DEVELOPMENTS IN ENERGY EDUCATION:

Reducing Boundaries

Summary Report

Copenhagen 9-10 May 2012

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 organisations, and other stakeholders.

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

Research, development and deployment (RD&D) 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 IEA's 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 support the CERT, feed into analysis of the IEA Secretariat, assist the Group of Eight (G8) and Clean Energy Ministerial (CEM), and provide a global perspective on national R&D efforts.

For information specific to this workshop, including the agenda, background information, and presentations,
see http://www.iea.org/workshop/developmentsinenergyeducationreducingboundaries.html.

[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

The IEA Experts' Group on R&D Priority Setting and Evaluation (EGRD) examined the challenges in providing the needed skilled personnel to design, build and maintain the energy system of the future.

The transition to a secure, sustainable and affordable energy system requires a highly skilled and diversified workforce that can operate and maintain the existing system while also create and develop the energy system of the future. Many countries face a workforce challenge in the energy sector and the educational needs are increasingly being addressed by the sector at large.

Governments launch open source initiatives to facilitate and disseminate energy education in the traditional educational systems, career development tools and continuing education and training, not least in the energy efficiency area. Universities and colleges develop new comprehensive energy educations and revitalize conventional educations to make it more attractive to the younger generations. New institutional structure and strategic partnerships bring together industry and universities in an integrated research, innovation and education set-up to accelerate knowledge creation and dissemination in relevant energy areas. International cooperation plays an important role, characterized by openness of the higher education systems, recognition and to some degree consistency between educational systems. Traditional student mobility mechanisms such as mobility, training and career development grants, international research schools and double degrees likewise contribute to disseminate energy knowledge across boundaries.

As this was the first time, the IEA EGRD addressed the developments in energy education, it was recommended to:

- Build on these first discussions and findings and further explore and analyse the proper role of different actors of the energy sector and to identify good practises in the energy education value chain and international capacity building.
- Further encourage the multiple efforts by governments, educational institutions and the industry to make the energy sector attractive to the youth.
- Further develop the good work in organising international research schools, career development programmes and competence gap analysis in selected technology areas and disseminate these experiences to other relevant IEA IAs and international fora.
- Further strengthen the scale up of international capacity building activities by a combination of virtual training, training the trainers and building partnerships with education and training providers.
- Explore and analyse opportunities in e-learning and digital education systems (e.g. Courses), in formal educational systems, international capacity building and public energy campaigns.

Introduction

The energy sector is designed, built and operated by people with strong engineering and technical competences. To achieve the shared vision of a sustainable energy society there is need for substantial improvement and growth in the talent pool to accelerate energy technology development and to operate a secure, affordable and efficient energy system. Many new energy technologies are physically and technically complex, not only in their manufacture but also their design, installation, system integration, operation and maintenance. At the same time, the overall energy system requires highly skilled and competent people at all levels to provide the energy needed.

However, many countries face a workforce challenge and need researchers, engineers and technicians capable of transforming the complex energy system in a sustainable and more efficient way. Many shares the premise that engineering students should be able to conceive, design, implement and operate (CDIO) complex value-added engineering systems in a modern team-based engineering environment to create systems and products. However, if the transition should be robust, workable and smooth, we should simultaneously address the educational needs to operate and maintain the existing energy system while also educating the creators and developers of the new energy system.

Educational and capacity building needs may differ from country to country and from region to region. OECD countries may have some needs, and non-OECD countries with emerging economies some other needs. And in developing countries, access to energy remains a daily challenge for many people.

As a means to accelerate innovation, cross-disciplinary whole system or cross-discipline approaches are on the rise. Cross-border university collaboration is also on the rise, with universities from one country founding excellence centres in another to capitalise on the expertise of the host country and to broaden the student base and international perspectives. On another axis of cross-boundary approach, research conducted in cooperation between a private company, an industrial doctoral student and a university aims at creating new knowledge relevant to the business while also educating the next generation of researchers.

As a result, intellectual and institutional boundaries are also becoming less distinct. The effect of these changes on the structure and role of knowledge institutions carrying R&D on energy technologies is the focus of this workshop.

The workshop aims at examining how these trends affect traditional education and competencies and the influence on innovation and addressed the following topics:

- Assessing the needs of competencies and requirements
- Examining the education value chain and its contribution to accelerating innovation
- Exploring capacity building at a global scale and the interfaces with education institutions
- Discussing the civil society and the role of energy education

Report structure

The report is organized by first providing a snapshot of the global energy discussion, insights of the Danish energy sector and competence needs assessment of the USA and the EU. A variety of educational initiatives from selected universities and the private sector illustrates the efforts to make higher education relevant to the sector and attractive to young people, also in an international context. The international capacity building of energy experts not only describes the many IEA activities at secretariat and IA levels but also the climate change and mitigation work provided by another international organization, such as UNEP. An integrated part of the educational activities comprises the education of the civil society in public campaign and outreach activities. Lastly, the challenges in the design and output of proper educational activities and recommendations are summarized in a discussion of the workshop findings.

Setting the scene

Opening remarks: Snapshot of the global energy discussion

Lars Georg Jensen, International Chief Advisor, Danish Energy Agency

- Link to presentation slides:
  http://www.iea.org/media/workshops/2012/egrd/Jensen.pdf

The overall ambition to provide sustainable energy is nothing new in the energy discourse but can be traced back to the 1987 UN report Our Common Future, which declares a safe and sustainable energy pathway as crucial to sustainable development and calls for energy efficiency and substantial changes to the global energy mix. Also, most energy policy makers agree on four key drivers of global and national energy policy:

- Energy security where people and societies get the amount of energy they need when they need it
- Economic development where energy is provided at a price which enables economic growth and welfare and also where energy poverty is eliminated
- Environmental priorities tackling climate change and local pollution
- Energy safety which provides energy in a manner consistent with safety for people and societies.

Some global trends in the energy sector (2012) are on the supply side characterized by high and fluctuating oil prices, lots of natural gas and coal on the market and concerns about prices, delivery and environmental impact, a very uncertain future for nuclear power and more competitive renewable energy sources. On the demand side, the global trends encompass the increasing demand in emerging economies along with very high energy demands in the OECD countries. And energy efficiency potential continues to not being harvested. As described in the IEA scenarios, this implies escalating GHG emissions unless strong political actions are taken to make energy cleaner and more efficient. Moving beyond fossil fuels has multiple benefits: It is good for the economy and although becoming fossil fuel free is not a free lunch, continuing with fossil fuel will not be cheap either. Prices will become more predictable for businesses and consumers and it will add to the geopolitical independence of oil and natural gas producing countries. Last but not least it is good for the environment.

In 2012, Denmark had the presidency of the EU and priority was given to a directive on energy efficiency in order to make binding measures for energy efficiency to complement the overall EU 2020 targets of 20% renewable energy, 20% reduction of GHG emissions and a non-binding target of 20% improvement of the overall energy consumption. This would also contribute to the overall EU long-term targets of reducing GHG with 80-95% by 2050 and to transform EU into a competitive low carbon economy. As for the Danish energy sector, 50% of electricity consumption will be based on wind power in 2020, coal will be phased out from the power plants in 2030 and all heat and power will be based on renewables in 2035. This will imply a GHG reduction of 40% by 2020 compared to 1990. The key messages from the Danish experience are that the transition to independence of fossil fuels are challenging in terms of

investments and structural changes, but it is technically feasible, economic affordable for the society and beneficial for first mover businesses.

To conclude, energy policy is driven by the three Es – energy security of supply, economics and environmental degradation and the global energy supply continue to be rather uncertain. Most countries invest in coal, oil and gas, but some renewables are becoming competitive and even more in the future, with RD&D playing a key role in making technological breakthroughs.

A Needs Assessment of Competences and Requirements

The session focuses on needs assessment of competencies and requirements and addresses the following questions:

- What are the human resource and educational requirements of energy enterprises in the global economy? How can they be identified?
- Do current educational programmes meet the needs of industry?
- How can industry work with educators to create stronger curricula?

Two perspectives are presented. One provides insight into the US initiatives at federal and private sector levels. The other describes the European effort to make a European Strategic Energy Technology Plan roadmap for education and training taking into account ongoing EU and national initiatives.

It is generally acknowledged that the new energy economy will require highly skilled people with specific technological skills in conventional and new energy technologies. But many countries face a workforce challenge in the energy sector. Therefore governments launch open source initiatives to facilitate and disseminate energy education in the traditional educational systems, career development tools and continuing education and training, not least in the energy efficiency area. New institutional constructs such as the DOE's Innovation Hub and the EU Knowledge and Innovation Centres bring together industry and universities in an integrated research, innovation and education set-up to accelerate knowledge creation and dissemination in relevant energy areas.

