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Nordic Energy Research

North America – Norden

Mapping of current cooperation efforts in energy R&D

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Imagine a virtually unlimited supply of electrical power from solar-energy systems, modelled the photosynthetic processes utilized by green plants, and power lines that could transmit this electricity [...] at nearly 100 percent efficiency. If the technological advances in information in the 21st century serve as a guide, disruptive advantages born out of pushing the science frontiers will be a key to addressing 21st century energy challenges.
Department of Energy (DoE), 2008

1. Introduction

As a society, we face serious challenges in posed by rising CO_2 emissions, and in ensuring a stable, secure supply of energy. It is evident that any conceivable solution to the climate and energy crisis will have to include a substantial increase in the amount of energy we get from renewable energy sources. However, that would require that we both invent new technologies and deploy the more market ready technologies to a larger extent. The use of renewable energy technology in the market today is not nearly enough.

In their latest "Energy Technology Perspectives" report for 2008, the IEA concludes that a technological revolution is needed if we shall be able to meet the necessary emissions targets set by our politicians. To achieve this technological revolution is a huge task. In order to meet our goals, we need to drastically increase the amount of time and money we allocate to research, development, demonstration and innovation in energy. This task needs to be approached in a combined effort, utilising the diverse strengths of different tools, countries and regions.

The Nordic region has a long history of cooperation in energy research and the institution Nordic Energy Research has existed for over 20 years. The model that the Nordic governments have chosen for energy research cooperation is a "smart money" approach, where the large money still is allocated at the national level, whereas the Nordic efforts complement the national initiatives.

The focus in the Nordic region has long been on cooperation with the adjacent areas and with the rest of the European Research Area (ERA). Over the last years, Nordic Energy Research has opened corridors of cooperation towards Northern Russia – and is currently looking at the possibilities for more cooperation with China.

The Nordic region has long standing ties with North America. Both the USA and Canada are important trade partners for Nordic companies, and important partners in research and development. This note is a first attempt to map the Nordic collaborative efforts with the USA and Canada in the field of energy research. We have primarily focused on renewable energy, hydrogen technology and to some extent Carbon Capture and Storage (henceforth CCS).

Nordic Energy Research participated in organising the event "Nordic Green" in Palo Alto, California, in the spring of 2008. The lesson from that conference was that the added value of increased cooperation between our two regions could be substantial. According to Ernst & Young (2007) the Nordic countries and North America are both very attractive regions for investments in renewable energy technology. This creates a substantial market potential for so-called green tech businesses. More relevant in the present case is that it creates a huge market for knowledge, research and innovation in energy technologies.

1.1. Brief remarks on methodology

The list presented here of cooperation between the Nordic region and North America is not to bee seen as an exhaustive account of these issues. The scope of this inquiry is to be a first attempt to map the different types of cooperation that exist between the two regions. Based on this initial survey, Nordic Energy Research will decide whether or not to start a more comprehensive investigation into these matters.

In order to achieve a meaningful benchmarking later in the process, it is helpful to begin with a mapping of the current cooperation efforts between the two regions.

The specific method chosen to acquire the information gathered here is basic analysis of publicly available literature. Based on the assumption that public research cooperation is not usually associated with any secrecy – the author has looked at the official websites of government institutions and universities. In some cases unstructured, exploratory interviews have been made. In those cases, the interviews have been exclusively for fact finding purposes.

There are different methods and approaches to transnational research cooperation. These are presented below, after a discussion on the rationale for international RD&D cooperation.

2. Why cooperate – and how

2.1. Benefits from transnational cooperation

In addition to the intrinsic value of furthering international research, there are other, concrete benefits from participating in international energy RD&D cooperation.

The various benefits can be grouped into four rough categories: Climate change, Attracting talent: building an economy and technology export.

2.1.1. Facing the climate challenge

The first is the clearest. We face grave challenges in climate change and global warming. The targets set by our politicians are ambitious, and require urgent action to be met. Pooling our efforts in energy research can bring us closer to meeting our targets. In terms of energy research and innovation, there are fairly clear cut goals with regards to CO_2 emissions, sustainability and combating climate change. As an ERA expert group states: *To tackle these challenges, manifold innovations are needed and new global innovation networks have to be built.*

In their “Energy Technology Perspectives 2008” the IEA argues that international RD&D cooperation offers a range of benefits. The most important are that a common pool of knowledge would reduce the funding need in national RD&D, and that technology development would be strengthened and accelerated by the clever use of diverse national comparative advantages (IEA 2008a: 193).

2.1.2. Attracting talent and fostering research

In their evaluation of the European Research Area (henceforth ERA), the ERA research group tasked with the international dimension described the rationale for international R&D cooperation. Among the many positive effects of increasing the international dimensions in both national and regional R&D efforts, they found that:

> Among the policy implications were that the EU could foster better international mobility of researchers and better attraction of talented researchers and research intensive organisations to Europe (COM 2008: 36).

