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INNER Report D3

Innovative energy research initiatives outside INNER participating countries

Colophon

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Table of contents

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Executive Summary

This report brings together completely different activities, from the European OPET project EMINENT "Early Market Introduction of New Energy Technologies" to the US federal programme on Basic Energy Research, which probably has a factor of thousand more budget than the former.

The common characteristic of the activities presented in this report is that they concern cutting edge energy research. Therewith, they are relevant for inspiration of the INNER ERA NET, which aims to strengthen and coordinate EU approaches to stimulate innovative energy research.

The activities considered in this report are summed up below:

- Innovative Energy R&D in the USA
- Innovative Energy R&D in Japan (to be completed)
- Innovative Energy R&D in China
- Innovative Energy R&D in Canada
- EMINENT (Early Market introduction of new energy technologies) (EU OPET project)
- AGHSET (Ad hoc group on science and energy technology), established by IEA CERT.

A summary of the separate activities is given below:

- In the US, there is a long-term and consistent approach to stimulate Basic Energy Research. There is relatively much budget reserved for basic energy research. The US prime approach to prepare for future needs is a series of workshops, the "Basic Research Needs…. Workshops". Acting on the results of the workshops, topical programmes are designed and implemented.
- In China, energy is a very important issue but it is not a separate R&D planning area. However, energy research is, and has been, an important topic in all major R&D programmes of the last 20 years. The Chapter in this report sketches the broad picture. How exactly the future priority topics are identified has received less attention and is the area of governmental planning organisations.
- In Canada, there is no programme focused explicitly on INNER related energy research. However, there are examples of recent activities elaborating, for example, on future perspectives of advanced biotechnological approaches applied to improve energy-efficient industrial processes. Probably, a future Canadian programme will have an enabling science programme which could really fund innovative ideas.
- The EMINENT project, which was initiated by the OPET Network, focuses on the early market introduction of new energy technologies. It considers quite innovative approaches, but it is most powerful when that first stage of a feasibility study of the new idea has been finalised and some performance data are available.
- AGHSET, the Ad hoc group on science and energy technology has been established by IEA CERT, to work on bridging the gap between science and energy technology. It operates therefore in the same area as INNER. AGHSET has staged workshops to inspire scientists worldwide to use the new fundamental insights in energy technology applications.

The report is a living document and will be completed with a description about other countries and other initiatives as the INNER project committee sees fit. Updates will be published on the Internet.

1 Introduction

1.1 ERA-Net INNER

ERA-Net INNER "Innovative Energy Research" has been established June 2005. Its goal is to structure and strengthen approaches to stimulate innovative energy research throughout Europe. There are ten participating countries, plus the Nordic Energy Research. This ERA-Net is financed by the European Commission through the Sixth Framework Programme ERA-Net scheme.

By innovative energy research, we mean research into energy technologies in the very first stages of development (new inventions). The INNER project will establish a cooperation between European national research programmes that stimulate innovative energy research. This cooperation will contribute to the coherence and coordination of the European Research Area, through benchmarking of approaches and a set of joint transnational programme activities. The activities are designed to allow a durable collaboration, beyond the duration of the INNER project.

In recent years more and more countries start to recognise the importance of dedicated attention to identify and stimulate new innovative energy options. INNER gathers programme managers and programme owners from ten European countries plus the Nordic Energy Research. They have adopted various strategies to bridge the gap between advances in fundamental research and innovations in energy technology. The INNER project brings these programmes together and will therewith structure and strengthen the European Union's activities to support innovative energy research.

The INNER project improves coordination and collaboration through information exchange and analysis of strategic elements in the first two years of operation. This leads to a benchmarking of approaches and a proposal for joint transnational pilot activities. The third and fourth year of operation will focus on implementing and evaluating these activities. Finally, a high level policy conference will mark the conclusion of the ERANET, and the beginning of a lasting collaboration.

INNER will contribute to maturing the national strategies for stimulating innovative energy research and improve coherence of national approaches.

1.2 INNER activities

The collaboration in INNER will be realised through a progressive, four-step approach, which starts with information exchange and ends with transnational pilot activities, that have a potential to last beyond the duration of the INNER project.

i. Exchange of information, to provide a basis for further collaboration.
ii. Analysis of the information, common understanding of strategic issues and best practices. Outline of a transnational pilot activity based on the analysis.
iii. Preparing the implementation of suitable transnational activities, including the transnational pilot activity from (ii).
iv. Implementing and evaluating the transnational activities (one year pilots, but with a potential for extension beyond the duration of the INNER project).

In the first two years of operation, the emphasis of the project will be on comparison and benchmarking of methodologies and approaches (i and ii). In the last two years, it will be on practical pilots for cooperation (iii and iv).

The transnational activities will each be implemented by different subgroups of the INNER consortium. This recognises that participating programmes differ widely. Establishing a standard approach within two to three years is neither realistic nor desirable. Defining several smaller activities will give more partners a chance to actively participate in a pilot that adds value for their country. At the same time, while all partners have access to the results of each pilot, it will contribute to more coherence of European national innovative energy programmes in the end.

The work in INNER has been structured in six Workpackages:

WP1 General management and coordination
WP2 Information exchange
WP3 Identification and analysis of common strategic issues
WP4 Development of joint activities
WP5 Implementation of joint transnational activities
WP6 Information dissemination

1.3 Report D3 on innovative energy research initiatives outside INNER participating countries

The current report on innovative energy research initiatives outside INNER participating countries is the second result of the activities in Workpackage 2 (WP2): Information exchange.

It reports on ongoing initiatives “outside” the national programmes in INNER participating countries such as EMINENT and the IEA AGHSET.

In the course of the INNER project, the report will be updated with new programmes and new experiences. These updates will be available through the INNER internet site: www.inner-era.net.

2 Innovative Energy R&D in the USA

2.1 Introduction - State of the Union

In his State of the Union address on 31 January 2006, President George W. Bush said the following:

"Keeping America competitive requires affordable energy. And here we have a serious problem: America is addicted to oil, which is often imported from unstable parts of the world. The best way to break this addiction is through technology. Since 2001, we have spent nearly $10 billion to develop cleaner, cheaper, and more reliable alternative energy sources -- and we are on the threshold of incredible advances.

So tonight, I announce the Advanced Energy Initiative -- a 22-percent increase in clean-energy research -- at the Department of Energy, to push for breakthroughs in two vital areas. To change how we power our homes and offices, we will invest more in zero-emission coal-fired plants, revolutionary solar and wind technologies, and clean, safe nuclear energy. (Applause.)

We must also change how we power our automobiles. We will increase our research in better batteries for hybrid and electric cars, and in pollution-free cars that run on hydrogen. We'll also fund additional research in cutting-edge methods of producing ethanol, not just from corn, but from wood chips and stalks, or switch grass. Our goal is to make this new kind of ethanol practical and competitive within six years. (Applause.) "

What the President said there will be made effective in the 2007 budget. And the first plans are already public. An increase of the budget for energy research has been requested, which will be a stimulus for the US energy research at large.

This chapter will explain the organisation structure of DOE (Department of Energy), the position of (basic) energy research in the Department, present IEA statistics on the budgets devoted to the various research areas, and then focus on the efforts of the Office of Basic Energy Sciences to move the frontiers of innovative energy research. It concludes with a summary of the activities of other relevant offices within US DOE.

2.2 Energy Research Policy

In the USA, Energy Research is the responsibility of US DOE (US Department of Energy). The Ministry is organised in 9 offices and a number of so-called organisations (staff offices, administrations) [2.1]. The offices include:

- Civilian radioactive waste management
- Electricity delivery and energy reliability
- Energy efficiency and renewable energy
- Environment, safety and health
- Environmental management
- Fossil energy
- Legacy Management
- Nuclear Energy, Science and Technology
- Science

The Office of Science [2.2] is the single largest supporter of basic research in the physical sciences in the United States, providing more than 40 percent of total funding for this vital area of national importance. It oversees – and is the principal federal funding agency of – the Nation's research programs in high-energy physics, nuclear physics, and fusion energy sciences.

The Office of Science manages its research portfolio through six interdisciplinary program offices:

- Advanced scientific computing research (also manages the DOE-wide Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) programs.)

- Basic energy sciences
- Biological and environmental research
- Fusion energy sciences
- High energy physics
- Nuclear physics.

2.3 Office of Basic Energy Sciences

The Basic Energy Sciences (BES) program [2.3] supports fundamental research in focused areas of the natural sciences in order to expand the scientific foundations for new and improved energy technologies and for understanding and mitigating the environmental impacts of energy use. BES also supports work that creates knowledge and develops tools to strengthen national security. The BES program plans, constructs, and operates major scientific user facilities (e.g. X-ray and neutron scattering facilities) to serve researchers from universities, national laboratories, and private institutions.

The BES program is one of the Nation's largest sponsors of the natural sciences by funding experiments at more than 160 research institutions through the following three Divisions:

- Materials science and engineering division
- Chemical sciences, geosciences and biosciences division
- Scientific user facilities division

The research portfolio of the Basic Energy Sciences (BES) program consists of distinct Core Research Activities (CRAs), which align with the above-mentioned divisions.