Preparing a Modern Energy Workforce: Federal and Private Sector Initiatives in the United States

Craig Zamuda, Senior Policy Advisor and Ann Shikany, Programme Analyst, Department of Energy, USA

- Link to presentation slides:
  http://www.iea.org/media/workshops/2012/egrd/Zamuda_Shikany.pdf

The former US Secretary of Energy, Dr. Steven Chu once said that "Competing in the new energy economy will require our country to harness all of our resources, including American ingenuity." The Department of Energy recognizes that as the energy market grows it will require innovative technologies both clean and conventional, the best minds, with specific technological skills, and a diversity of ideas and perspectives. It reaches out to academia and industry and enables today's students to be a part of the clean energy transformation.

Like many other countries, the US faces a workforce challenge in the energy sector. Many firms in energy efficiency and renewable energy are finding that they are not able to find people with skills matched to their new requirements. Retirements of skilled workers adds to the problem. This lack of alignment between what employers need and what skills are taught and delivered is not least a problem for the energy sector.

The framing questions have been: What are the human resource and educational requirements of energy enterprises in the global economy? How can they be identified? Do current educational programmes meet the needs of industry? And, how can industry work with educators to create stronger curricula?

The Department of Energy offers a portfolio of educational tools and programmes:

- The energy literacy and information tool Energy 101 aims at creating a nationally recognized interdisciplinary general education course for colleges and universities. Energy 101 uses the National Training and Education Resource (NTER), which is an open source tool for authoring and sharing course content and allows for easy modification and customisation of course to fit the individual colleges.
- Career mapping tools are yet another push to map and highlight diverse jobs across the industry, charting possible progression between jobs and identifying training necessary to do these jobs well (http://www1.eere.energy.gov/solar/careermap/).
- Internships and fellowships comprises federal level programmes as well as DOE specific programmes such as The Science Undergraduate Laboratory Internships and the DOE Office of Science Graduate Fellowship.
- Strategic partnerships with universities and industry is promoted through DOE's Innovation Hubs which combine basic and applied research with engineering to accelerate discoveries in critical energy issue areas. Existing hubs focus on Energy-efficient building system design, fuels from sunlight and nuclear energy modeling and simulation. Education and workforce is specific to the Greater Philadelphia Innovation Cluster focusing on energy efficient building and includes continuing education workshops, training and educational materials.
- DOE is part of the federal government diversity and inclusion programme and has the ambition to deliver the best public service by leveraging diversity and inclusion
- The Clean Energy Education and Empowerment (C3E) is a women's initiative led by DOE in partnerships with MIT's Energy Initiative to advance the careers and leadership of professional women in the field of clean energy.

Lessons learned are that firstly, information about education and jobs needs to be easily available and organized. Federal programs are generally dispersed across the agencies and not consolidated in one place, making it challenging to discover and access them. Secondly, students need to be inspired to choose a career in the energy sector, for example through flagship programmes. Thirdly, there is a need to define the proper role of government, institutions, private sector, etc., in addressing the workforce challenge and doing so in a collaborative manner. And fourthly, improved capabilities are required to characterize the needed talent pool to accelerate energy technology research and innovation.

European Strategic Energy Technology Plan – Energy Education and Training Roadmap

Miroslava Nanevar, Energy Policy Officer, DG Research and Innovation, European Commission

- Link to presentation slides:
  http://www.iea.org/media/workshops/2012/egrd/Naneva.pdf

The European Strategic Energy Technology Plan (SET-Plan) was launched in 2007 as the technology pillar of the EU energy and climate policy in order to address the energy innovation challenge. Since then, it has established a strategic frame for the development and advancement of low carbon energy technologies, encouraging joint actions among the Commission, Member States and industry/research organisations in order to pool resources and achieve quicker and cost-efficient implementation at EU level.

In moving forward the energy technology innovation, the SET-Plan has recognized that one of the key elements for successful implementation at EU level is the mobilisation and development of the right human capital. The transformation towards a low carbon energy sector will affect employment and jobs, requiring education and training. Occupations in traditional markets will be reduced while new jobs will be created within the low carbon sector. Therefore education and training initiatives in the right fields are crucial to assist this transition and to boost the low carbon technology market.

Human resources are one of the driving forces behind the transition. The EU needs researchers, engineers and technicians capable of moving forward the development and uptake of new solutions. Core science and engineering knowledge remain crucial as an important base for each energy field. Such core knowledge and competences needs to be "topped off" by specialised education on the respective energy applications based on the latest research results. At the same time, competences in business and entrepreneurship, economic and social sciences will be important drivers for moving technology development and uptake forward.

In order to respond to these challenges, the SET-Plan Education and Training Roadmap puts forward a structural approach, calling for large-scale education and training actions that aim to stimulate long-lasting efforts. It is designed with the following three main guiding objectives:

- To address knowledge, skills and competences needs and gaps via building networks, pooling capacities and allowing quick and wide replication.
- To reinforce the education and training system's link with the business and research environment.
- To plan and enable skill development and recognition, at the same time facilitating the dissemination of new knowledge, techniques and tools.

The roadmap process builds on 13 assessment reports which have been coordinated by the European Commission and key organisations in the field of energy education, research and innovation. Extensive

consultations have been organised in the course of the roadmap development process and attention has been paid to ensure added value and complementarities with the SET-Plan initiatives as well as with other EU frameworks on energy, education and employment. The Roadmap document is expected to be published by the end of 2013, and will be publicly available on the SET Plan Information System (SETIS) website. [2]

In addition, a number of ongoing initiatives were presented, namely:

- The European Institute of Innovation and Technology (EIT)[3] that promotes and integrates higher education, research and innovation of the highest standards. It operates through Knowledge and Innovation Communities (KICs). The activities in the energy field are organised in KIC InnoEnergy consisting of 30+ stakeholders and 50+ partners from research institutes, universities, business schools, companies and cover the whole energy mix.
- Marie Curie Actions[4] support mobility, training, career development and collaboration schemes though open call for proposals. All types of activities are open also for applications from the energy field.
- The Build Up Skills Initiative[5] is an initiative under the Intelligent Energy Europe Programme (2011-2013) that focuses on continuing education and training of the existing workforce in the building sector, addressing new skills and qualifications needs related to buildings' energy performance, renewable energy integration, and others.
- Educational initiatives in the nuclear energy field at EU level include, for example, the European Human Resource Observatory in the Nuclear Energy Sector (EHRO-N)[6] monitoring short, medium and longer term needs of human resources and expertise in nuclear energy and safety, the European Nuclear Education Network (ENEN)[7] preserving and further developing nuclear education, training and expertise, the EURATOM Fission training schemes and their use of the European Credit System for Vocational Education and Training (ECVET).

[2] http://setis.ec.europa.eu/
[3] http://eit.europa.eu/
[4] http://ec.europa.eu/research/mariecurieactions/
[5] http://www.buildupskills.eu/
[6] http://ehron.jrc.ec.europa.eu/
[7] http://www.enen-assoc.org/

The Education Value Chain

The education value chain session addresses the following questions:

- What can educational organizations do to accelerate innovation?
- What initiatives are proven to accelerate innovation, what initiatives look promising, and what new ideas are there?
- To what extent can cross-disciplinary educational programmes and initiatives accelerate innovation?
- What are the spillover effects of education developments on employment?

Education, competence and capacity building are founded in national institutions and targeted towards national energy sector needs. Knowledge does not recognise boundaries and higher education has traditionally always appreciated mobility across institutional boundaries, being an engineering students doing her master thesis in close cooperation with a firm, being a graduate student staying one semester at another university in another country, being a post graduate student member of a national research programme or being a student obtaining a double degree from two different universities in two different countries.

Whole Energy Systems Graduate and Postgraduate School

Mats Söderström, Programme Director Linköping University, Sweden

- Link to presentation slides:
  http://www.iea.org/media/workshops/2012/egrd/Soderstorm.pdf

The main goal of the Energy Systems Programme is to develop new knowledge that enables long-term growth in the direction of sustainable and resource-efficient energy systems. Long-term strategic thinking is vital to guiding the change process in the short term, and knowledge must be applied in harmony with social goals and democratic influences.

The energy markets are being deregulated and internationalised. Requirements calling for the environmentally friendly and long-term sustainable management of our resources are intensifying. New alternative energy sources such as biofuel and solar energy are expected to play an ever-increasing role in the systems of the future. Efforts to make industrial, residential, transportation, and public sector energy use more efficient are also being stepped up. Addressing the dilemmas facing our energy systems will require broad competence. Technical knowledge must be combined with social science insights into the environment in which the technology is being incorporated. This means that energy systems should be viewed as socio-technical systems that will be analysed not only on the basis of technical and financial factors, but also with regard to their social functions.

The Energy Systems Programme is a national research programme and postgraduate school with participation of Linköping University, Uppsala University, Chalmers University of Technology and KTH. The Energy Systems Programme has, since 2001, been funded mainly by the Swedish Energy Agency (STEM), Linköping University, industry, energy companies, and municipalities.

The research conducted within the Energy Systems Programme is organised in three cross-university and cross-faculty fields of research that strongly encourage the interdisciplinary exchange of knowledge. These are:

- Buildings in the energy systems
- Industrial energy systems
- Local and regional energy systems

The interdisciplinary research combines social science and engineering competences including the exchange of methods and knowledge. This is enabled by a common course package and lively discussions of methods and results among the programme participants.