The challenge for Europe and the Nordic region, as well as North America is to continue to attract the best minds, and to continue to build a reputation for being strong in innovation, science and technology. International research cooperation is the best way to both achieve more necessary technological advances in renewable energy, and to build up a competent regional science and technology sector, that are able to compete globally for the best minds.

For the individual university and research community the benefits from cooperation are clear, as cooperation exposes those institutions to new knowledge and ideas. A number of, if not all, large universities in the Nordic region have established internationalisation strategies and have set up offices specially tasked with facilitating the exchange of ideas, research and students in an international perspective (see for example Gothenburg University 2005; Lund University 2008).

As Lund University writes in their international strategy:

> Priority will be given to long-term relationships. Strategic networks and agreements involving international cooperation will be found at all levels of the university. The university will be active in ensuring that cooperation agreements are consolidated

and extended to encompass educational provision, research and administration (Lund 2008: 2).

2.1.3. Building an economy

In the Lisbon agenda the EU sets out to be the most competitive and knowledge intensive region in the world by 2010. A crucial part of reaching this goal was a substantial increase in the regional RD&D efforts. Within 2010 the EU countries should have R&D funding in the range of 3 percent of the national GDP. Of the 3 percent, 1 % should be public and the remaining two should be private. While there is short term reasons for maintaining a technology based competitive advantage on a neighbouring country through not cooperating, the long term benefits of being able to reduce duplication in RD&D funding, as well as being able to build on the scientific efforts and findings on others, outweigh the short term drawbacks. The same realisation has been evident in the Nordic region.

In regional, transnational research cooperation, we separate between initiatives in the NORIA, ERA and ERA + the rest of the world.

In the 7^{th} framework programme it is stated that

> To become more competitive and play a leading role globally, the European Community needs a strong and coherent international science and technology (S&T) policy (EU 2008).

According to Johansson (Et.al 2007), countries who wish to increase the effectiveness of their own innovation system, and hence make their economy more innovative (the goal of both the Nordic region and EU) should increase international research cooperation. Johansson suggest further that the countries should import more R&D as well and using building on it through national efforts. Following his line of thought, increased internationalisation would mean that the participating economies improve, and the society as such move closer to acquiring the technologies and solutions we need.

2.1.4. Exporting technology

The Nordic green tech export is increasing. Much of the increase is towards the emerging economies in China, Brazil and Russia, but the US remains the biggest market for these companies. In 2006 the total energy technology export to the US from the Nordic countries was worth € 1.8 billion (Trong 2007).

The USA and Canada are two of the most important trade partners for the Nordic region. That means that we have much in common, and it means that we participate on the same marketplace. Companies from the US and Canada export their goods to the Nordic region, and Nordic green tech companies export to the North American market. The companies and corporations based in the different countries all benefit from the national competences and the national research and development efforts strive to increase the countries' competitive advantages in the global competition against others.

As the above shows, there are multiple benefits from international cooperation. In essence, these are:

- Increasing focus on international energy research brings a solution to the climate challenge closer.
- Participation in international energy research cooperation makes it easier to attract talent from other regions in the world.
- Increasing the net amount of research and innovation available to national and regional stakeholders increases the innovation in the economy, and contributes towards economic growth.
- Participating in international energy research cooperation increases the export potential for national and regional green tech businesses – as they thrive on talent and research results.

While there are indisputable benefits from RD&D cooperation, there are different methods for doing the actual cooperation, these are presented below.

2.2. Different approaches

In the current literature in the field on Science and Technology cooperation (see for example COM 2008) the line is often drawn between a bottom-up and a top down cooperation. Science and research has always been international in character – the research discourses are international, and scientific conferences and periodicals encourage international discussion. Although the forms of cooperation vary from instance to instance, we shall attempt to create a typology that could help us map the cooperation efforts between North America and the Nordic countries.

Within the study of Science and Innovation cooperation, it is common to separate between the following types of cooperation:

- Informal cooperation (Paper cooperation)
- Formal cooperative agreements (bilateral scientific programmes)
- Multinational collaborative programmes

2.2.1. Bottom up

Research has always been transnational in nature. International science conferences and cooperation between individual scientists have always been crucial to the scientific discourse in most fields. The type of research cooperation that takes place on the level of the researcher, universities and institutes are often labelled "bottom up". This type of cooperation does not require big funds in order to function. There are, obviously, differences of scale between these levels of cooperation– from smaller projects to bigger, more capital intensive university cooperation. In essence, however, the cooperation between researchers and institutes is primarily dependent on small grants and mobility funds in order to work at its most basic level (COM 2008: 20).