2.4 R&D Expenditure

According to IEA statistics [2.4] the public expenditure for energy research is as follows (all numbers in Million EUROS):

Table 2.1 Public expenditure for energy research in the USA (Million Euros) [2.4]

	2000	2001	2002	2003	2004
1.1 Industry	119,691	126,417	120,592	79,561	74,92
1.2 Residential Commercial	107,228	110,767	104,771	47,928	48,192
1.3 Transportation	199,249	217,24	205,942	143,118	143,292
1.4 Other Conservation	43,163	40,272	52,367	51,352	49,124
TOTAL CONSERVATION	469,331	494,697	483,672	321,958	315,527
2.1 Enhanced Oil & Gas	51,173	57,556	63,046	52,031	45,845
2.2 Refining Transp. & Stor.	12,315	17,735	11,874	9,345	7,196
2.3 Oil Shale & Tar Sands	0	0	0	0	0
2.4 Other Oil & Gas	11,904	19,894	10,846	9,983	9,807
Total Oil & Gas	75,392	95,184	85,766	71,36	62,848
3.1 Coal Prod. Prep. & Trans.	3,686	3,65	4,097	4,772	4,819
3.2 Coal Combustion	65,652	147,484	184,053	184,044	213,678
3.3 Coal Conversion	6,034	6,429	20,919	17,611	17,651
3.4 Other Coal	29,928	47,34	60,282	63,963	64,082
Total Coal	105,3	204,903	269,35	270,39	300,23
TOTAL FOSSIL FUELS	180,692	300,087	355,116	341,75	363,078
4.1 Solar Heating & Cooling	1,668	3,327	3,94	..	..
4.2 Solar Photo-Electric	56,242	63,846	59,867	..	..
4.3 Solar Thermal-Electric	12,999	11,662	11,029	..	..
Total Solar	70,909	78,834	74,837	67,651	67,131
4.5 Wind	27,641	33,644	31,971	34,216	33,255
4.6 Ocean	0	0	0	0	0
4.7 Biomass	60,43	73,379	73,365	70,078	69,609
4.8 Geothermal	20,323	22,89	22,62	23,328	20,534
4.9 Total Hydro	4,234	4,244	4,172	4,122	3,949
TOTAL RENEWABLE ENERGY	183,537	212,991	206,965	199,395	194,478
10.1 Nuclear LWR	..	..	..	..	..
10.2 Other Converter Reactors	..	..	..	..	..
10.3 Nuclear Fuel Cycle	..	..	..	..	..
10.4 Nuclear Supporting Tech.	30,289	40,231	41,2	106,847	104,644
10.5 Nuclear Breeder	0	0	0	0	0
Total Nuclear Fission	30,289	40,231	41,2	106,847	104,644
11. Nuclear Fusion	207,527	211,367	201,73	197,781	211,357
TOTAL NUCLEAR FISSION/FUSION	237,815	251,599	242,93	304,628	316
12.1 Electric Power Conversion	75,306	71,042	62,568	64,557	67,582
12.2 Electricity Transm. & Distr.	29,57	38,922	..	..	..
12.3 Energy Storage	2,95	5,093	58,684	70,055	61,496
TOTAL POWER & STORAGE TECH.	107,826	115,057	121,252	134,611	129,078
13.1 Energy Systems Analysis	..	..	..	..	..
13.2 Other Tech. or Research	795,159	1019,498	972,379	957,393	976,371
TOTAL OTHER TECH./RESEARCH	795,159	1019,498	972,379	957,393	976,371
TOTAL ENERGY R&D	1974,359	2393,928	2382,314	2259,734	2294,532

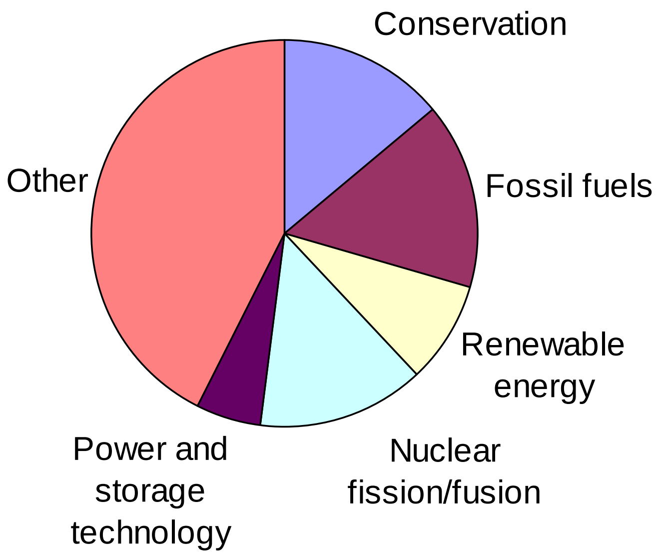

Figure 2.1 Public expenditure for energy research 2004 in the USA [2.4]

Most notable compared to other countries is the high expenditure for other energy research areas. Most of this money is being spent on Basic Energy Sciences (about 840 million Euros), part on advanced computing and part on hydrogen.

- Expenditure for energy conservation dropped from 2000-2004.
- Fossil fuel research increased significantly, due to increased attention for coal research
- Efforts for renewable energy research have been level at about 200 million Euros in the years 200-2004
- A major increase (by more than € 60 million) in nuclear energy research occurred in 2003.
- Power and storage technologies and other energy research have received fairly stable amounts of about € 120 million and about € 1,000 million annually.

More detail on the US activities on the various research areas is presented in the "*Energy Policies of IEA Countries – The United States 2002 review*" [2.5]. In this 2002 publication, the IEA commented that technology is central to the achievement of US energy policy goals. However, mechanisms to ensure deployment of research results should be better integrated into the design of research projects. (An update of the publication will probably become available in 2006.)

2.5 The "Basic Research Needs …." Workshops

The Basic Energy Sciences office actively interacts with the research community and beyond to develop its strategy. These strategic planning activities have clear overarching goals [2.6]:

Two major imperatives:
- Reduce USA dependence on energy imports
- Reduce greenhouse gas emissions

Two substantial improvements:
- Increase efficiency
- Increase capacity and reliability of the current electric distribution system

Two important advances for the 21st century:
- Diversify energy sources and create national infrastructures for them
- Create decades-to-century visions and strategies

In October 2002, the workshop "*Basic research needs to assure a secure energy future*" was held. The report can be found on [27.]. This foundation workshop set the model for the focused workshops that have followed and will follow in the future.

The workshop brought together more than 100 scientists and engineers from academia (27%), industry (16%), and federal laboratories (39%) and agencies (18%). The general procedure was that chairpersons were selected for the topical areas listed below. Their initial task was to identify a small group (4-6) to help them identify some needed basic research directions. The second phase of the subpanel's work was the workshop "Basic research needs… "held in Gaithersburg October 21–25, 2002. Prior to the workshop, additional members were identified to expand the small groups into Topical Teams of 10 to 12 members. The Teams were selected to be representative of the stakeholders: they included members from academia, the National Laboratories, industry, and the applied mission Offices of DOE. As a resource for the workshop participants, a factual document was compiled that summarized the state of energy sources and use at a national and international level.

There were eight (plus one) topics:
- Fossil Energy
- Nuclear Fission Energy
- Renewable and Solar Energy
- Fusion Energy
- Distributed Energy, Fuel Cells, and Hydrogen
- Transportation Energy Consumption
- Residential, Commercial, and Industrial Energy Consumption
- Cross-Cutting Research and Education
- Energy Biosciences Research (through a follow-up workshop 12-14 January 2003, Palo Alto)

The results of the workshop are a compilation of 37 proposed research directions (PRDs). At a higher level, these fell into ten general research areas, all of which are multidisciplinary in nature:
- Materials Science to Transcend Energy Barriers
- Energy Biosciences
- Basic Research Towards the Hydrogen Economy
- Innovative Energy Storage
- Novel Membrane Assemblies
- Heterogeneous Catalysis
- Fundamental Approaches to Energy Conversion
- Basic Research for Energy Utilization Efficiency
- Actinide Chemistry and Nuclear Fuel Cycles
- Geosciences

Nanoscale science, engineering, and technology were identified as cross-cutting areas where research may provide solutions and insights to long-standing technical problems and scientific questions.

These themes formed the basis of a series of follow-up workshops. This is an ongoing activity.

The following related focused workshops were organised or will be organised in future.

	Date	Report
Basic research needs for the hydrogen economy	13-15 May 2003	[2.7]
Basic research needs for solar energy utilization	18-21 April 2005	[2.7]
Nanoscience research for energy needs	16-18 March 2004	[2.7]
Basic research needs for superconductivity	April 2006	
Basic Research needs for solid state lighting	June 2006	
Basic Research needs for energy storage	Mid 2007	
Advanced computational materials science: application to fusion and generation IV fission reactors	31 March – 2 April 2004	[2.7]
The path to sustainable nuclear energy: basic and applied research opportunities for advanced fuel cycles	September 2005	[2.7]

2.6 After the "Basic Research needs …" workshops

The workshop "Basic research needs for the hydrogen economy" workshop, which was organised in May 2003, is taken as an example to show what the Office of Basic Science does to act on the conclusions of the workshop.