A key word in the programme is cooperation, which is based on the individual strengths of the involved departments. This attitude influences not only individual research activities but also undergraduate education and interdisciplinary research and networking at each university. The main contribution to society is the research results related to complex systems and very educated people having a broad knowledge on energy systems. So far after 15 years, the programme has produced 52 PhD thesis, 3 Lic Eng thesis and more than 400 publications and not least long lasting networks with organisations, government, industry and other research communities.

Teaching New Energy Technologies and Systems

Paulien Herder, Professor, Faculty of Technology, Policy and Management, Delft University of Technology, the Netherlands

The Delft Energy Initiative at the University of Delft in the Netherlands was founded to create a one stop shop to provide easy access to the more than 700 energy researchers at the university. It brings together researchers, students, companies and governments to tackle the energy challenge to provide clean, reliable and affordable energy for the world's population and at the same time exploit new economic opportunities.

The Initiative rests on three pillars.

- Research is often made in collaboration with industry and covers a diversity of fields including solar power, geothermal energy, wind energy, energy storage and grids or networks, institutions and markets.
- Entrepreneurship and innovation embraces a number of on campus activities: The Green Village is a lively village on the TU Delft campus where sustainable energy technology is developed, demonstrated and used real time and the campus becomes greener and greener. Examples are charging points for electric cars and a new system of intelligent street lighting on the campus developed by a TU Delft alumnus. The YES!Delft is the high-tech entrepreneurs centre where students, professionals and scientists are inspired to make their first steps on the path to becoming an entrepreneur . YES!Delft focuses on companies with a technical, innovative and

scalable product or process. One such example is the spin-off Ephicas producing fuel-saving aerodynamic aids for road transport.

- Education consists of various cross disciplinary programmes at BSc, MSc, PhD and continuing education levels where the future energy leaders obtain the necessary skills to make the energy transition come true. TUDelft offers a MSc in sustainable energy technology with possibility to specialize in energy from biomass, solar energy, wind energy, sustainable hydrogen, electrical power engineering and energy and the society. Other programmes comprise the European MSc Economics and Management of Energy Networks supported by Erasmus Mundus, the European Wind Energy Master, also supported by Erasmus Mundus and the Erasmus Mundus PhD programme Sustainable Energy Technology Systems (SETS). For post-graduate and practitioners, the Toptech Master of Business in Energy is offered. The student association has organised more than 1,000 students in The Energy Club. The club organises lectures, events and other activities and provides an important link between students and industry regarding internships, MSc thesis projects, spinoffs, networks etc.

Talent Factory for Wind Power

Anders Dalegaard, Project Manager, Danish Wind Industry Association

- Link to presentation slides:
  http://www.iea.org/media/workshops/2012/egrd/Dalegaard.pdf

Danish Wind Industry Association (DWIA) is an industry association with more than 240 members across Denmark, both large and small firms. Members consist of wind turbine manufacturers, energy companies and the wide range of companies that provide components, services and consultancy and the mission is to promote these firms interest in the best way and create networks.

The rationales behind the establishment of the Talent Factory initiative was the increased challenge in the wind power industry experiencing global development and growth, while a decreasing interest in engineering among young Danes and existing engineer students with limited knowledge on wind power. This led to new ideas to approach the students and new ways to show responsibility towards educating the next generation of engineers in the wind power industry.

The Talent Factory represents a wish from the industry to show a larger engagement in the education of new engineers. It provides a web portal with knowledge about wind power and through its activities the industry has the opportunity to get contact to the young talents at an early stage of their education and also to recruit highly qualified employees.

The voice of the wind industry is clear when it comes to education: there is a strong need for candidates which are highly skilled in classical engineering fields. Companies will do the necessary specialization – on the job training. However, there are specific demands for two types of engineers - power engineers and test engineers.

The Talent Factory provides a 'one-door-approach' with the objective to improve the knowledge and student interest in the wind power industry. One measurable outcome is an increase in student projects in collaboration with firms from the wind industry.

The role of the Danish Wind Industry Association is mainly to serve as facilitators in building networks and thereby links between education, innovation and knowledge.

The list of activities from the talent factory includes:

- Wind Power Tours – students
- Wind Power Tours – educators
- Summer Schools
- Conference and exhibition visits
- Competitions
- Guest Lectures
- Company visits

The Talent Factory visits sites together with talented and motivated students e.g. we filled up a bus with 50-100 students to the European Wind Energy Association (EWEA) conference for free and each year there is a boat trip to the offshore wind farm at Lilleoere (DK). Currently, there are 2500 profiles on the Talent Factory website and industry uses this talent bank to search for future employees.

In conclusion, nothing is solved by a web-site and it is a constant challenge to reach out to the students and to maintain the contacts. A very positive outcome is that companies now think pro-actively about how to engage in student projects. So far The Talent Factory is mainly focused on building networks via the Danish wind industry and universities.

Achieving Understanding of Complex, Interdisciplinary Energy Systems

John Loughhead, Executive Director, United Kingdom Energy Research Centre, UK

- Link to presentation slides: http://www.iea.org/media/workshops/2012/egrd/Loughhead.pdf

UKERC conducts research in future sustainable energy systems. These areas are divided into six basis 'business areas'. These are: Networking and capacity building; Cohesion of UK energy research community; Main gateway to international energy research community; Support interdisciplinary research students; Training: Summer School: and finally, they inform UK policy development and research strategy.

The activities are run by the universities – 35 different universities – 130 researchers, and basically 7 people that run the activities on the operational level. The philosophy of the summer school is that energy is a vast field, rather than an exact science. The summer school started in 2005 with the purpose of giving an understanding of the whole energy systems to PhD students. There were 23 people at the first summer school in 2005 – then they made it international and doubled the size.

The objectives of the summer school are:

- Give students a taste/understanding of whole energy system issues and challenges
- Broaden student perspectives and introduce multidisciplinary needs in energy - is there any generic interest? (a lot of these needs are transferable to other areas)
- UK students encounter other national approaches. By bringing in the non-UK student, they communicate that they want to make it visible that they are other way of doing shaping and creating and energy system than the UK way.
- Initiate professional networks -You also need network to be in this business
- Non-UK students exposed to UK energy research landscape and concepts
- Ideally, spark collaborative thinking, while tapping in to the others resource bank

The school is free and accepted by application. Every year there are typically 400+ applications for the summer school of which 100 are invited to participate with a gender mix of 60/40 male/females. It aims at PhD students at their second year of their PhD where students are open minded for input and networking. The school is professionally facilitated through a tutor team and provides a mix of lectures, projects and skills training. It entails strong social elements mixed with technical exchanges between students.

Each year is different - it is a dynamic crowd with different group dynamics. In general, PhD student are young, they are enthusiastic and intelligent: The people of the summer school provides the right input – but it important that it is the students themselves take takes ownership and create commitment – from the administrative role - it is getting the right people involved that matters – they then sparkle (shine). As the dynamics are very different–each school is different – and therefore they never bring back alumni. Each batch has created its own network. Some students discover that specializing in the field energy is not for them. This is not a failure: we have given them an experience – and some now know that they actually want to be an energy specialist.

Sino-Danish Center for Research and Education – Sustainable energy Programme

Birte Holst Jørgensen, Principal Coordinator of the SDC sustainable Energy Programme

- Link to presentation slides: http://www.iea.org/media/workshops/2012/egrd/Birte.pdf

The Sino-Danish Center for Research and Education is a bilateral university collaboration between the eight Danish universities and the University of China Academy of Science (UCAS) and the Chinese Academy of Science (CAS) institutes to do joint research and master programmes in China. The agreement was signed in 2010 at a signing ceremony attended by high level Chinese and Danish politicians and decision makers.

It is an innovative institutional structure aiming at partnership and equal footing in strategic guidance, daily management, research and teaching. The many PhDs will receive a double degree from both CAS as well as from the Danish university and the master students will receive a double degree from the Danish university and the CAS institute. A SDC building will be built at the Yangihu campus and will host teaching facilities, accommodation for researchers, social spaces and conference areas.

The Sustainable Energy Programme is one of five programmes and is founded in a shared energy vision to assure energy security of supply, combat environmental degradation and to create a sustainable economic growth. The programme builds on previous and on-going Sino-Danish collaboration, including:

- Research Centres of Excellence supported by the Danish National Research Foundation and the National Natural Science Foundation of China
- Strategic energy research projects supported annually by the Danish Strategic Research Council and Ministry of Science and Technology of China (MoST) since 2010
- Sino-Danish renewable energy programmes, including the Wind energy Programme 2007-2010 and the Renewable Energy Programme 2009-2013. Both hosted by Energy Research Institute (ERI) under the National Reform and Development Commission (NDRC)
- In addition, in 2012 the Danish Minister of Climate, Energy and Building Martin Lidegaard signed three Memorandums of Understanding (MoU) during the visit of President Hu Jintao to Denmark: 1) National Energy Administration (NEA) underlining and supporting the cooperation with China National Renewable Energy Centre (CNREC); 2) Ministry of Housing and Urban-Rural Development (MoHURD) cooperating on energy efficiency in buildings; 3) Ministry of Science and Technology (MoST) cooperating on development and demonstration projects.