A list of bottom up cooperation between Nordic and North American scientists naturally has to be somewhat limited. In this note/paper/memo we do not look at all the mobility programmes and cooperation between individual researchers or research groups. Bottom up will for our purposes be defined as the type of cooperation that arises between universities and research centres, and which is not initiated by central governments. The many mobility and scholar exchange programmes between universities in North America and the Nordic region will not be addressed here.

The benefits with bottom-up cooperation is that it grows naturally out of scientific discourse, making sure that cooperation exist where cooperation is valuable. The downside, in general, is that bottom-up cooperation naturally does not attract the biggest funds.

2.2.2. Top down

The other form of R&D cooperation is labelled "top down". This kind of cooperation is based on more formal forms of cooperation between public bodies. The initiatives are often politically based, and the cooperation could require a surrounding institution to coordinate. This category encompasses the big cooperation between countries, such as the above mentioned International Energy Agency, CERN, and the formal bilateral cooperation agreements between countries.

Top-down methods of R&D cooperation also include bilateral agreements. These agreements create the organisational and political frameworks for the cooperation. The agreements are therefore often very general. Our concern in this case has been those agreements that focus *explicitly on energy research and development.* In the case of North America and the Nordic countries the bilateral agreements are between the governments in both signing countries. And in some cases the government in one Nordic country and one state from the US. Sweden for example has one agreement with the state of California.

The top-down cooperative agreements are as mentioned mostly larger and more cost intensive than the agreements between universities. The bilateral top-down agreements most certainly involve larger sums of money than the kind of cooperation that grows naturally out of the scientific cooperation. The latter is however preferred by some research funding organisations. The Swedish Research Council for instance has a policy not to engage in bilateral research agreements. They prefer that researchers themselves engage in active cooperation, and then apply for funding.

The benefits of using a top-down approach is that one can attract a large amount of research funding to one specific problem. In addition, a top-down research agreement between governments could potentially yield many small scale bottom-up initiatives as a result.

Top-down and bottom-up models of international research cooperation have the potential to unlock great benefits by combining national strengths. Outside the theoretical realm it is best to think of these models as complementary and adapted to different purposes.

2.3. Multilateral and bilateral arrangements

In energy research and development we can separate between research cooperation that takes place between two countries (bilateral), and cooperation that takes place within a regime such as the IEA or the EU (multilateral).

National strategies differ from country to country – and between different periods of time. The various bilateral agreements and multilateral regimes set in place to coordinate international energy R&D cooperation also differ greatly in order to suit the specific needs of the signatories.

3. Different structures for Energy R&D

Different countries organise their R&D funding in different ways. Below is a summary of the most important institutions in R&D funding in the US and Canada.

3.1. USA

In the federal US system of research funding the following are important actors[1]:

The department of Energy (DoE)
The DoE handles the huge programs in energy research in the US. Their annual budget for renewable energy/new energy sources is 1.2 billion USD (2004). The DoE is a federal department.

The "Committee on Climate Change Science and Technology Integration"
This committee reports to the office of the President. The committee oversees the Climate Change Science Program, see table

The Environment Protection Agency (EPA)
The EPA also finances a number of programs on sustainable energy.

The National Science Foundation (NSF)
The NSF is basic research oriented organisation that has a more passive role in the US R&D financing system.

In addition to these institutions, there are a number of national laboratories that are run by the government. These are closely related to the long term policy goals of the government.

As regards to international cooperation, the DoE and the National laboratories are generally open for international partners, as long as the majority of partners come from the US (NFR 2004).

The US Department of Energy is currently starting up a new programme labelled "Energy Frontier Research Centres" (EFRC). These centres are to focus on basic science challenges related to our climate and energy challenges. These centres can become attractive

[1] These are the public research financers in the US. In addition to these, there are of course numerous private foundations, organisations and even private persons who fund energy related research. Some of these, like Rockefeller (http://www.rockfound.org/) and the Carnegie foundation (http://www.carnegiefoundation.org/) are especially important. As international research cooperation goes, the emphasis in this note is on public bodies.

cooperation partners for Nordic actors in the future. As the DoE states: "We are particularly interested in tapping the imaginations and creativity of the scientific community to address the fundamental questions of how nature works and how to harness this new knowledge for some of our most critical real-world challenges" (DoE 2008: 3).

The States in the USA have a rather wide mandate. The prerogative of the federal level is primarily to assist the state level on many issues, while the main area of the federal level is defence and foreign relations.

Concerning international research cooperation the state level might seem a little outside the scope. However, the State of California has signed a bilateral research cooperation agreement on energy with the government of Sweden, proving that the state level is relevant also in this case.

The federal bodies in the US have some state level activity. The Department of Energy for instance has got a California office.

In addition to this, the California Energy Commission is one of the central actors in the State of California.

For a full introduction to California and energy issues, see www.energy.ca.gov.