The steps in research coordination can be summarised as follows [2.6]:

1. Conduct formal workshops to identify the "Basic Research Needs …"
2. Develop a basic research agenda that addresses short and long term problem areas
3. Coordinate basic and applied research
4. Engage in outreach

For the example of hydrogen, the following high priority research areas were identified in the workshop report. The requirements go beyond incremental advances in present state of the art:

- Novel materials for hydrogen storage
- Membranes for separation, purification, and ion transport
- Design of catalysts at the nanoscale
- Solar hydrogen production
- Bio-inspired materials and processes

As a follow-on of the workshop, the Office of Basic Science solicited a budget of USD 21 million for basic research for the hydrogen economy, in the FY 2005. In April 2004, BES could already issue a request for pre-proposals for the "Hydrogen Fuel Initiative". July 2004, 668 preproposal were received. In May 2005, 70 full proposals were awarded.

It is important to note that in the course of the process, there is frequent collaboration with other offices at US DOE. The offices EERE (Energy efficiency and renewable energy) [2.8], FE (Fossil Energy) [2.9] and NE (Nuclear Energy, Science and Technology) [2.10] all have their own hydrogen activities. The following examples show how activities are coordinated:

- For the EERE hydrogen storage/hydrogen production solicitations, BES staff provided recommendations on the scientific scope and assisted in the review procedure
- For the BES basic research solicitation, EERE, FE and NE staff reviewed research topical areas and helped review preproposals.

- The annual DOE Hydrogen programme [2.11] involves EERE, FE, NE and SC (of which BES is a part).

The table below shows which issues are addressed by the projects stimulated by BES: A tentative conclusion from the information above together with table 2.2 is that the approach has been successful. The results from the workshop could be translated into research themes; there has been enthusiasm among researchers to come up with ideas; and the awarded projects cover almost all identified research themes.

Table 2.2 Contribution of BES Basic Research to overall Hydrogen Fuel Initiative (HFI) [2.6]

	HFI Hydrogen Production	HFI Hydrogen Storage	HFI Fuel Cells
BES Novel materials for hydrogen storage		- Complex hydrides - Nanostructured & other novel materials - Theory, modeling, and simulation - Novel analytical and characterization tools	
BES Membranes for separation, purification, ion transport	- Integrated nanoscale architectures for H separation and purification (fossil fuels reforming, thermochemical processes) - Theory, modeling, and simulation of membranes for H production needs		- Fuel cell membranes - Theory, modeling, and simulation of membranes for fuel cells
BES Design of catalysts at the nanoscale	- Nanoscale catalysts for H production - Theory, modeling, and simulation of catalytic pathways for H production	- Nanoscale catalysts for improving H storage kinetics - Theory, modeling, and simulation of catalytic pathways for H intake and release	- Nanoscale fuel cells catalysts - Novel synthesis & characterization of fuel cells catalysts - Theory, modeling, and simulation of catalytic pathways
BES Solar hydrogen production	- Light harvesting and novel photoconversion concepts - Organic semiconductors and other high performance materials for H production - Theory, modeling, and simulation of photochemical processes for water splitting		
BES Bio-inspired materials and processes	- Enzyme catalysts for H production - Bio-hybrid energy coupled systems - Theory, modeling, and nanostructure design to aid H production	x Biomimetic-based H storage approaches *	- Enzyme catalysts for fuel cells applications

* Only research area not addressed by the awarded projects.

2.7 Future

For FY 2007, the President has requested a budget of USD 1,420,980 for Basic energy sciences, an increase of 25% compared to the FY 2006 budget [2.12]. This increase will be spent to finance a significant increase in hydrogen research (54%), and specific topics, such as solar energy utilization, advanced nuclear energy systems, ultrafast science, mid-scale instrumentation, chemical imaging and complex systems.

Background of this increase was the growing concern that there is a "gathering storm" which threatens the competitivity of the US economy. The National Academies were charged to address this issue and come up with recommendations to curb this development. They recommended amongst others to sustain and strengthen the nation's commitment to long-term basic research [2.13].

In the State of the Union Address of 31 January 2006, President Bush announced the American Competitiveness Initiative "to encourage innovation throughout the US economy […..] and to double the Federal commitment to the most critical basic research programs on the physical sciences over the next 10 years."

2.8 Other relevant offices of US DOE

EERE (Energy Efficiency and Renewable Energy office) [2.8]
EERE is organized around 11 energy programs:

- Biomass program
- Building technologies program
- Distributed energy program
- Federal energy management program
- Freedom CAR & vehicle technologies program
- Geothermal technologies program (will be completed by FY 2007)
- Hydrogen, fuel cells & infrastructure technologies program
- Industrial technologies program
- Solar energy technologies program
- Wind and hydropower technologies program
- Weatherization & intergovernmental program

The programmes above in general conduct research, development, demonstration and technology transfer, often in public-private partnerships. Evidently, there is an interface with the activities of BES.

Office of Fossil Energy
The primary mission of DOE's Office of Fossil Energy is to ensure that the US can continue to rely on clean, affordable energy from fossil fuels. The Office operates research and development programmes on such priority projects as pollution-free coal plants, and more productive oil and gas fields. It is also responsible for the continuing readiness of federal emergency oil stockpiles. Evidently, also here there is an interface with the activities of BES.

Office of Nuclear Energy, Science and Technology
The Office of Nuclear Energy, Science and Technology has three divisions, operations and management, nuclear operations, and technology. Within the technology division, the structure is "Advanced nuclear research", "Nuclear power technology, safety and security" and "International nuclear collaboration". These three parts of the organisation also have an obvious research task. There will be an interface with BES activities.

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3 Innovative Energy R&D in China

3.1 Introduction

China is the world's most populous country, with 1.3 billion inhabitants, over 20% of total world population. China is a key player in the world energy market, the third largest energy producer in the world (behind the United States and Russia), and accounting for about 9.5% of the world's annual total energy production. China is also the second largest energy consumer (behind the United States), accounting for nearly 10% of the world's total annual energy consumption. China's energy demand has been greatly increasing and is expected to grow at about 5.5% per year through the year 2020. By 2030, the International Energy Agency predicts China will account for one-fifth of the world's total annual energy demand [1].

The national R&D energy programmes are under the leadership of the Ministry of Science and Technology, the policy maker for science and technology development in China.

3.2 Energy Overview

China's fast-growing economy has been fuelled primarily by coal. Coal meets about 70% of China's primary energy need (Figure 1): 70% coal, 25% oil, 3% natural gas, 2% hydro. The Chinese economy relies on coal and that makes China the second largest CO_2 emitter in the world, after the United States. Therefore, important issues on the Chinese political agenda are to:

- diversify the energy mix
- improve energy efficiency
- security of energy supply
- protect the environment.

China is seeking a shift towards cleaner energies (e.g. natural gas, oil, coal-bed methane), improving efficiencies (industrial boilers, motors, …) and utilization of renewable energies, in short to move to a more sustainable energy supply mix.

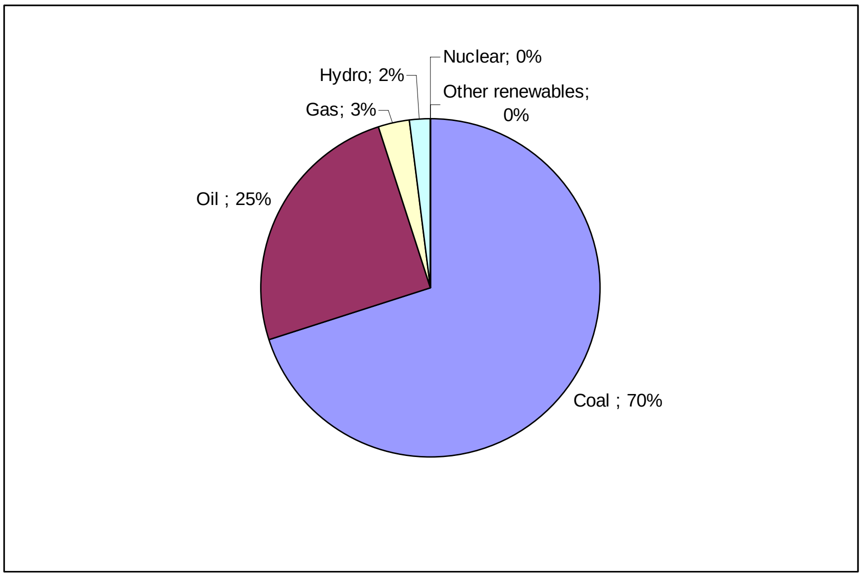

Figure 3.1: Primary energy demand in China in 2000 (Source: IEA World energy outlook 2002)