The Programme is managed by two Chinese and Danish principal coordinators assisted by two Chinese and Danish Head of Educational programmes. Most sub-themes of common interest were agreed upon in 2009 and include fusion energy, solar energy, wind energy and bio-energy. Since then thermal energy and energy systems analysis and policy have been added to the sub-themes, demonstrating the wish to address sustainable energy technologies without picking the winner. Each sub-programme is led by a Chinese and Danish researcher responsible for developing the research cooperation, mostly through PhD candidates. On the Danish side, five universities are involved with DTU being the most dominant. On the Chinese side more than 11 CAS institutes are involved together with prominent universities and research institutes. The PhD candidates have both a Danish and a Chinese supervisor, are expected to spend at least 6 months at a CAS institute respectively a Danish university and may obtain a double PhD degree.

In conclusion, it takes time and much energy to build an international research and education programme but cooperation has been facilitated by long-term research and technology cooperation, high level commitment from the Chinese and Danish governments and the persistent and good cooperation at all levels of the programme.

Capacity Building – A Global Responsibility

The session on capacity building – a global responsibility explores the following:

- What are the barriers and opportunities to expanding university, training or capacity-building programmes across borders or regions?
- What does it take to influence education institutions to expand their programmes?

Capacity building is an integrated part of the dynamic development of the energy system and can be characterized as technical assistance to those in need of expertise, tools and data to plan and execute energy policy and climate change mitigation measures. Most often such assistance is organized as a partnership and scales up the training by a combination of on-line training, training the trainers workshops and building partnerships with local stakeholders. Some IEA IAs take responsibility to address the need for skilled staff within new energy technology areas and organize international research educational activities. Also in a highly specialized field such as energy modeling, it takes time to build up the necessary capacity even with very good university candidates. Therefore, international research and practitioners networks play an important role in the training, maintaining and development of the modeling and system analysis around the world.

United Nations Environment Programme Capacity Building

John Christensen, Head of Risoe UNEP Centre, Denmark

- Link to presentation slides:
  http://www.iea.org/media/workshops/2012/egrd/Christensen.pdf

Since the very introduction of the Clean Development Mechanism (CDM) and Carbon Finance in the international effort to combat climate change, the UNEP Risoe Centre at DTU has been deeply involved in capacity building at institutional and individual country levels.

In short, CDM allows Annex 1 countries to meet part of their emission reduction requirements for 2008-2012 at lower costs in non-annex 1 countries than could be done domestically. This implies that Annex 1 countries are allowed to acquire Certified Emission Reductions by implementing GHG mitigating CDM projects in non-annex 1 countries. The implementation of this new CDM has been faced with a number of challenges. The CDM modalities and procedures are new and complex and sellers, buyers and intermediaries have different insight and knowledge of the mechanism. There is an outspoken lack of trained national CDM expertise and entities capable of bundling projects for the buyers.

The CDM capacity development approach is illustrated in the figure below.

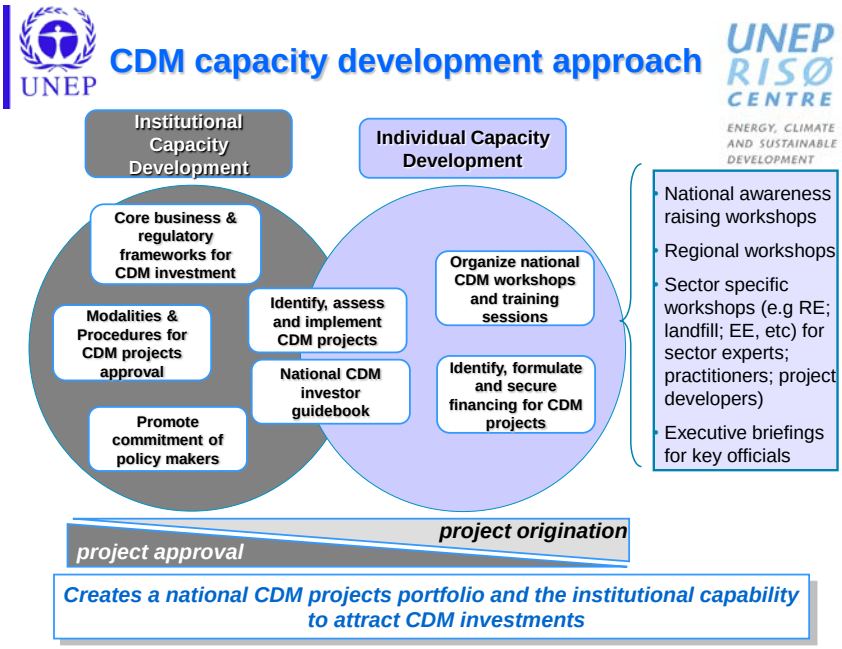

Figure 1. CDM capacity development approach

The capacity building effort aims at creating a national CDM project portfolio and the institutional capability to attract CDM investments. At institutional level it focuses on the core business and regulatory framework, modalities and procedures for CDM approval and political commitment. At the individual country level national CDM workshops and trainings sessions are organized for sector experts, practitioners and project developers. So far, UNEP/URC capacity development activities take place in 28 countries in Africa, including 11 least developed countries and in 9 countries in Latin America and the Caribbean. The capacity building approach is driven by a continuous barriers analysis in order to include countries and sectors left behind. The focus is on complementarity and synergy between international, regional, national and inter-sectoral interventions. This means that emphasis is on partnership. National activities are undertaken with governmental focal points and engage national experts and institutions. Also, technical support is provided in collaboration with regional centres of excellence and experts from other countries in the region. And finally, the activities are undertaken in partnerships - with UNDP on CDM in Latin America and Africa, with the World Bank on national projects and regional carbon forum and events and with UNFCCC Secretariat on CDM Bazaar and Pipeline.

In the practical capacity building, tailor made workshops are designed for different groups in the public and private sector. Practical hands on and participatory training sessions have been made on how to identify and formulate Project Idea Notes (PIN) and Project Design Documents (PDD), Certified Emission Reductions (CER) commercialisation and portfolio dissemination and promotion. The URC has developed a number of necessary guidance and training materials. The URC provides web-based information and knowledge relevant for the CDM community:

- A data base compiling all CDM projects, including market surveillance and projections of GHG reductions
- The CDM Bazaar portal for sellers, buyers and service providers

- CDM Methodology Selection Tool which facilitates choosing a methodology that is applicable to a given CDM project
- CDM Methodology Fact Sheets, giving a snapshot review of technologies used to date in CDM activities

The URC is also involved in capacity building in the area of Carbon Finance. Short course collaboration has been made between URC and the University of Twente on CDM and project development training, and the challenge now is to integrate the topic into formalized education and training. This takes time and given the changing nature of the topic, it should take account of the dynamics of the field.

In conclusion, capacity building in climate mitigation mechanisms has evolved with the implementation of the mechanism. Capacity building and technical assistance take place in many countries and are performed in close partnership with national, regional and other international partners. A combination of training materials, targeted training workshops for national stakeholders and web based databases, tools and analysis has facilitated the difficult implementation of CDM activities in non-Annex 1 countries. So far, it has been a challenge to integrate the topic into formal education and training also due to the dynamic changes of the field.

Forming Tomorrow's Leading Experts on Carbon Capture and Storage

Carrie Pottinger on behalf of John Gale, General Manager and Tim Dixon, Greenhouse Gas IA

- Link to presentation slides: http://www.iea.org/media/workshops/2012/egrd/Gale.pdf

The IEA Greenhouse Gas R&D Programme (IEAGHG) is an international collaborative research programme established in 1991 as an Implementing Agreement under the International Energy Agency (IEA). Carbon capture and storage (CCS) is now generally seen as a major contributor to reducing emissions of CO_2 into the atmosphere. However, a potential barrier to future implementation of CCS is shortages of skilled staff in the future. There is lack of engineering and geoscience skills in general and on top of that, the oil and gas sector is a competitor in the labour market. Also in academia the knowledge base is limited. There are few CCS-specific study programmes and diplomas, field research is costly and students from non-OECD countries have fewer educational opportunities.