3.2. Canada

The key R&D funding institutions for energy in Canada are:

AERI Innovations Assistance Program

The Innovations Assistance Program supports early stage inventions that will contribute to the technology or practices of Alberta's energy industry. This program is intended to help small inventors develop and test ideas before they are brought to the marketplace.

The National Research Council (NRC)

The Canadian National Research Council is the most important instrument of the Canadian government in R&D funding in general. The Research Council also handles energy R&D funding.

A number of sub agencies have been created under the NRC since its formation in 1916. These are:

- Atomic Energy Canada Ltd.
- Canadian Space Agency.
- Communications Security Establishment
- Defence Research Board
- Medical Research Council (now known as Canadian Institutes of Health Research)
- Natural Sciences and Engineering Research Council

The Natural Sciences and Engineering Research Council (NSERC)

NSERC is the strategic investment agency in Canada for Science and Technology. As NSERC describes:

> NSERC is the national instrument for making strategic investments in Canada's capability in science and technology. NSERC supports both basic university research through discovery grants and project research through partnerships among universities, governments and the private sector, as well as the advanced training of highly qualified people (NSERC 2008).

Natural Resources Canada (NRCan)

Natural Resources Canada (NRCan) ensures the responsible development of Canada's natural resources, such as energy (NRcan 2008).

The Canadian system of municipalities and states is kept outside this brief survey, as no Nordic country has any direct agreement there.[2]

4. Bilateral cooperation

The bilateral cooperation's between North America and the Nordic region are many. In this note the focus lie on the bilateral connections between the individual Nordic countries and USA or Canada. On the Nordic side, universities, institutes and governments has been in focus. And, and mentioned above, the researcher-researcher cooperation and very small scale institute cooperation is left out in this survey.

This section outlines some of the bilateral research cooperation that exists between the Nordic countries and North America. The full list can be found in Appendix 1.

In 2004, the US had 32 bilateral, top down, science and technology agreements. The major research nations in Europe have not singed such agreements with the US, yet have extensive cooperation none the less. Very few countries have bilateral agreements with Canada (Norwegian Ministry of Education and Research).

4.1. Norway

The formal, bilateral top down cooperation between Norway and the USA and Canada revolves around a Memorandum of Understanding between the US government and the Norwegian government from 2004. This outlines the cooperation between the two countries in energy research. The Norwegian government also has a bilateral Science and technology agreement with the US, which covers the entire scientific spectrum.

Norway has no bilateral agreement with Canada.

In 2003, a survey was made by TRUST, of the bilateral partnerships in research (Mykletun 2003). The survey found that the cooperation between Norway and the North American states had significant room for improvement, and that the Norwegian institutions and government could do a better job in presenting themselves and advertising themselves in regard to the North American states.

There is however a number of partnerships and cooperative efforts between Norwegian actors and US and Canadian actors in energy research (se Appendix 1 for more detailed information).

The most active Norwegian university in this context is NTNU/SINTEF. They have several ongoing cooperative arrangements with the US.

4.2. Sweden

Sweden has one general bilateral Science and Technology agreement with the US from 2006, which serves as the starting point and umbrella for the more theme specific agreements. The agreement on renewable energy, clean tech and efficient energy systems was signed in June 2006. In addition, Sweden has a bilateral agreement with the State of California.

The position of the Swedish Research Council is that bilateral research agreements are best organised and carried out on the researcher level – and hence their policy the last couple of years has been not to enter into bilateral agreements on a higher level (Swedish Research Council 2008). In essence this means that the Swedish Research council has decided that bilateral research agreements should only be bottom up.

The Swedish Energy Agency (Energimyndigheten), who has the primary responsibility for energy research funding in Sweden on the other hand has formal bilateral research agreements with the US.

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[2] The region Nunavut in north west Canada has cooperated with Nordic Energy Research and the Nordic Council of Ministers Task force for Renewable Energy in Isolated Locations on a symposium in 2007 (www.nordicenergy.net/symposium). The purpose of this symposium was to exchange ideas and experiences between the West Nordic countries and Nunavut on energy issues specific to remote and isolated locations.

Sweden has no comprehensive bilateral agreement with Canada – although the Canadian government are said to have been interested in such an agreement.

The Swedish universities, such as Chalmers are fairly active in their cooperation with North American universities (see Appendix 1)

4.3. Finland

The Finnish Ministry of Employment and the Economy have a bilateral Energy Science and Technology agreement with the USA. The agreement has been in effect since 1995, and is soon expired. The negotiation concerning a new agreement is currently underway. Finaldn also has a general Science and Technology cooperation agreement that covers this cooperation in general. This agreement comprises all different types of technology.

Currently, Finland has no agreement of this kind with Canada. Some Finnish universities and Collages do have student exchange programmes with Canadian universities, but as far as this analysis goes, no large scale cooperation has been identified. Through TEKES, the energy research funding agency in Finland (under the Ministry of Employment and the Economy), there are some partnership agreements with US actors, especially in the field of bioenergy.