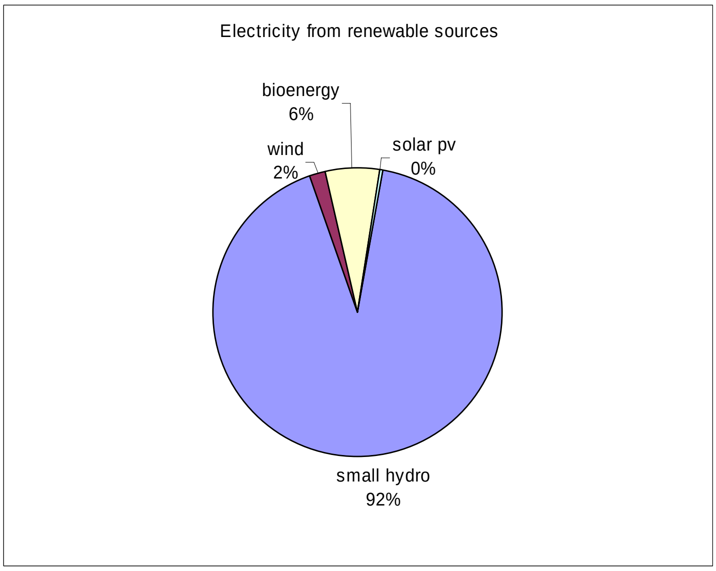

Figure 3.2: Electricity from renewable sources in China (2003) Source: ERI, NDRC

As is clear from Figures 3.1 and 3.2, renewable energy is primarily hydroenergy in China. By the end of 2003, the capacity of renewable energy generation was as follows:

- grid-connected installed capacity of wind power 567 MW
- total installed PV capacity 55 MWp
- 30,000 MW small hydro (smaller than 50MW)
- 2000 MW biomass electricity generation.

3.3 Energy legislation and policy

After the promulgation of Agenda 21 by the United Nations in 1992, a White Paper on Population, Environment and Development is adopted in the "China Agenda 21" in 1994. Sustainable energy production and consumption became one of the priorities on the government agenda.
The following energy related research priorities have been set in China's "Agenda 21":

- Water resources security;
- Security of oil and natural gas;
- Security of mineral resources;
- Marine monitoring and resource exploitation;
- Clean energy and renewables;

Concerning energy legislation, the following laws are relevant for the organisation of the energy sector and energy research in China

<u>Electricity Law (1995)</u>
The Electricity Law was promulgated in 1995. The law legalized the status of power enterprises as commercial entities, and established the legal basis for private ownership. The purpose is to stabilise the power supply and to regulate the power market.

The electricity law played an important role in the energy sector reform from 1995–97. The Ministry of Electric Power is replaced by the State Power Corporation which holds the state ownership of the power sector and oversees the reform on the separation of power generation and power transmission. The electricity law was amended after 8 years enforcement.

<u>Energy Conservation Law (1998)</u>
The Energy Conservation Law was promulgated in 1998. It is an important step towards legitimatizing energy conservation as an element of the Chinese policy. It defines energy conservation as a long term

strategy for national economic development and sets a list of rewards and penalties to improve energy conservation.

Renewable Energy Law (2006)
The Renewable Energy Law was promulgated in 2006. The aims of the law are to reduce air pollution, improve environmental quality and provide power to off-grid areas and consequently to contribute to the mitigation of climate change.

3.4 National energy research programmes[1]

In fact, there was/is no specific national energy R&D programme in China. However, the energy related R&D actions are one of important components of many of the national R&D programmes.

Science and Technology have played a critical role in tackling the challenges in the area of China's national economic growth and social development. Science and Technology creates new force for the national economy with the commercialization of R&D results. MoST (the Ministry of Science and Technology) is mainly responsible for the R&D programmes.

3.4.1 The Torch programme (1988)

The China Torch Program is designed to develop new and high technology industries in China. It was approved by the State Council in August 1988. The Ministry of Science and Technology (MoST) leads and manages the program. The programme is updated in every 5 year-period (the first update was in 2003).

Two out of the six priorities of the programme are:
- New energy technology and high-efficiency energy conservation technology
- Environmental protection technology

The programme supports the national strategy, promotion of commercializing laboratory into market activities; and it encourages new business organizations spun-off from R&D institutes. These are called "New Technology Enterprises".

The sources of the funding are mostly from industry according to the result of year 2004: 71.9% from industry, 21.3% from financial institutions as loan and 2.2% from central & local government. 33% of the fund was spent on R&D activities, but the amount of the fund spent on *energy* R&D activities is not available.

3.4.2 National high-tech R&D programme (863 programme)

To meet the global challenges of new technology revolution and competition, actions were proposed to accelerate China's high-tech development in 1986. Since this programme was approved in March 1986, therefore it is called 863 (86-3) programme. Its formulation has also been influenced by the Star Wars Program of USA and EUREKA programme of the EC in the 1986. The programme has been run for 20 years and contributed to the China's overall high-tech development, R&D capacity, socio-economic development, and national security.

The objectives of the program in the 10th Five-Year Plan (1995-99) are to boost innovation capacity in the high-tech sectors, particularly in strategic high-tech fields, and to achieve "leap-frog" development in key high-tech fields and to support the strategic objectives of the Chinese modernization process.

[1] All mentioned national programmes are main national R&D programmes. They are not energy oriented programmes, but energy is one of the components of the programmes. In fact, there are no specific energy programmes in China. Therefore the direct goal concerning energy aspects and budget are unclear, and implementations of activities are not well categorized in the most public documents.

Energy Technology is one of the 6 R&D priorities in the programme. The funding of the programme is from the government. In 2004, the budget allocated for energy activities is 16% of the total.

In the energy technology areas, two themes were identified in 1986: 1) Coal-based magneto hydrodynamics, 2) Advanced nuclear reaction technology. In the tenth-five year plan period (1995-99), two new energy relevant themes were introduced:

- Renewable energy, hydrogen, fuel cell, nuclear energy. This theme has focused on e.g. large scale wind-turbine (> 1 MWe) technology, solar energy - thin-film PV-technology, biomass, hydrogen and high temperature gas cooled reactors;
- Clean coal technologies. This theme has focused on coal production and processing, high efficiency energy conversion, high efficiency-clean combustion, coal gasification, liquefaction, IGCC and triple-generation, high efficiency ultra super critical technology and flue-gas cleaning technology.

The programme supports the integration of local high-tech development and also encourages international cooperation. Special funds are earmarked to facilitate the integration of the 863 Programme with the "Programme on Major International Cooperation Projects", and supports and encourages the implementation of international cooperative projects within the framework of the 863 Programme.

3.4.3 Key technology R&D programme

The programme "Key technology R&D programme" started in 1983. It focuses on promoting technical upgrading and restructuring of industries, and tackles major technical issues. It provides technical support to industrial restructuring, the sustainable development of society, and the enhancement of living standards by key technologies, technical innovation, and applying new technologies. The major goal of the Programme is to address pressing major S&T issues in national economic and social development.

R&D activities in energy and energy saving are one of the priorities of the programme. The technology priorities are:

- The 6th 5 year R&D programme (1975-79): new energy, energy saving and coal technologies
- The 7th 5 year R&D programme (1980-84): coal combustion and conversion technology and rural renewable energy;
- The 8th 5 year R&D programme (1985-89): new energy, coal combustion and conversion technology;
- The 9th 5 year R&D programme: (1990-94) large scale wind turbine, solar energy and biomass;
- The 10th 5 year R&D programme (1995-99): circular flow-bed desulphurization, flow-bed desulphurization, chemical desulphurization, building energy saving and solar technology integration in buildings, renewable energy (wind, biomass and solar PV) commercialization.

3.4.4 National Key Basic Research Programme (973 programme)

Energy drives the high growth of the Chinese economy. The objectives of the "National Key Basic Research Programme" are to assist the national politic goal on economy, science & technology and social development. The objective of the programme is to mobilise China's scientific talents in conducting innovative research on major scientific issues of agriculture, energy, information, resources and environment, population and health, new materials.

To sustain the economy development, large energy systems become a priority of the Chinese energy strategy. Meanwhile, coal still dominates the energy supply in China and combustion of coal makes China one of the largest polluters in the world. To tackle the problems, the national key basic research programme was launched in 1997. The research priorities are:

- Clean and high efficiency combustion of fossil fuels;
- Large scale coal gasification and liquefaction;
- Large scale non-fossil fuels;

The specific activities are:

- Large scale and high efficiency coal utilisation technology;
- Large scale coal gasification and liquefaction;
- Large scale non-fossil fuels;
- High-voltage – long distance- high capacity transmission;
- Energy-efficiency and energy storage;
- Exploration of oil and gas;
- Sustainable energy system.

Energy is only one of the research areas of the 973 programme. It shares about 14 % of the research activities in 2004.

3.5 Players in the national energy policy and energy programmes

NDRC (National Development and Reform Commission)
NDRC is the most important policy maker under the State Council. NDRC is an architect of the Chinese economy and formulates macro-policies for national economic and social development. NDRC makes long term national strategy on economic and social development. In energy aspects, NDRC formulates all energy national policies e.g. on coal, oil, natural gas, renewable energies etc.