To address this issue IEAGHG has worked to form tomorrow's CCS experts by:

Summer school

The IEAGHG CCS summer school aims to provide students from diverse academic backgrounds with a broad understanding of the issues surrounding CCS and encourage their active participation in this area. The summer school lasts for one week and includes presentations and discussion groups led by international experts in the field of CCS. In addition to the discussion programme, the students are divided into teams to undertake short research activities on issues of importance within the CCS area, with a presentation to their peers at the end of the week. Students leaving at the end of the week will have developed a network of contacts in the field of CCS and will have gained a broad overview of the issues surrounding technology development and implementation in CCS. Attendance to date is 279

students representing 35+ countries and six continents. The summer school is sponsored by a broad range of energy stakeholders

The CCS student mentoring programme

The premier international conference on greenhouse gas mitigation technologies – the GHFT series – provides the opportunity to hold student mentoring activities on the margins. The first mentoring programme was held at the GHGT-10 conference in Amsterdam in 2010 and was hosted by IEAGHG and the Global Carbon Capture and Storage Institute. Students were selected from the 2010 summer school applicants representing various disciplines and varying level of experience. A total of 23 students participated – 11 from 7 non-OECD countries and 11 from 10 OECD countries. Non-OECD students are 100% funding and OECD students get a 100€ travel allowance and free registration. The programme is tailored to student needs and consists of an introductory session, tailored conference programme and daily Ask-a-mentor sessions.

CCS Academic Community Task Force

This initiative aims at identifying and engaging programmes on CCS in the world to help determine the path forward for the Carbon Sequestration Leadership Forum and is chaired by IEAGHG and the Brazilian Center of Excellence in Research and Innovation in Petroleum, Mineral Resources and Carbon Storage. The tasks ahead are to map CCS post-graduate course worldwide, to make a gap analyse and propose targeted activities where needed. A first study has been made on CCS education in the UK which will be expanded to include Europe, US, South America, Japan, Korea, South Africa, New Zealand and Australia.

Assistance with other CCS programmes

Other activities include the UK CCS Consortium Early Career Researchers' Programme. This programme supports researchers' training for an academic career as well as those whose future lies outside academia. The programme is aimed at academic staff in the early stages of their research careers, to give participants support in networking, career planning and the development of their CCS research capacities. It consists of two core events – a 3-4 days Winter School and the Annual Summer Meeting.

The CO2 Geological Storage Europe Spring School is a week long research school for young scientists. It is organized by the European coordination action on CO2 Geological Storage - CGS Europe – which pools together the expertise of the key research institutes in the area of CO2 geological storage in European Member States and Associated Countries.

In conclusion, in order to avoid gaps in skilled engineers and scientists in the future, it is necessary to raise awareness of and interest in CCS. This is a task for industry, government and academia a like. But especially for academia, it is important to establish relationships with PhD and post-graduate students through summer schools and mentoring programmes and to review academic programmes to ensure that CCS is covered and industry needs properly incorporated.

International Energy Agency Training and Capacity Building

Assen Gasharov, Programme Manager, Training and Capacity Building Programme, IEA

- Link to presentation slides:
  http://www.iea.org/media/workshops/2012/egrd/Assen.pdf

The core role of IEA is to gather energy information globally and then disseminate globally and thereby contribute to reducing knowledge boundaries related to energy systems. IEA is not an education institution with the necessary staff to train on a larger scale. The main focus is to provide policy advice for member governments based on data gathering, research and analysis. But since there is a strong interest in IEA's unique expertise and tools, this demand can be seen as an opportunity to expand remit. The IEA training and capacity programmes have run since the beginning of 2010 with a ministerial mandate. Today, IEA has organised more than 20 training events with more than 500 participants on average per year. Over 100 countries have been involved, especially from non-IEA countries. The capacity building programme is demand driven and includes a variety of energy topics and training formats. The rationale behind the training programme is that speaking the same language enables collaboration among countries - IEA and non-IEA countries alike. The programme combines theory and practice and provides hands-on exercises, simulations and problem oriented discussions. Study tours, site visits and real cases are organized by the responsible institution with whom IEA collaborates.

The training takes place at the IEA in Paris and in host countries. The training at IEA includes:

- The multilateral and interdisciplinary Energy Training Week in spring
- The multinational Energy Statistics Course in spring and autumn
- Other multinational thematic workshops 2-3 times per year
- Multinational emergency / preparedness courses twice a year
- Bilateral training 1-2 times per year for each single country

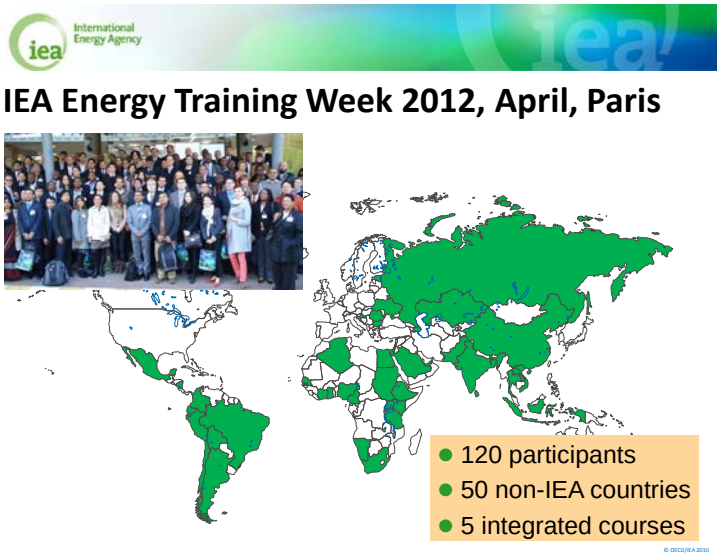

Figure 2. IEA Energy Training Week

The training in host countries can be both bilateral and regional and includes:

- Regional interdisciplinary training course 2-3 times a year
- Bilateral training 3-5 times per year for each single country
- Contributions to other agencies' training

The multilateral training courses facilitate peer learning, case studies and discussions among participants. The bilateral training often follows a two-step approach, starting out with a smaller group at IEA in Paris and followed by training in the host country with a larger group to maximise learning benefit and dissemination.

The next level for the IEA is to scale up training. This is done by a combination of virtual and on-line training, training the trainers on a country of regional basis and building partnerships with other training providers.

In conclusion, the IEA capacity building effort is demand driven and uses diverse training formats and tailored approaches to improve the outcomes. It relies on local partners to make it happen and to ensure that the lessons learned can be applied afterward in the daily work. So in short, the training is hands on and focuses on practical elements, being tools, methods and skills.

Capacity Building through Energy Modelling and Systems Analysis

Uwe Remmen, Senior Analyst, Energy Technology Perspectives Division, IEA

- Link to presentation slides: http://www.iea.org/media/workshops/2012/egrd/Remme.pdf

Energy modelling and systems analysis play a key role in assisting decision makers in energy policy, energy planning and assessment.

Over the years a universe of energy models has emerged consisting of economic models (e.g. GEMINI-E3, E3MG, IMACLIM-R, OECD ENV-LINKAGES), energy systems models (e.g. MARKAL, TIMES, MESSAGE, LEAP, PRIMES, NEMS), engineering models (e.g. RETScreen) and integrated assessment models (e.g. AIM, REMIND-R, WITCH). Which model to choose depends on the questions to be answered.

IEA uses the energy system model TIMES in its energy outlook analysis. It is a bottom up model that includes the supply of resources, costs and emission balance, the primary and secondary energy and demand services.

Since 1976, the Implementing Agreement ETSAP (Energy Technology systems Analysis Programme) has worked to develop, maintain and expand a consistent multi country energy/economy/environment/engineering analytical capability. The national teams in almost 70 countries share a common methodology, mainly based on MARKAL/TIMES model generators, a consistent set of energy technology sources for more than 50 energy supply and demand technologies and systems analysis. The MARKAL/TIMES around the world is used by more than 150 institutions in 63 countries as illustrated in the figure below.

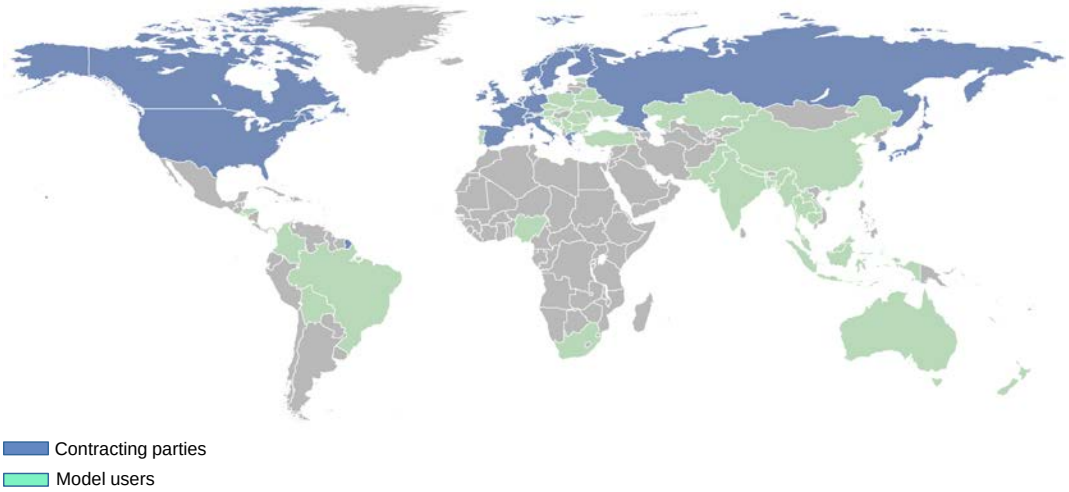

Figure 3. Application of MARKAL/TIMES

The energy modelling and system analysis is a highly sophisticated capability that needs formal as well as on the job training. The question is what are the barriers and opportunities to expanding university and training and capacity building programmes across borders and what does it take to influence education institutions to expand their programmes? The barriers related to the methodology itself that requests a relatively steep learning curve, including data intensive analysis and interdisciplinary expertise. Other institutional barriers are the change in staff, cost of software and the fact that model development is a long-term and continuous process. On the other hand, the modelling community organise training workshops, networks of modellers, energy sector and technology experts have emerged and universities educate and research in energy modelling.