4.4. Iceland

The bilateral cooperation in energy research and development between Iceland and North America consist of a bilateral Memorandum of Understanding between the government in Iceland and the California Technology, Trade and Commerce Agency. This agreement focuses on renewable energy technology.

In this MoU special emphasis is given to the area of geothermal energy, as this is an area where Iceland has international expertise. Currently there are negotiations underway between the Icelandic Government and the Government in USA on a Science and Technology agreement for Geothermal Energy technology. This prospective agreement will be on the federal level in the US.

Iceland also has a bilateral Memorandum of Understanding with the Regional Agency for Economic Development in Nova Scotia, Canada. This agreement is not exclusive to energy technology, yet energy technology and environmental technology is mentioned explicitly in the agreement text.

4.5. Denmark

Denmark has bilateral cooperative top-down agreements with the US. For instance, the Danish Research and Innovation Ministry participate in a partnership agreement with University of California Berkeley within several sciences, including energy technology. This agreement means that Danish scientists are able to participate in research cooperation with US partners. What separates this from an ordinary bilateral cooperation agreement is that this agreement actually means that the Danish Research and Innovation Ministry has bought some places in a research network. A similar agreement exists with Stanford, Santa Cruz and UC Davis.

Currently the Danish ministry is in negotiation with US counterparts about an ordinary bilateral research agreement that will be the basis of future R&D cooperation between the two countries.

A Denmark-Canada bilateral research cooperation focused on biotechnology expired in the beginning of 2008, whether this is scheduled for renewal in unclear.

> The Danish Agency for Science, Technology and Innovation also contributes actively to international developments in areas where Denmark has special competencies or where Denmark especially wants to influence international developments (Danish Agency for Science, Technology and Innovation 2008).

The Danish university DTU is active in cooperation with US universities. An agreement between DTU and the Helios Solar Energy Research Centre at Lawrence Berkeley National Laboratory is currently being negotiated. The initiative to this cooperation came from the US.

5. Multilateral cooperation

There are a range of multilateral institutions and collaborative efforts/agreements facilitating energy research cooperation between the Nordic and at least one of the North American countries. Probably the most notable is the International Energy Agency. The IEA facilitates cooperation over a large range of different energy related topics, including research and development.

5.1. The International Energy Agency

Much of the energy related cooperation between the Nordic region and North America is organised through the International Energy Agency. This is true both for the really large scale top down cooperation, and for some of the smaller scale research cooperation that finds liveable conditions under the IEA umbrella.

The IEA was established in 1974 as a result of the oil crisis in the early 1970ies.

As the organisation writes on their website (www.iea.org):

> The International Energy Agency (IEA) acts as energy policy advisor to 27 member countries in their effort to ensure reliable, affordable and clean energy for their citizens. Founded during the oil crisis of 1973-74, the IEA's initial role was to co-ordinate measures in times of oil supply emergencies. As energy markets have changed, so has the IEA. Its mandate has broadened to incorporate the "Three E's" of balanced energy policy making: energy security, economic development and environmental protection. Current work focuses on climate change policies, market reform, energy technology cooperation and outreach to the rest of the world, especially major consumers and producers of energy like China, India, Russia and the OPEC countries (IEA 2008b).

Both the US and Canada are members of the IEA – the same applies for the Nordic countries apart from Iceland. The IEA energy research are organised under the various "Implementing agreements" as annexes and sub programs (See appendix 2). These are technology specific. The Nordic countries and the US and Canada generally participates in most of these. The specific programs are presented in the table in Appendix 1.

5.2. The International Partnership for the Hydrogen Economy

Another example of multilateral energy R&D cooperation is the International Partnership for the Hydrogen Economy. This is a partnership where Canada, the US, Norway and Iceland participate. The partnership functions as a platform for the exchange of knowledge and research, and for demonstration of Hydrogen technology.

> The IPHE provides a mechanism for partners to organize, coordinate and implement effective, efficient, and focused international research, development, demonstration and commercial utilization activities related to hydrogen and fuel cell technologies. The IPHE provides a forum for advancing policies, and common technical codes and standards that can accelerate the cost-effective transition to a hydrogen economy; and it educates and informs stakeholders and the general public on the benefits of, and challenges to, establishing the hydrogen economy (IPHE 2008).

The IPHE was created by ministerial signing of the Terms of Reference. This is an ad hoc international regime – whose special task is to assist governments in moving towards the hydrogen economy. While the IEA focuses on all energy technologies, this one limits itself to one. The positive effects of having these targeted international regimes are that one achieves a more specialised focus, in relation to a permanent organisation such as the IEA.