MOST (Ministry of Science and Technology)
MOST is a policy maker under the State Council. MOST formulates policies related with Science& Technology, innovation and research and development; makes long-term national strategy on Science &Technology. MOST developed, implemented and managed a number of national R&D programmes. The contact information at MoST: DG High and New Technology and industrialization are Mr. Xu Jing and Mr Li Baoshan.

In the energy aspect, NDRC is the most powerful organ in the Chinese hierarchy. However, in the R&D perspective, the MoST plays more important role than NDRC. MOST makes the policy related to R&D, and is implementing and managing energy related R&D programmes.

3.6 References

[3.1] World Energy Outlook 2002, IEA, 2002

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http://english.people.com/cn/200601/26/eng20060126_238359.html or
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China Agenda 21 http://www.acca21.org.cn/ca21pa.html ;
China Torch Program http://www.chinatorch.gov.cn/eng/ejym/NatureAndObjective.htm
China Electric Vehicles http://www.chinaev.org/html/nyjs/index.html (Chinese)
863 Programme http://www.863.org.cn/863_105/annals/annals_2004/200512060004.pdf (Chinese)
http://www.863.org.cn/english/index.html
Key technologies R&D Programme http://gongguan.jhgl.org/index.asp (Chinese)
973 programme http://www.973.gov.cn; http://www.973.gov.cn/English/Index.aspx (English)
National Development and Reform Commission http://en.ndrc.gov.cn/ (English)
Ministry of Science and Technology http://www.most.gov.cn; http://most.gov.cn/eng/index.htm (English)

4 Innovative Energy R&D in Japan

This chapter will be completed in a later stage, if possible.

4.1 R&D Expenditure

According to IEA statistics [4.1] the public expenditure for energy research is as follows (all numbers in Million EUROS):

Table 4.1 Public expenditure for energy research in Japan (Million Euros) [4.1]

	2000	2001	2002	2003	2004
1.1 Industry	421,584	442,486	361,488	279,195	..
1.2 Residential Commercial	22,809	26,608	5,943	10,784	..
1.3 Transportation	26,735	28,961	34,058	24,609	..
1.4 Other Conservation	13,533	17,245	131,53	84,273	..
TOTAL CONSERVATION	484,661	515,299	533,02	398,862	366,904
2.1 Enhanced Oil & Gas	14,472	21,594	0	0	0
2.2 Refining Transp. & Stor.	2,506	1,938	71,697	47,65	131,764
2.3 Oil Shale & Tar Sands	0	0	0	0	0
2.4 Other Oil & Gas	5,012	4,749	164,835	149,444	49,901
Total Oil & Gas	21,991	28,281	236,532	197,094	181,672
3.1 Coal Prod. Prep. & Trans.	7,271	5,028	0	0	2,219
3.2 Coal Combustion	10,371	8,225	16,873	12,073	35,395
3.3 Coal Conversion	48,549	21,465	30,724	32,898	56,551
3.4 Other Coal	1,843	1,187	4,849	4,409	0
Total Coal	68,033	35,906	52,447	49,373	94,172
TOTAL FOSSIL FUELS	90,024	64,187	288,971	246,467	275,845
4.1 Solar Heating & Cooling	0,445	0,415	0	0	0
4.2 Solar Photo-Electric	100,592	71,733	92,325	81,623	147,067
4.3 Solar Thermal-Electric	0	0	0	0	0
Total Solar	101,037	72,148	92,325	81,623	147,067
4.5 Wind	4,405	7,045	4,711	11,042	10,016
4.6 Ocean	3,41	5,436	0	0	0
4.7 Biomass	0	14,305	28,593	26,413	53,543
4.8 Geothermal	18,68	16,966	12,843	0	0
4.9 Total Hydro	0	0	7,929	0,663	0
TOTAL RENEWABLE ENERGY	127,531	115,9	146,396	119,733	257,98
10.1 Nuclear LWR	97,959	86,761	37,277	32,604	27,702
10.2 Other Converter Reactors	81,446	59,581	22,034	38,044	50,877
10.3 Nuclear Fuel Cycle	651,881	690,594	781,786	731,097	672,223
10.4 Nuclear Supporting Tech.	846,641	920,534	1359,715	1349,137	1097,585
10.5 Nuclear Breeder	302,905	249,646	112,562	115,515	105,834
Total Nuclear Fission	1980,832	2007,115	2313,373	2266,396	1954,221
11. Nuclear Fusion	197,365	170,181	106,3	101,948	92,594
TOTAL NUCLEAR FISSION/FUSION	2178,196	2177,296	2419,673	2368,344	2046,815
12.1 Electric Power Conversion	68,711	97,253	7,263	2,65	0
12.2 Electricity Transm. & Distr.	39,689	41,42	28,738	18,624	47,004
12.3 Energy Storage	28,937	19,047	27,76	11,741	0
TOTAL POWER & STORAGE TECH.	137,337	157,721	63,761	33,016	47,004
13.1 Energy Systems Analysis	1,292	1,18	0,072	0	0
13.2 Other Tech. or Research	61,263	69,172	293,125	255,05	195,717
TOTAL OTHER TECH./RESEARCH	62,555	70,353	293,197	255,05	195,717
TOTAL ENERGY R&D	3080,304	3100,755	3745,025	3421,464	3190,265

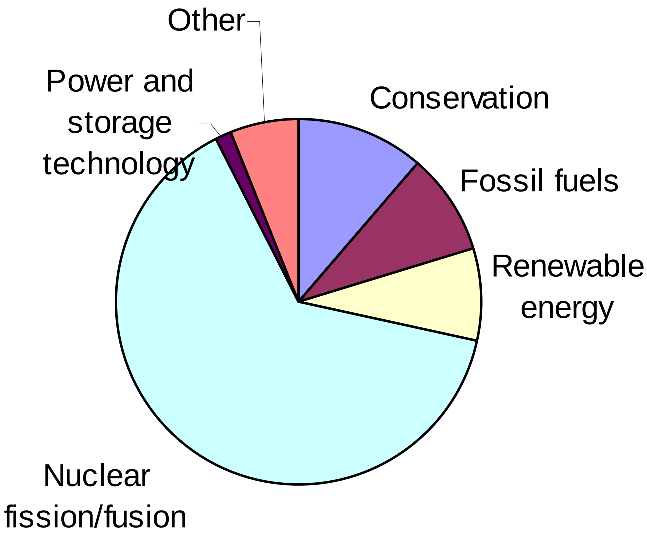

Figure 4.1 Public expenditure for energy research 2004 in Japan [4.1]

Compared to other countries, the spending on nuclear fission and fusion research is high, as is the overall spending on energy research.

4.2 References

[4.1] Internet site of IEA www.iea.org

5 Innovative Energy R&D in Canada

5.1 Introduction

Although at present in Canada there is no program focussed explicitly at INNER related energy research, a strong interest to move in that direction is expressed by Mr. Hamid Mohamed, NRCan, Office of Energy R&D, who is also involved in the IEA AHGSET initiative. This chapter will provide a short overview of Energy R&D in Canada, as well as describe ideas how to move on with regard to innovative Energy Research.

"I believe that the presently accepted approach to peer review across the western world tends to entrench the status quo. I always wonder where we would be if Faraday had to submit to peer review or if the Wright Brothers had to get a government grant". [Hamid Mohamed, NRCan, Office of Energy R&D]

5.2 Energy Research and Development

In Canada, Natural Resources Canada (NRCan) is the key-player with regard to Energy related R&D. Natural Resources Canada (NRCan) is a federal government department specializing in the sustainable development and use of natural resources, energy, minerals and metals, forests and earth sciences. Federal energy R&D in Canada is planned and conducted with energy policy guidance from NRCan, strategic directions from the Interdepartmental Panel on Energy R&D and an external advice from the National Advisory Board on Energy Science And Technology NABEST) at the overall programme level [5.1].

The most important governmental Energy R&D funding instrument is the Programme of Energy Research and Development (PERD). This programme is administered by NRCan's Office of Energy Research and Development.

PERD is primarily an applied research and technology development programme. It is implemented by NRCan's three dedicated energy research laboratories (CANMET Energy Technology Centres: CETC-Ottawa, CETC-Devon and CETC-Varennes), which receive 60% of their budget from PERD, and other federal departments and agencies with energy-related capabilities and activities. PERD also funds research at universities and the private sector through joint projects, grants and consortia.

Although PERD covers a broad spectrum of activities in the field of energy R&D, it is mainly focussed on six non-nuclear strategies chosen to address the government of Canada's energy priorities.

The six current PERD priorities are:

- Diversifying Canada's Oil and Gas
- Cleaner Transportation for the Future
- Energy-efficient Buildings and Communities
- Energy-efficient Industry
- Canada's Electricity Infrastructure
- Climate Change

Along these lines, PERD is further divided into 37 "Programmes at the Objective Level" (POL), managed independently from each other. Every POL has a POL committee and a community around it, including all stakeholders (universities, industry and governments) and relevant Implementing Agreements of the IEA.