In the context of IEA, energy technology modelling is included in the Energy Training Week and is also offered in in-depth courses. ETSAP offers likewise training courses which take place twice a year linked to the ETSAP workshops and also offers courses on request as well as a website forum.

Model outreach activities are made by other institutions:

- LEAP (Long range energy Alternatives Planning system) developed by the Stockholm Environment Institute (SEI) is an integrated energy planning tool for the economy and used in more than 150 countries. It has lower initial data requirements and relies on simpler accounting principles (www.energycommunity.org).
- AIM (Asia-Pacific Integrated Energy Model) developed by the National Institute for Environmental Studies in Japan integrates emissions, climate and impact models and is applied on local level, on country level within the Asia-Pacific region up to global level.
- IAEA has a tool kit for integrated energy planning and assist member countries to build up capacity through training courses, distance learning and ICT support.
- OSEMOSYS is an open-source energy modelling system and was developed which has been developed by a coalition of organizations including Stockholm Environment Institute, the International Atomic Energy Agency (IAEA), the UK Energy Research Center, and the Royal Technical

University (KTH) in Sweden. It provides a simple and transparent tool to develop new model formulations.

- ENPEP-BALANCE (Energy and Power Evaluation Programme) is developed by Argonne National Laboratory in the USA and is a market share algorithm to determine equilibrium between supply and demand. It is available for free, training courses are offered and it is used in more than 80 countries.
- Numerous university programmes around the world

In conclusion, there is a growing need for even more sophisticated, detailed and reliable energy modelling and systems analysis. But it takes time to build up capacity in the energy sector although the universities and research institutes educates good candidates for developing modelling capability further. Here international such as ETSAP and other international and national networks contributes to the constant demand for training, maintaining and developing the modelling and system analysis capabilities around the world.

Civil Society and the Role of Energy Education

The session on civil society and the role of energy education focuses on the following:

- What are the most effective approaches to educating the public? Why?
- What entity is best suited to teach the public - universities, government, private sector, or non-profits?
- Are top-down or bottom-up approaches more successful?
- What can be done to improve and further careers in the field of public energy education and training?

Energy saving information campaigns can be effective and impact large number of consumers by reinforcing messages via multiple media. Campaigns should motivate and enable changes by improving awareness, creating understanding of the issues, and changing social norms and attitudes. Many aspects of the information campaign will depend on the target group, including the message and the channels used to communicate. Traditional mass media, including televisions, are still the most commonly used communication channels for energy-saving information campaigns, but the social media revolution has open up new channels of communication, not least towards the younger generation.

Real living laboratories are fascinating and stimulating environment for students, researchers, businesses, public authorities and educational institutions. New building techniques are developed, designed, constructed and researched as true living laboratories and functions as an inspiration for other institutions around the world.

Educating the Public to Save Electricity in Times of Crisis

Sea Rotmann on behalf of Sara Pasquier, Programme Manager, Energy Efficiency, IEA

- Link to presentation slides:
  http://www.iea.org/media/workshops/2012/egrd/SavingElectricity&Education(forSea).pdf

Electrical shortfall is a great opportunity to educate the public about energy saving strategies and provides officials with a three steps process to mitigate shortfalls – what are the cause and the duration of the electrical shortfall, what are the opportunities for energy saving and how to implement a comprehensive and balanced package of energy-saving, demand-side tools.

Electricity shortfalls (drought leaves hydro facility dry, political dispute disrupts gas imports, etc.) can be caused by shortages in energy supply for electricity generation and/or insufficient generation, transmission and distribution capacity.

The impact of an electricity shortfall on an economy perspective can be high. Prolonged electricity shortfalls can reduce economic competitiveness by creating uncertainty in electricity supply and increasing electricity costs. The environmental impacts of a prolonged electricity shortfall can also be significant. Faced with mandatory rationing or indiscriminate blackouts caused by load shedding,

consumers often invest in expensive on-site electricity generation produced by air-polluting fuels such as diesel (ESMAP, 2010).

IEA analysis shows that many of the negative impacts experienced as a result of an electricity shortfall can be avoided, or at least minimised, with the application of proven energy-saving strategies that are anchored on educating the public about energy use and conservation. In particular, educating the public in times of crisis can lead to big energy savings by encouraging people to quickly curb wasteful energy practices, delay certain activities to non-peak times and replace old technologies with more energy-efficient ones.

Some educational cases are the following examples:

- Japan, 2011: An earthquake and tsunami struck Eastern Japan, forcing several large nuclear and thermal power stations out of service (now all of Japan's nuclear facilities are out of service for political reasons). A team of policy makers and an advertising consultancy, led by ANRE/METI, were tasked with preparing a multi-dimensional energy-saving information campaign. Elements included displaying electricity forecasts on peak-power/supply-demand balances on web sites, in major train stations and on television; promoting casual and cooler clothing through the Super Coolbiz campaign; publicising electricity-saving tips; creating a power-saving contest in the residential sector; and offering rewards to residential and commercial customers for meeting electricity - saving targets.
- Juneau, Alaska, 2008: An avalanche severed Juneau's transmission link to its hydroelectricpower supply, prompting the utility to switch immediately to reserve diesel generators. Diesel fuel supplied almost all of the city's demand until the line was repaired six weeks later. Juneau's municipal government realised the only way to prevent skyrocketing electricity bills was to prompt consumers to cut consumption. The city led the way by switching off alternating streetlights, certain equipment and lights in public buildings. A city-wide energy-saving campaign, called "Juneau Unplugged", provided end users with advice on how to quickly and safely conserve electricity. This mass-media campaign (using radio, newspaper and internet) was relatively inexpensive and easy to establish. New Zealand, 2008: New Zealand faced the risk of an electricity shortfall in 2008 as a result of a drought. Not only was the drought causing hydro shortfalls – but New Zealand also had to shut down one of the only two gas plants for maintenance at the time. This all happened just before a national election and thus it also became a huge political issue. A mass media campaign was issued to advocate for energy savings. An information campaign was launched and included advertisements in newspapers, television, radio, public transport and websites. Officials also established a dedicated website with news, feedback on consumption data, regional comparisons of savings and information on hydro lake levels and inflows. This was a short term campaign, but it initiated some significant savings across the residential and industry sectors.
- South Africa 2008/09: An acute electricity shortfall that first struck in January 2008 continues to affect South Africa. The shortfall was brought on by insufficient generation supply relative to growing demand, maintenance closures and unplanned generator outages. One such tool is a "Power Alert" message, displayed at 30-minute intervals on the internet and on television, which provides real-time information on the electricity shortfall.

- Chile 2007/08: Chile experienced an electricity shortfall brought on by a drought, interrupted gas imports from Argentina and technical problems arising from fuel switching in thermal power stations. Chile was able to avoid electricity interruptions by implementing a package of measures within the framework of the National Energy Efficiency Programme, including public information campaigns and a programme to distribute CFLs.

Information campaigns are very effective at stimulating energy-saving behaviour. They can be designed and launched quickly, and impact a large number of consumers by reinforcing messages via multiple media. The guiding learning points are that campaigns must motivate and enable changes by improving awareness, creating understanding of the issues, and changing social norms and attitudes. Furthermore; officials should identify the group that they wish to target with the information campaign. The target audience can be anyone from school children to professionals in the industrial or commercial sectors.

Many aspects of the information campaign will depend on the target group, including the message and the channels used to communicate. Traditional mass media, including televisions, are still the most commonly used communication channels for energy-saving information campaigns. Some developing countries, such as South Africa, have implemented road shows and demonstration projects to spread messages in areas without televisions. And finally, several studies advocate that campaigns convey saving energy as "fun and feasible" rather than as "onerous tasks of self-deprivation.

In conclusion, the lessons learned from educating the public in electricity shortfalls is that it is of utmost importance that the population is informed continuously and that the messenger is a trusted one, and not the one to be blamed. Also energy saving behaviour may be caused by the threat of higher prices rather than the actual price increases.