5.3. The Carbon Sequestration Leadership Forum

The Carbon Sequestration Leadership Forum is another important international energy research cooperation regime. The Forum is an international climate initiative that focuses on ensuring a broad availability of Carbon capture and sequestration technology (CCS). The Forum was founded in 2003, and among the tasks of the Forum is the task of fostering international RD&D collaboration in energy research. The charter of CSLF clearly states the purpose of this regime:

> The CSLF will seek to realize the promise of carbon capture and storage over the coming decades, making it commercially competitive and environmentally safe (CSLF 2003).

On the organisation of the CSLF, the activities of the CSLF will be conducted by a Policy Group, which governs the overall framework and policies of the CSLF, and a Technical Group. The Technical Group reviews the progress of the projects, and recommends to the Policy Group on needed actions. Collaborative projects may be undertaken by the CSLF when authorized by the Policy Group at the recommendation of the Technical Group.

The Forum has 22 members. Canada and the USA are both members, as is Norway and Denmark. The other Nordic countries are not members. However, the European Commission is a member of the Forum, so Sweden and Finland are indirect members. As they are neither direct members of the forum, nor members of the EU, Iceland is not a part of this regime (CSLF 2008).

5.4. The European Union

The European Union has, in both the sixth and seventh framework programmes encouraged international cooperation. As a step towards "opening the ERA to the world", the EU has had both joint calls with third countries, and through for example the Marie Curie actions, funded researcher mobility programmes (EU 2008).

Both the USA and Canada has bilateral, so called "third country" S&T cooperation agreements within the 7th framework programme. This enables researchers from these countries to participate in calls in the Framework Programmes.

In the 7th framework programme, the EU has opened for countries that have "eligibility for different specific and work programmes" – as in the 6th programme, the US and Canada is eligible.

The European Research Area has a number of research projects that include North American scientists. One of these general programs is the ERA-CAN project (http://www.era-can.ca/) has the overall objective to increase research cooperation between Canada and the ERA countries. Energy and environmental issues is part of this.

The ERA-CAN cooperation includes the three main R&D funding institutions in Canada:

- Canadian Institutes for Health Research
- Natural Sciences and Engineering Research Council of Canada (NSERC)
- Social Sciences and Humanities Research Council of Canada.

The network will participate in an event in Copenhagen to discuss cooperation on Hydrogen and Fuel Cell research. The event will take place on 7 October 2008.

The Nordic region as such has no formal R&D or S&T cooperation with either Canada or USA. There are some elements of experience sharing, and conference activity – although this remains at a very small scale and outside the realm of R&D per se.

6. Conclusion

This brief summary of energy R&D cooperation between North America and the Nordic This brief summary of energy R&D cooperation between North America and the Nordic countries has shown that there is a rather extensive level of cooperation between the US and the Nordic countries. It has also shown that cooperation with Canada is less common on these issues.

A complete list of the initiatives identified is shown in Appendix 1 below.

The smaller, more informal types of cooperation are not always dependent upon public policy to form. In most cases small mobility funds or other very small scale funding is enough to foster good cooperation (COM 2008).

The ERA expert group has identified that international research cooperation in increasing. This is true for all forms of cooperation.

The analysis and survey presented here has given us a number of questions and items to follow up in a prospective future study on the possibilities for energy R&D cooperation with North America:

- How can the Nordic Council of Ministers, and Nordic Energy Research contribute to increased cooperation with the US and especially Canada?
- What kinds of cooperation agreements yield the greatest results?
- What can we expect in outcome from increased cooperation?
- What are the greatest barriers for cooperation (IPR etc)?
- Are there any cultural differences we need to take into account?
- Is increased cooperation directly with States such as California the way to go?
- How could a future joint call between North American Actors and Nordic Energy Research be designed?

An interesting point for further analysis is what we plan to receive as output from cooperation – meaning what are the success criteria for R&D cooperation between North America and the Nordic countries? For a researcher success might be to publish an article or a book, but for the national research councils and energy ministries a successful cooperation might yield more concrete results. A broader study of this issue should attempt to benchmark these questions, in order to make qualitative assessments of the cooperation. This understanding could lead to better design of cross-border research cooperation.

In 2008 there has been some discussion about possible cooperation models between the USA and the Nordic countries. The Department of Energy from the USA was for instance on a round trip to the Nordic governments to discuss this issue. There should in other words be a good climate for building cooperation between the Nordic countries and North America.