5.3 Innovative Energy Research – status

Present situation:

The linkage between basic science and energy technology development is not done at the overall PERD level, but at the individual POL [5.1]. Basic energy-related research in Canada is primarily done by universities, with a lesser amount done by NRCan's and the National Research Council's (NRC) laboratories.

However, there are examples of recent activities elaborating, for example, on future perspectives of advanced biotechnical approaches applied to improve energy-efficient industrial processes. Further basic science activities, conducted under the auspices of the National Research Council of Canada, with special regard to energy technologies, are also under investigation.

There have also been two very small programs related to the reduction of greenhouse gases that solicited innovative ideas from universities (run through the university granting council) and from government laboratories (run through the NRCan Office of Energy R&D) [5.2]. These provided a small amount of money to do proof of concept and then expected applied research programs to follow up the best ideas. The results were mixed. There were a lot of incremental changes to existing and a small number of really innovative ideas. The feeling is that reasons for this were that the amount of money was small and the follow up was not assured.

Presently Canada does not have a separate program devoted to basic energy research. However, there are some basic research projects (such as organic PV, nanoscale combustion sensors) supported in the government funded energy research programs.

On the broader than energy front there is new Nanotechnology Institute, which will include research that also has energy relevance. Also, of course, Canadian universities are engaged in basic research which has energy relevance.

Future:

The hope is expressed [5.2] that future Canadian energy research plans will have an enabling science program which could fund really innovative ideas.
If there will be funding for an enabling science related to energy program also universities will be included in the network.

5.4 R&D Expenditure

According to IEA statistics [5.3] the public expenditure for energy research is as follows (all numbers in Million EUROS):

Table 5.1 Public expenditure for energy research in Canada (Million Euros) [5.3]

	2000	2001	2002	2003	2004
1.1 Industry	15,333	18,393	20,983	15,722	15,864
1.2 Residential Commercial	7,501	9,095	10,054	14,642	18,47
1.3 Transportation	6,343	9,295	17,64	25,872	23,701
1.4 Other Conservation	2,814	3,81	12,877	5,901	4,032
TOTAL CONSERVATION	31,992	40,593	61,554	62,137	62,068
2.1 Enhanced Oil & Gas	5,56	7,429	6,73	2,513	3,218
2.2 Refining Transp. & Stor.	4,246	4,753	5,764	6,894	5,198
2.3 Oil Shale & Tar Sands	12,734	15,497	13,842	17,015	14,094
2.4 Other Oil & Gas	12,694	15,34	12,649	17,188	18,151
Total Oil & Gas	35,234	43,019	38,984	43,61	40,661
3.1 Coal Prod. Prep. & Trans.	0,304	0,277	0,387	0,246	0,958
3.2 Coal Combustion	0,463	0,533	0,64	2,791	0,361
3.3 Coal Conversion	1,293	1,328	1,74	1,368	1,492
3.4 Other Coal	1,027	1,082	0,753	1,006	0,765
Total Coal	3,087	3,221	3,52	5,411	3,576
TOTAL FOSSIL FUELS	38,321	46,239	42,504	49,021	44,237
4.1 Solar Heating & Cooling	1,527	1,417	1,468	2,229	3,067
4.2 Solar Photo-Electric	1,689	2,931	2,176	7,879	4,993
4.3 Solar Thermal-Electric	0,181	0,306	0,18	0,558	0,557
Total Solar	3,397	4,654	3,824	10,666	8,616
4.5 Wind	3,331	1,927	1,694	2,341	1,947
4.6 Ocean	0	0	0	0,07	0
4.7 Biomass	7,097	6,156	9,112	13,188	11,499
4.8 Geothermal	0,198	0,23	0,492	0,894	0,604
4.9.1 Large Hydro (>10 MW)	3,986	..	2,806	1,259	1,415
4.9.2 Small Hydro (<10 MW)	1,773	..	1,476	1,361	1,325
4.9 Total Hydro	5,759	4,5	4,282	2,62	2,74
TOTAL RENEWABLE ENERGY	19,783	17,468	19,404	29,78	25,406
10.1 Nuclear LWR	0,395	0,414	0,429	0,392	0,44
10.2 Other Converter Reactors	45,236	37,562	38,647	33,432	31,979
10.3 Nuclear Fuel Cycle	0,395	0,533	1,315	0,394	0,471
10.4 Nuclear Supporting Tech.	1,559	1,357	0,429	0,509	0,548
10.5 Nuclear Breeder	0,395	0,414	0,429	0,392	0,44
Total Nuclear Fission	47,979	40,28	41,249	35,118	33,878
11. Nuclear Fusion	0,83	0,806	0,811	0,34	0,382
TOTAL NUCLEAR FISSION/FUSION	48,809	41,086	42,06	35,458	34,26
12.1 Electric Power Conversion	9,563	10,427	13,779	19,002	13,476
12.2 Electricity Transm. & Distr.	3,494	5,088	3,821	2,576	2,722
12.3 Energy Storage	2,136	3,852	5,307	11,81	8,635
TOTAL POWER & STORAGE TECH.	15,193	19,367	22,907	33,387	24,833
13.1 Energy Systems Analysis	0,35	2,72	2,267	1,92	1,703
13.2 Other Tech. or Research	24,974	27,695	20,978	20,842	19,238
TOTAL OTHER TECH./RESEARCH	25,324	30,415	23,245	22,761	20,941
TOTAL ENERGY R&D	179,422	195,169	211,675	232,545	211,745

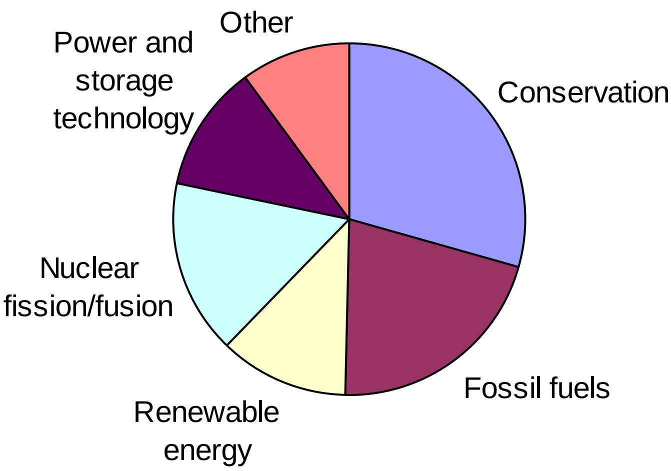

Figure 5.1 Public expenditure for energy research 2004 in Canada [5.3]

5.5 Innovative Energy Research – how to move on?

The following paragraph gives an overview of the views expressed by Mr. Mohamed (NRCan - Office of Energy R&D) on the issue of Innovative Energy Research [5.2]:

Widespread fundamental changes are required to our energy supply, transportation and end-use systems. We have to recognize that this a long term transformative challenge which will need to take time and continuing commitment and investment to succeed. However, even though the issue is long-term in nature, we must start now by expanding investment in developing the knowledge base for such transformative approaches, accelerating the development of potential technologies and ensuring that supportive mechanisms are available through government, academic and private sector engagement to move the new technologies from "mind to market".

We need to approach basic sciences and new energy technologies from three aspects which are mutually inclusive:

- "understanding phenomena" - identifying promising ideas in basic energy sciences such as the Chakravarty - Kee -Volker theory of high temperature superconductivity, negative refraction of sound. Using the understanding of phenomena to do applied research of new energy technologies including systems combining several advances for new energy systems (e.g. several taken together, such as the Mazur Group "black silicon" PV- lithium iron phosphate electrochemical storage for a new solar powered light weight automobile, with individual electric motors on each wheel and magneto-rheological fluids for brakes, seals, etc) and individual advances by energy disciplines. Here are SOME of the broad areas that came out of the IEA AHGSET workshop: photon capture, superconductivity, post-genomic science, electrochemistry, catalysis, and biophysics.
- "mining scientific advances" - continually reviewing advances in other areas of science such as Helbing and Fasold traffic flow models applied to industrial processes, biophysics and biological processes, etc; and determining which has potential for development of new energy technologies and systems and increased efficiency of energy use. Communicating that information to energy

research organizations, and facilitating cooperation among these organizations in applied energy R&D in the areas identified.

- "grand challenges" - challenging the scientific community with questions such as: what kind of material (s) would we need for a very high efficiency non-toxic, easy to recycle, inexpensive PV (using combinatorial chemistry techniques to find such materials, and nanotech to make them?); new non-toxic, easy to recycle, inexpensive (rechargeable of course) electricity storage batteries.

Some views on how these could be pursued are:

- Hold energy-related workshops on scientific advances in broad areas to review advances that point to potential energy systems and technologies. Must have "papers" written by designated experts.
- Hold workshops on specific fields to explore ideas (e.g. superconductivity, ultrasonics, tribology, diamond, ionic liquids, etc). These can be hosted by country laboratories. Engage learned societies, for examples materials research - ask them to hold a meeting to explore materials and new energy technologies for example. Include advances in mathematics and their application to energy. Biologists may have a different way of looking at systems than chemists and physicists and engineers – is there something they can teach each other?
- Develop mechanisms to pursue the research ideas that will result from the workshops - get labs working together using virtual organization, e-science, etc
- Develop approaches to getting the fundamental researchers working together with applied scientists and engineers – the US Man on the Moon and the Japanese Fifth Generation Computer are some examples of how this may be done. The German Fraunhofer Institute has a good approach on photovoltaics.
- Following from the above identify an area – e.g. the energy storage "grand challenge" noted above – challenge the scientific and engineering communities and see what they come up by raising what if questions.

