinner	

Appendix D: Useful References

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