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Appendix 1: Current cooperation
Bilateral

Name	Purpose/Mandate	Type of technology/branch/department	Participating Nordic countries	Participating North American Countries	Type of cooperation	Multilateral or bilateral	Duration / Start	Website / Source
Partnership agreement	Allow Danish researchers and students to participate in cooperation with US scientists.	All	Denmark (Energistyrelsen)	USA (UC Davis, Stanford, Santa Cruz, UC Berkeley)	Top down	Bilateral		
Bilateral Science and technology agreement (Under negotiation)	Facilitate science and technology cooperation between the US and Denmark.	All	Denmark (Energistyrelsen)	USA (DoE)	Top down	Bilateral		www.ens.dk
Intent to form a Cooperative Research Alliance	To promote the development of advanced catalytic materials for solar energy utilization.	Multi-disciplinary research	Denmark (DTU - Centre for Atomic-scale Materials Design)	USA (Lawrence Berkeley National Laboratory and UC Berkeley)	Bottom-up	Bilateral	2008 -	www.innovationcentredenmark.dk (Søren Nedergaard)
Research partnership on Sustainable and Green Chemistry	Research partnership on sustainable and green chemistry between DTU and the University of New Mexico.	Chemistry	Denmark (DTU-Centre for Sustainable and Green Chemistry)	USA (University of New Mexico)	Bottom up	Bilateral		http://www.csg.dtu.dk/index.html
Danish-American collaboration on energy research	Establish a solid platform for the collaboration in energy R&D between the two institutions.	Renewable energy technology	Denmark (Risø-DTU)	USA (NREL)	Bottom up	Bilateral	2007 -	www.dtu.no (Birte Røgen, DTU)
Agreement relating to scientific and technological cooperation between the Government of the Republic of Finland and the Government of the United States of America	Foster Science and Technology cooperation between actors in USA and Finland.	All	Finland (Ministry of Employment and the Economy)	USA (Government)	Top Down	Bilateral	1995 -	http://www.tem.fi/?l=en&s=2379

Memorandum Of Understanding, Energy Research and Development Cooperation[3]	Facilitate energy technology research and development cooperation between USA and Finland.	All energy related areas	Finland (Ministry of Employment and the Economy)	USA (DoE)	Top down	Bilateral	1996 -	http://www.tem.fi/?l=en&s=2379
Name	Purpose/Mandate	Type of technology/branch/department	Participating Nordic countries	Participating North American Countries	Type of cooperation	Multilateral or bilateral	Duration / Start	Website / Source
Bio Energy partnership 1	Strengthen the Finnish-US research on biofuels.	Bio energy	Finland (TEKES)	USA (DoE)	Top down	Bilateral	2000 -	http://web.abo.fi/meddelanden/forskning/2000_04_bio.sht
Bio Energy partnership 2	Strengthen the Finnish- US research on bio fuels	Bio energy	Finland (TEKES)	USA (DOE)	Top down	Bilateral	2000 -	http://web.abo.fi/meddelanden/forskning/2000_04_bio.sht
Memorandum of Understanding (MoU) between the USA and Norway	This is a bilateral research cooperation agreement within energy. This agreement represent a formal framework for continued R&D cooperation between researchers in the US and Norway.	Oil and Gas, CCS, Hydrogen and Renewables	Norway (Ministry of Petroleum and Energy)	USA	Top down	Bilateral	2004 -	www.oed.no
North America Partnership Program	Increase contact and cooperation in Research and Development between Norway and North America	All	Norway (Ministry of Education and Research)	USA and Canada	Top down	Bilateral	2008 - 2010	www.siu.no
"Paired professors"	Build further on the cooperation between MIT and NTNU	All energy related	Norway (NTNU)	USA (MIT)	Bottom Up	Bilateral	2006 -	www.ntnu.no
The Effects of International Regimes: Insights Across Issue Areas	This project seeks to better understand the effects of international regimes by looking across various issue areas, including the environment, human rights, international economic policy and security.	Political Science	Norway (UIO)	USA (Oregon and Georgia State)	Bottom up	Bilateral	2003 -	www.uio.no

[3] This agreement has recently expired, and its renewal is under discussion.

Centre for Development and the Environment	The Centre for Development and the Environment is primarily a research institution. It was established by the University of Oslo in 1990 in response to the report of the Brundtland Commission: Our Common Future.	Political Science/economics	Norway (UIO)	USA (University of California at Berkeley , the University of Maryland, Yale, Stanford and Harvard, University of Texas, University of Columbia, International Food Policy Research Institute (IFPRI), Indiana University, MIT)	Bottom up	Bilateral	1990	www.sum.uio.no
Name	Purpose/Mandate	Type of technology/branch/department	Participating Nordic countries	Participating North American Countries	Type of cooperation	Multilateral or bilateral	Duration / Start	Website / Source
Energy and Environment (through BILAT grant from RCN)	Continuing cooperation on energy R&D.	All	Norway (UIO, IFE, SINTEF and NTNU, RCN)	USA (University of Maryland UMCP),	Bottom up	Bilateral	2006 -	www.sintef.no
Norwegian Centennial Chair program (NCCprog)	The purpose of this cooperation is to form Transatlantic Research Teams of scientists, undergraduate and graduate students at the University of Minnesota (UMN) and Norwegian University of Life Sciences (UMB)	Bioenergy, biobased products and functional genomics	Norway (UMB)	USA (University of Minnesota (UMN))	Bottom up	Bilateral	present	http://www.umb.no/?avd=138
Agreement on Science and Technology Cooperation between the Government of the United States of America and the Government of the Kingdom of Sweden	Promote cooperation between energy researchers in Sweden and the US	All	Sweden (Energistyrelsen)	USA (Gov)	Top down	Bilateral	2006	www.energimyndigheten.se
Implementing agreement between the government of the Kingdom of Sweden and the government of the United States of America on renewable energy R&D	Within the framework of the bilateral S&T agreement between the US and Sweden, this sub-agreements task is to promote the cooperation within renewable energy RD&D	All	Sweden (Energimyndigheten)	USA (DoE)	Top down	Bilateral	2007	www.energistyrelsen.se
Memorandum of Understanding (MoU) between the State of California and the government of the Kingdom of Sweden on renewable fuels and energy	Facilitate training of personnel, capacity building and technical support in renewable fuel technologies, products, energy feedstock.	All	Sweden (Energimyndigheten)	USA (Government of California)	Top down	Bilateral	2006 -	http://www.energimyndigheten.se/