In general though, ways need to be found to get engineers to pose "if we had this questions" to scientists, and, on the other hand get scientists to say "we have found out this which may have some promise in an area of engineering".

This could be done through workshops such as advances in mathematics and their applications to modelling – a meeting of modellers and mathematicians, where the mathematicians talk about advances and the modellers talk about "if we had such and such" we could improve our models. AHGSET did something like this in the Germany workshop.

5.6 References

[5.1] *Energy policies of IEA countries - Canada 2004 review*, IEA, 2004, ISBN 92-64-10802-5, downloadable from http://www.iea.org/textbase/nppdf/free/2004/canada.pdf p153 -163.
[5.2] Information provided directly by Mr. Hamid Mohamed, NRCan Office of Energy R&D, 23 + 24 March 2006
[5.3] Internet site of IEA www.iea.org

6 EMINENT

The EMINENT (Early Market Introduction of New ENergy Technologies) project was launched by the EC DG TREN in 2003. Recently, a continuation up to 2007 has been granted. EMINENT is aimed at new energy technologies, and therefore it could be interesting for INNER. The following chapter describes the aim and background of the project and the achievements.

6.1 Aim and background of EMINENT

The main objective of the EMINENT (Early Market Introduction of New ENergy Technologies) project is to identify and accelerate introduction and implementation of leading edge European energy and environmental technology into the market place in Europe and worldwide.

The principal method which EMINENT has been developing to achieve this goal is a software tool, which allows an early analysis of the advantages and disadvantages of the new technology.

The tool compares various energy supply chains, as shown in Figure 6.1.

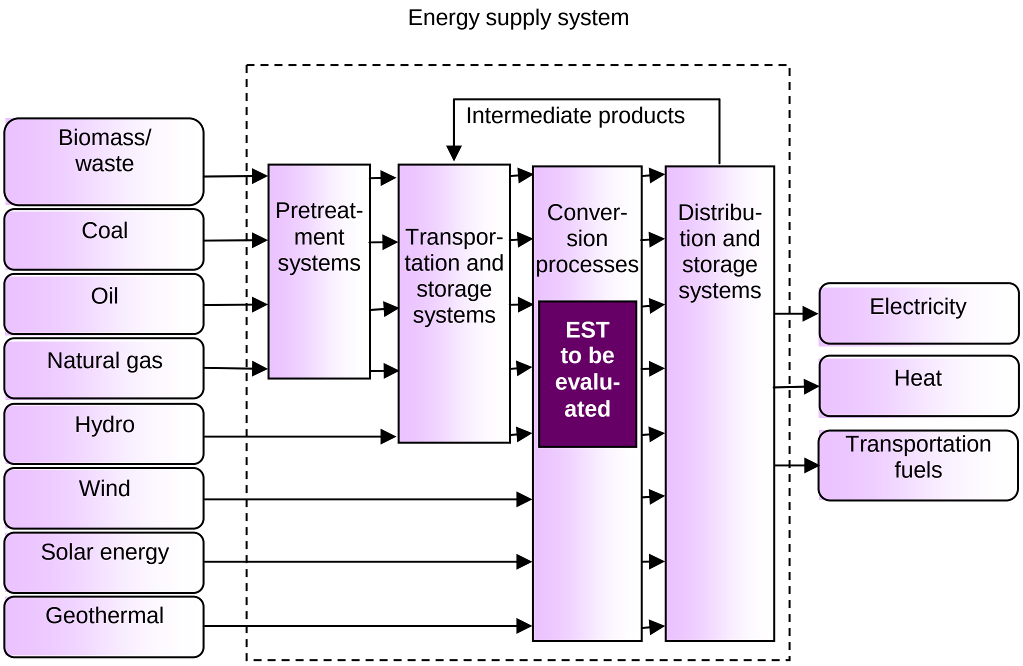

Figure 6.1: EMINENT Software tool analyses various EST (Early Stage Technologies) and energy supply chains

The EMINENT project has been supported by the OPET Network. The OPET Network (Organisations for the Promotion of Energy Technologies) is an initiative of the European Commission that aims to promote public awareness of current energy research through a new and challenging series of activities. These activities are intended to further the deployment of innovative technologies and increase the pace of market uptake of research results that support European Energy Policy priorities.

Participants in the first phase of the EMINENT project were TNO (the Netherlands), SINTEF (Norway), University of Manchester (UK), Instituto Superior Tecnico (Portugal), PTJ (Germany), VTT Processes (Finland), Riga Technical University (Latvia), UPEI (Czech Republic), Risoe National Laboratory (Denmark), Moscow State University (Russia).

A second phase has recently been awarded.

6.2 Brief description of EMINENT software tool

The software tool developed within the EMINENT project has the aim to design possible energy supply chains and to evaluate them based on weight factors given by the user. It consists of integrated resource manager, demand manager, EST (Early stage technology) manager, and databases on resources, demand and EST's as well as the analysis tool (Fig 6.2). The databases contain information about the energy demand in specific countries, and numerous technical data, which can all be viewed by the user and adapted as required. The EMINENT software tool was described in detail by Jansen *et al* (2004) [6.1].

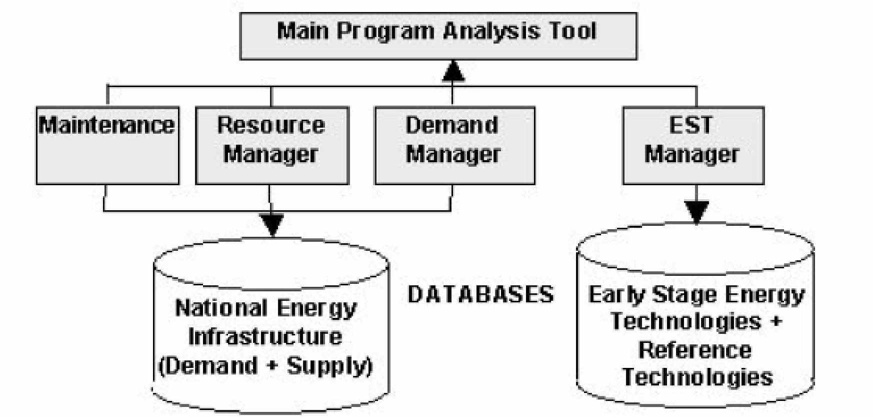

Figure 6.2: Overview of interaction between various parts of EMINENT software tool

The result of calculation with the tool is a calculation of cost per kWh, chain efficiency, percentage renewables, CO_2 emission per kWh. A comparison with a reference technology is very straightforward. The databases already contain a lot of information on resources available in various countries etc. A manual for the software tool has been issued [6.2].

The relevance for INNER is limited, since some good-quality data are necessary to make a just assessment of a technology. The tool could not identify which technologies we might need in 2020.

The most actual information on EMINENT is available on the project's website [6.3].

6.3 References

[6.1] P. Jansen, J. Koppejan et all., *EMINENT accelerates market introduction of promising early stage technologies for transport and energy, CISAP-1*, 1st Italian Convention on Safety & Environment in Process Industry, 28-30 November, 2004 - Palermo, Italy, available for download on http://www.cpi.umist.ac.uk/eminent/Confidential/actions/pdf/CISAP1.pdf
[6.2] J. Koppejan, *Eminent assessment tool for identification of markets for early stage energy technologies, software manual and training cases, version 3.0*, Produced by TNO MEP, the Netherlands, j.koppejan@mep.tno.nl
[6.3] Eminent Internet Site http://www.cpi.umist.ac.uk/eminent/

7 IEA AHGSET

The importance of linkages between basic science and energy technology R&D was addressed at the IEA Conference “Linking basic science and the Development of New Energy Technologies” that was held in Paris in April 2003.

In March 2004 the Ad Hoc Group on Science and Energy Technologies (AHGSET) was established as a reflection of IEA’s commitment to continued exploration of this important issue.

7.1 Mission

The mission of the Ad-Hoc Group on Science and Energy Technologies (AHGSET) is to support the development of new energy technologies by strengthening the connections between basic science and applied energy programmes.

7.2 Structure

The Ad Hoc Group on Science and Energy Technologies is directly linked to the IEA committee on Energy Research and Technology (CERT), that is positioned directly under IEA’s Governing Board [7.1]. Figure 7.1 gives an overview of the structure of the IEA Technology Network, and the position of AHGSET.