The Districts of Tomorrow

Ludo Kockelkorn, Zuyd University of Applied Sciences, the Netherlands

- Link to presentation slides: http://www.iea.org/media/workshops/2012/egrd/Kockelkorn.pdf

The Districts of Tomorrow is an innovative programme in which educational institutions, researchers, businesses, public authorities and the environment join together to create a centre for a transition to a sustainable built environment at the European Science and Business Park Avantis in Aachen. It was started in 2006 by the directors of the building and technology faculties of Zuyd University to set up a Research and Innovation Centre for Building and New Energy to give students a stimulating environment for new building techniques, with the emphasis on sustainability.

The centre is a real living laboratory where four buildings will be constructed for different purposes – a passive house for living and working, zero concept for demonstration, an 0- or +energy house for living and homecare services and a recyclable house. Besides houses many other elements are developed, designed, constructed and researched, including e.g. public lighting electric transport and 0-water district.

The first building – Tilt to the Sun – is finished and utilised for research and demonstrations. The fourth building – Flower – is a zero-energy and zero-materials building as it is not only self sufficient regarding to energy but over the next 50 years, building materials will be regrown on its roof.

The centre engages actively with the public and the industry. It demonstrates the use of sustainable technologies and the zero concept and thereby assists in realising the targets of some of its partners. It also stimulates new business activities and attract more than 100 students a year and highly competent employees.

The programme has given inspiration to the establishment of new programmes, for example the Future Proof Technology Education in Parkstad, the EU Cradle to Cradle Network of the Province of Limburg and the Tempus Circle of Districts with partners in Russia, Finland and Germany.

In conclusion, the District of Tomorrow is cross-disciplinary programme that accelerates innovation and addresses the need of industry in a global economy. Its educational programme produces more and better employees. Internationally there are many opportunities for collaboration but even more barriers. And there might be a cross fertilisation from higher education to public education and vice versa but it is a psychological, social, financial challenge rather than a technical challenge. It is important to demonstrate and show the most innovative technologies and concepts in living laboratories

Shared Learning: from Theory to Practise

Sea Rotmann, CEO, Sustainable Energy Advice

- Link to presentation slides:
  http://www.iea.org/media/workshops/2012/egrd/EGRDSeaRotmannSharedLearning.pdf

Shared learning is the process of working collectively to achieve a common objective in the group and is guided by some main principles about empowerment, learning from experiences, and a problem driven multidisciplinary approach and engagement. This approach is the opposite of what has governed formal education since the industrial age, which tends to be theoretical, decontextualised, one way and is a simple transfer of knowledge from teacher to student. This is important to have in mind when designing public education campaign in the energy sector.

A public energy campaign is an organised effort through various communication media to alert the public about a given area of significant interest or concern and to change behaviour. There is no single formula to do so and each campaign is tailored for the audience, message, strategy and materials.

The Energy Education Forum was established by the US Secretary of Energy in 2005 and is a multi stakeholder forum with the task to educate the public about energy. As a starting point, they defined energy literacy as “It is a society that understands and appreciates the role energy plays in its economic well-being and the economic cost energy production and use have on the society’s (environmental) quality of life. Such a society is capable of making informed, well-reasoned decisions as to its choices for its usage of energy. Such a society is also capable if directing its elected representatives to formulate stable and sustainable energy policy reflecting those choices”.

Examples of public education range from top down to bottom up:

- Public education led by government implies that front-line civil servants often have to be educated before educating the public.
- The industry led Energy4me global petroleum education outreach programme encourages members to educate in their own context, being at a school in their neighbourhood or participating in a university career.
- Traditional media represents a special challenge to educate the public and the message can easily be misused, distorted or simply not get through.
- Advertising may be an influential means to promote a message and a feeling but seldom much knowledge on energy.
- Social marketing is a more systematic application of marketing along with other concepts and techniques to achieve specific behavioural goals for a social good.
- Action learning is an educational process whereby the participant studies their own actions and experiences in order to improve performance. An example from New Zealand is the Enviroschools Foundation and its process creating a whole school vision, forming an envirogroup, working with the community and implementing action projects.
- Community-led campaigns are e.g. the 11th Hour Project being a non-partisan public education and communication programme to spread awareness about climate change and promote solutions.
- Open innovation started out with the globalisation wave and started to pick up speed 10 years ago with Connect + Develop initiative. In the future it will probably take advantage of social media to reach out to the global community.
- Social media revolution has given us apps for energy and OPOWER save energy with your facebook friends.
- Participatory action research has become popular in, for example, urban planning and is a methodology for intervention, development and change within communities and groups.
- Storytelling is the oldest form of teaching and learning and can be used to teach ethics, values and cultural norms and differences.

The IEA Demand Side Management Implementing Agreement (DSMIA) Task 24 aims at closing the loop in behavioral change in demand side management. It consists of five major activities, including an overview of models, frameworks, cases and evaluation metrics, a number of in depth analysis in areas of greatest needs, an evaluation tool for stakeholders, some country specific project catalogues of ideas, plans and pilot projects and an expert social media platform bringing all the knowledge together. This Task also uses storytelling in many forms to 'translate' the important message for the different stakeholders, sectors and disciplines involved in energy behavior change itnerventions.

In conclusion, no approach is better than the other and the choice depends on the context. What is needed is dedicated people and practitioners educated in energy education.

Discussion and Conclusion

The IEA Experts' Group on R&D Priority Setting and Evaluation (EGRD) examined the challenges in providing the needed skilled personnel to design, build and maintain the energy system of the future.

It is generally acknowledged that the new energy economy will require highly skilled people with specific technological skills in conventional, fluctuating energy technologies and system integration as well as a broader energy system understanding. Many countries – OECD and non-OECD countries alike - face a workforce challenge in the energy sector. The energy sector at large has taken different initiatives. Governments launch open source initiatives to facilitate and disseminate energy education in the traditional educational systems, career development tools and continuing education and training, not least in the energy efficiency area. Universities and colleges develop new comprehensive energy educations and revitalize conventional educations to make it more attractive to the younger generations. New institutional constructs and strategic partnerships bring together industry and universities in an integrated research, innovation and education set-up to accelerate knowledge creation and dissemination in relevant energy areas. International cooperation plays an important role, characterized by openness of the higher education systems, recognition and to some degree consistency between educational systems. Traditional student mobility mechanisms such as mobility, training and career development grants, international research schools and double degrees likewise contribute to disseminate energy knowledge across boundaries.

The following are identified as important topics in developments in energy education:

- **Making energy professional careers attractive**. It remains a challenge to mobilise and develop the right human capital in the energy sector, which is characterized by divergent interests, perspectives and competence needs. A general challenge is to make it more attractive for young people to choose an engineering career. The universities and colleges have strongly improved their promotion efforts towards young people in areas relevant to the energy sector and offer a portfolio of traditional engineering and sustainable energy educations. Also the new energy technology industry engages in developing new educational arenas, offering study tours, career portal, awards and company access.
- **Basic engineering knowledge to be topped up by specialized education.** There is a strong need for traditional energy / power engineering education as well as specialized new energy technology and systems education provided by technical universities at bachelor and MSc level. Such formal educational activities are often provided in new problem driven settings, working laboratories and demonstrations, project work and at best involving companies. Innovation management, business development and entrepreneurship are also topics included in modern engineering education.
- **PhD education ranging from specialized technologies to the whole energy system perspectives.** Post-graduate education is highly specialized and hence mirrors the diversity of the energy system. Within specialized areas such as for example CCS, international cooperation has worked to form the future CCS experts through regular research schools, a student mentoring programme and an

academic community task force. It is judged to be important to also have an understanding of the whole energy system. Therefore, research schools are organized for PhD students with different disciplinary backgrounds to broaden their perspective, to introduce multidisciplinary needs in energy and to initiate professional networks. Such schools are focused, participative, stimulating environments with participants from different countries, with different perspectives and experiences. Understanding of the entire energy system is also a specialization in its own rights, combining technical knowledge with social science insight of the context as it is illustrated in the Swedish national research programme and post-graduate school.

- **New institutional constructs.** Around the world, new institutions emerge to address not only the energy sector needs but also the request to make industry more competitive. For example, geographical clusters of traditional educational institutions, companies and other stakeholders enter into strategic collaboration to take advantage of the geographical proximity and synergies to develop to the point continuing education offerings and materials. Another institutionalised network construct is the EU Knowledge and Innovation Centre (KIC) with many universities and private partners distributed in specialized co-location centres for research, innovation and education around Europe. A third new construct is the bilateral Sino-Danish Centre for Research and Education, merging the best of two very different educational systems, but also characterized by considerable barriers to be overcome when offering double master and PhD degrees in sustainable energy.
- **Institutionalising international capacity building**. Capacity building is an integrated part of the dynamic development of the energy system and can be characterized as technical assistance to those in need of expertise, tools and data to plan and execute energy policy and climate change mitigation measures. Most often such assistance is organized as a partnership and scales up the training by a combination of on-line training, training the trainers workshops and building partnerships with local stakeholders. In a highly specialized field such as energy modeling, it takes time to build up the necessary capacity even with very good university candidates. Therefore, international research and practitioners networks play an important role in the training, maintaining and development of the modeling and system analysis around the world. Likewise, some IEA IAs take responsibility to address the need for skilled staff within new energy technology areas and organize international research educational activities.
- **Public campaigns**. Energy saving information campaigns can be effective and impact large number of consumers by reinforcing messages via multiple media. Many aspects of the information campaign will depend on the target group, including the message and the channels used to communicate. Traditional mass media, including televisions, are still the most commonly used communication channels for energy-saving information campaigns, but the social media revolution has open up new channels of communication, not least towards the younger generation. Real living laboratories demonstrating new building techniques are stimulating environment for students, researchers, businesses, public authorities and educational institutions.