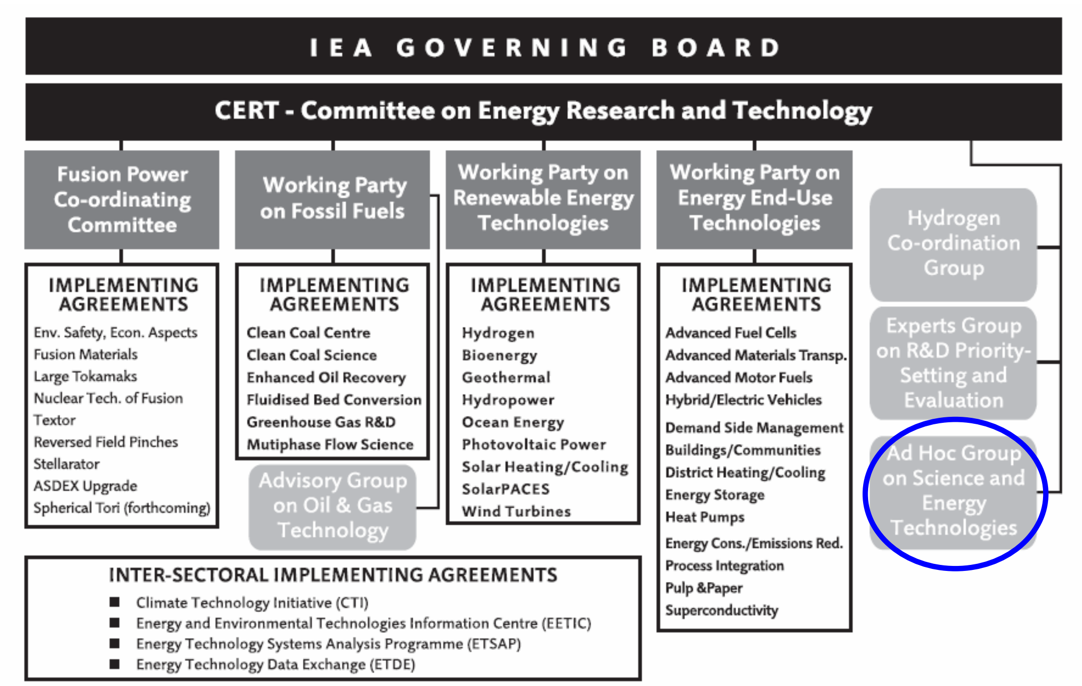

Figure 7.1: The IEA Energy Technology Network

7.3 Activities

One of the central activities of AHGSET is to sponsor workshops, bringing together key stakeholders from the scientific, energy technology and public policy domains to explore what energy technologists need from basic science (demand pull) and what the results of basic science can contribute to energy technologists’ needs (science mining)

Up to now three workshops have been organised by AHGSET:

- **8-9 November 2004, Berlin, Germany**
  'New Links Between Basic Research and Applied R&D – the Computational Approach'
  The workshop's programme was designed to take into account the technical "pull" from engineers and the scientific "push" from applied mathematicians. The topics selected covered issues relating to the generation and conversion of energy, as well as the end-use sector. Workshop documentation can be found at [7.2].
- **3-4 March 2005, Paris, France**
  'Methodologies and Tools for Multicriteria Evaluation of Energy Chains and for Energy Technology Perspectives'
  Its goal was to address the need for more advances socio-economic decision-aiding tools and technologies for the prioritisation of energy R&D options. Closer integration of environmental and social sciences is the major challenge here. The workshop enabled AHGSET to characterise the scope and the limits of existing decision-aiding processes and to study the outlook for development of more advanced tools.
- **15-16 November 2005, Oak Ridge, USA**
  'Transforming Our Energy Future: Advancing the Role of Science and the Critical Connections with Applied Energy Programs'
  This strategic planning workshop addressed both technical issues in Science & Technology and institutional factors that can affect long-term success. Specifically the workshop sought to:
  - Identify and challenge the science community with the critical energy technology barriers
  - Identify priority opportunities for broad-based, or crosscutting science "push"
  - Develop actionable strategies for research integration, innovation and collaborations
  Workshop documentation can be found at [7.3].

7.4 References

[7.1] *Mobilising Energy Technology – activities of the IEA Working Parties and Expert Groups*, IEA, 2005, p 11, 69 – 74, downloadable from http://www.iea.org/dbtw-wpd/Textbase/nppdf/free/2005/MobilsingEnergyTech_WEB.pdf
[7.2] http://spider.iea.org/impagr/cip/Comp_Approach/index.htm
[7.3] http://www.science.doe.gov/sc-5/AHGSET

8 FP6 NEST and FP7 IDEAS

The FP6 (Sixth Framework Programme) New and Emerging Science and Technology (NEST) programme aims to support unconventional and visionary research with the potential to open new fields for European science and technology, as well as research on potential problems uncovered by science. Its targets are similar to INNER, but the scope is much wider and not limited to energy.

8.1 General description

The NEST website [8.1xx] mentions:
"EST is designed to be flexible and interdisciplinary research is encouraged. There are no restrictions on the scientific fields to be addressed except that the research carried out under NEST should cut across or lie outside the thematic priority areas. NEST will not support projects which simply cannot find their home in one of FP6's thematic priorities.
In addition to developing new scientific understanding and capabilities, and opening up new fields, NEST activities aim to consolidate European efforts in emerging fields of research and assist in planning future activities in support to a European Research Area. They will help to nurture themes that will need larger-scale support in future European research programmes."

NEST involves three complementary Action Lines, each contributing to the overall goal of improving European anticipation of future scientific and technological needs:

- ADVENTURE projects are 'visionary' research projects that will develop new scientific and technological opportunities in areas identified by the researchers themselves;
- INSIGHT projects assess new discoveries or newly-observed phenomena which could indicate risks or problems to society;
- PATHFINDER initiatives are focused on specific, highly challenging objectives in emerging scientific and technological fields, and involve groups of complementary projects.

In addition, NEST SUPPORT actions are being carried out, such as methodological studies and activities to promote dialogue with the research community on emerging scientific and technological developments.

8.2 The future: IDEAS at the ERC

In FP7 (Seventh Framework Programme) there will probably no longer be a NEST activity.

8.3 Energy research in NEST

Table 8.1 below summarises the NEST projects that have a link to energy.

Table 8.1 NEST projects with a link to energy

Acronym	Focus of project	Contact	Type*	Rele-vance**
BIOMODULARH2	Photosynthetic bacterium for sustainable H_2 production	Probably University of Valencia, Spain	P	++
EA-BIOFILMS	Identifying electrochemically-active biofilms for various applications such as bioenergy	France: Laboratoire de Génie Chimique – CNRS, Dr. A. Bergel	A	+
EMERGENCE	Setting the bases for	Info at	P	?

	synthetic biology in Europe	Christian.Krassnig@ec.europa.eu		
NANOCASE	Casimir force to design nanotechnology devices that can transmit force without contact	UK, University of Leicester, Prof. C. Binns	A	+
SOLAR-H	Photosynthetic processes to split water and form renewable H_2	Sweden, Uppsala University, Prof. S. Styring	A	++
SYNBIOLOGY	European perspective on synthetic biology (analysis)	Portugal, Sociedade Portuguesa de Inovação, Prof. A. Guimarães de Medina	P	?
TESSY	Towards a European strategy for synthetic biology	Info at Christian.Krassnig@ec.europa.eu	P	?
VIMPA	Micro-electromechanical systems as portable power source	Italy, Scuola Superiore Sant' Anna, Prof. P. Dario	A	+

* P = Pathfinder, A = Adventure
** Relevance for INNER ++ high; + positive; ? unknown
Sources see http://cordis.europa.eu/nest/findproj.htm
Latest PATHFINDER projects on Tackling Complexity in Science, Synthetic Biology, What it means to be human, Measuring the Impossible, and Cultural Dynamics
Fact Sheets 2004/2005 of PATHFINDER projects on Tackling Complexity in Science, What it means to be human and Synthetic Biology
Fact Sheets 2004/2005 of ADVENTURE, INSIGHT, NEST SUPPORT projects Search FP6-NEST projects

The table shows that there are only few projects with a direct link to energy, two related to biological production of H_2, and one other related to the same subject. Furthermore, there is one nano-technology, and one micro-electromechanical project related to energy as well. The biological H_2 production projects might be fed from projects related to synthetic biology. “Synthetic biology aims to create novel biological functions and tools by modifying or integrating well-characterized biological components (i.e. genes, promoters) into higher order genetic networks using mathematical modelling to direct the construction towards the desired end product.”

8.4 NEST support actions related to INNER

Table 8.2 below summarises the NEST support actions relevant for INNER

Table 8.2 NEST support actions relevant for INNER

Acronym	Focus of project	Contact
CREA	Find the most creative researchers in genetics and nanoscience and learn what makes for excellence in research	Germany: Fraunhofer Institute for Systems and Innovation Research, Prof. S. Kuhlmann
NEST-PROMISE	Gather and analyse information on an extremely wide range of existing research initiatives operating along NEST lines and draw experience from their successes and difficulties	Israel: the Israel science foundation, Prof. E. Pollak

8.5 References

[8.1xx] What is NEST? http://cordis.europa.eu/nest/whatis.htm