The transition to a secure, sustainable and affordable energy system requires a highly skilled and diversified workforce that can operate and maintain the existing system while also create and develop

the energy system of the future. The educational needs are increasingly being addressed by the sector at large, but more can be done.

As this was the first time the IEA EGRD had addressed the developments in energy education, it was recommended, to:

- Build on these first discussions and findings and further explore and analyse the proper role of different actors of the energy sector and to identify good practises in the energy education value chain and international capacity building.
- Further encourage the multiple efforts by governments, educational institutions and the industry to make the energy sector attractive to the youth.
- Further develop the good work in organising international research schools, career development programmes and competence gap analysis in selected technology areas and disseminate these experiences to other relevant IEA IAs and international fora.
- Further strengthen the scale up of international capacity building activities by a combination of virtual training, training the trainers and building partnerships with education and training providers.
- Explore and analyse opportunities in e-learning and digital education systems (e.g. Courses), in formal educational systems, international capacity building and public energy campaigns.

Appendix A: Acronyms

CAS	China Academy of Science
CCS	carbon capture and storage
CDM	Clean Development Mechanism
CERT	Committee on Energy Research and Technology
CO_2	carbon dioxide
DOE	U.S. Department of Energy
DTU	Technical University of Denmark
DWIA	Danish Wind Industry Association
EGRD	Experts' Group on R&D Priority Setting and Evaluation
EU	European Union
FP	European Framework Programme for Research
GDP	gross domestic product
GHG	greenhouse gas
IA	Implementing Agreement
ICT	information and communication technologies
IEA	International Energy Agency
KIC	Knowledge and Innovation Centre
MoST	Ministry of Science and Technology of China
OECD	Organisation of Economic Co-operation and Development
PV	photovoltaic
R&D	research and development
RD&D	research, development, and demonstration
SDC	Sino-Danish Centre for Research and Education
SET-Plan	The European Strategic Energy Technology Plan
UNFCCC	United Nations Framework Convention on Climate Change
UNEP	United Nations Environment Programme

Appendix B: Agenda

Wednesday 9 May

Technical University of Denmark
Anker Engelundsvej 1, Building 101, Room S09
DK-2800 LYNGBY

WELCOME AND INTRODUCTIONS			
9:00	1	**Welcome**	*Dr. Martin P. Bendsøe, Senior Vice President and Dean, Technical University (Denmark)*
9:10	2	**IEA Experts' Group on R&D Priority-Setting and Evaluation**	*Rob Kool, EGRD Chair, NL Agency (Netherlands)*
9:20	2	**Introduction and Meeting Objectives**	*Birte Holst Jørgensen, Vice Chair EGRD, Dep. Dir., Management Engineering, DTU (Denmark)*
9:30	3	**Opening Remarks**	*Lars Georg Jensen, International Chief Advisor, Danish Energy Agency*
A. NEEDS ASSESSMENT OF COMPETENCIES AND REQUIREMENTS			
Moderator: Rob Kool, EGRD Chair (Netherlands)			
10:00	1	**Preparing a Modern Energy Workforce: Federal and Private Sector Initiatives in the United States**	*Craig Zamuda, Senior Policy Advisor, Department of Energy (United States) Ann Shikany, Programme Analyst, Department of Energy (United States)*
10:30	2	**European Strategic Energy Technology Plan – Energy Education and Training Roadmap**	*Miroslava Naneva, Energy Policy Officer, DG Research and Innovation, European Commission*
11:00	3	Break	
11:30	4	**Discussion and Key Messages**	*Moderator*
12:00		Lunch – invitation by DTU	
B. THE EDUCATION VALUE CHAIN			
Moderator: Herbert Greisberger, EGRD Vice Chair (United States)			
13:00	1	**Whole Energy Systems Graduate School**	*Magnus Karlsson Director of Studies, and Mats Söderstrom, Linköping University*
13:30	2	**Teaching New Energy Technologies and Systems**	*Paulien Herder, Faculty of Tech., Policy and Management, Delft University of Technology*
14:00	3	**Talent Factory for Wind Power**	*Anders Dalegaard, Danish Wind Industry Association*
14:30	4	**Sustainable Energy, Sino-Danish Center on Research and Education**	*Birte Holst Jørgensen, Principal Coordinator, DTU*
15:00		Break	

15:30	5	**Achieving Understanding of Complex, Interdisciplinary Energy Systems**	*John Loughhead, Executive Director, United Kingdom Energy Research Centre*
16.00	6	**Discussion and Key Messages**	*Moderator*
17:00		**Close Day 1**	

Thursday 10 May

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C. CAPACITY BUILDING – A GLOBAL RESPONSIBILITY			
Moderator: Carrie Pottinger, EGRD Secretary (IEA)			
9:00	1	**United Nations Environment Programme Capacity Building**	*John Christensen, Head of UNEP Risø Centre*
9:30	2	**Forming Tomorrow's Leading Experts on Carbon Capture and Storage**	*John Gale, General Manager, and Tim Dixon, Greenhouse Gas IA*
10:00	3	**International Energy Agency Training and Capacity Building**	*Assen Gasharov, Programme Manager, Training and Capacity Building*
10:30	4	**Capacity Building through Energy Modelling and Systems Analysis**	*Uwe Remme, Senior Analyst, Energy Technology Perspectives Division, IEA*
11:00	5	**Discussion and Key Messages**	*Moderator*
12:00		Lunch	
13:00		Visit to DTU PowerLab	*Prof. Jacob Østergaard*
D. CIVIL SOCIETY AND THE ROLE OF ENERGY EDUCATION			
Moderator: Sea Rotmann, EGRD Delegate (New Zealand)			
14:30	1	**Educating the Public to Save Electricity in Times of Crisis**	*Sara Pasquier, Programme Manager, Energy Efficiency, IEA*
15:00	2	**The District of Tomorrow**	*Ludo Kockelkorn, Zuyd University of Applied Sciences (Netherlands)*
15:30	4	**Shared Learning: from Theory to Practice**	*Sea Rotmann, CEO, Sustainable Energy Advice*
16:00	5	**Discussion and Key Messages**	*Moderator*
E. NEXT STEPS			
Moderator: Birte Holst-Jørgensen, EGRD Vice Chair (Denmark)			
17:00	1	**Discussion and Key Messages**	*Moderators*
17:15	2	**Workshop Conclusions**	*Moderator*
17:30	3	**End of Workshop**	

Appendix C: Speakers and Moderators

Name	Position & Affiliation
Martin P Bendsøe	Senior Vice President, Technical University of Denmark
Rob Kool	Chair of the IEA EGRD, and Manager, Centre for Energy and Climate Cooperation Europe, Innovation and Sustainability Agency, The Netherlands
Birte Holst Jørgensen	Vice chair of the IEA EGRD and Deputy Director of DTU Management Engineering, Technical University of Denmark
Lars Georg Jensen	Chief Advisor of International Affairs, Danish Energy Agency
Craig Zamuda	Senior Policy Advisor, Office of Policy and International Affairs, Department of Energy, USA
Ann Shikany	Programme Analyst, Office of International Climate Change Policy and Technology, Department of Energy, USA
Miroslava Naneva	Policy Officer, DG Research and Innovation, EU Commission
Herbert Greisberger	Vice chari of IEA EGRD and Managing Director of the Lower Austrian Energy and Environment Agency
Mats Söderstrom	Programme Director of The Energy Systems Programme, Sweden
Paulien Herder	Professor and Research Director, Faculty of Technology, Policy and Management, Delft University of Technology, The Netherlands
Anders Dalegaard	Project manager, Danish Wind Industry Association
John Loughhead	Executive Director of the United Kingdom Energy Research Centre (UKERC)
Carrie Pottinger	Programme Manager, Technology R&D Networks, IEA
John Christensen	Director of UNEP Risoe Centre, DTU
John Gale	General Manager for Greenhouse Gas R&DE Programme Implementing Agreement (IEAGHG)
Assen Gasharov	Head of the Energy Training and Capacity Building Programme at IEA
Uwe Remmen	Energy analyst, Energy Technology Policy Division, IEA
Sea Rotmann	CEO of Sustainable Energy Advice
Sara Bryan Pasquier	Energy Efficiency Programme Manager at IEA
Ludo Kockelkorn	Programme Manager for Sustainable Built Environments at the Zuyd University of Applied Sciences, the Netherlands