Memorandum of Understanding between the Ministry of Industry and Commerce, Iceland, and Economic Development Nova Scotia, Canada	Increase focus on business growth, cooperation and investment in among other things Energy Technology, Advanced Manufacturing and Environmental Technology,	All	Iceland (Ministry of Industry and Commerce)	Canada (Economic Growth, Nova Scotia)	Top Down	Bilateral	2002	http://os.is/Apps/WebObjects/Orkustofnun.woa/1/swdocument/25533/2002++-++Nova-Scotia.pdf
Name	Purpose/Mandate	Type of technology/branch/department	Participating Nordic countries	Participating North American Countries	Type of cooperation	Multilateral or bilateral	Duration / Start	Website / Source
Memorandum of Understanding between the California Technology, Trade and Commerce Agency and the Icelandic Ministry of Industry and Commerce[4]	Facilitate the exchange of, and creation of knowledge about renewable energy sources, and the extraction of geothermal energy.	All energy technology, emphasis on geothermal	Iceland (Ministry of Industry and Commerce)	USA (California Technology, Trade and commerce agency).	Top down	Bilateral	2001	http://os.is/Apps/WebObjects/Orkustofnun.woa/1/swdocument/25532/2001++-++California.pdf

[4] Currently, the Icelandic government is in discussions with the US government on how to increase research in geothermal energy. An agreement is expected to be ready to sign ultimo August/primo September.

Multilateral

Name	Purpose/Mandate	Type of technology/branch/department	Participating Nordic countries	Participating North American Countries	Type of cooperation	Multilateral or bilateral	Duration	Source
The International Energy Agency (IEA)	The International Energy Agency (IEA) acts as energy policy advisor to 27 member countries in their effort to ensure reliable, affordable and clean energy for their citizens.	all	Denmark, Norway, Finland, Sweden	USA and Canada	Top down	Multilateral	1974 -	www.iea.org
Carbon Sequestration Leadership Forum (CSLF)	The Carbon Sequestration Leadership Forum is an international climate change initiative that is focused on development of improved cost-effective technologies for the separation and capture of carbon dioxide for its transport and long-term safe storage.	Policy	Norway	USA	Top down	Multilateral	2003 -	http://www.cslforum.org/index.htm
Transes	The principal objective of TRANSES is to aid governments, industries and communities to meet their future energy service needs in a cost-effective and sustainable manner in a liberalized energy market environment.	System analysis	Norway (NTNU/SINTEF), Sweden (Chalmers)	USA (MIT)	Bottom up	Multilateral		http://sintef.no/content/page1____9037.aspx
International Partnership for the Hydrogen Economy (IPHE)	The IPHE provides a mechanism for partners to organize, coordinate and implement effective, efficient, and focused international research, development, demonstration and commercial utilization activities related to hydrogen and fuel cell technologies.	Hydrogen technology	Norway and Iceland	USA and Canada	Top down	Multilateral	2003 -	http://www.iphe.net/

Name	Purpose/Mandate	Type of technology/branch/department	Participating Nordic countries	Participating North American Countries	Type of cooperation	Multilateral or bilateral	Duration	Source
WCRP, World Climate Research Programme	The programme aims to improve knowledge about climate, climate variations, and the mechanisms behind climate change. Objectives are to determine the extent to which climate and climate change can be predicted and the extent of human influence on climate.	Meteorology	Denmark (Danish Meteorological Institute), Sweden (Swedish Meteorological and Hydrological Institute). Finland (Finnish Meteorological Institute), Iceland (Icelandic Meteorological Office), Norway(Norwegian Meteorological Institute),	Canada (Meteorological Service of Canada) and USA (National Oceanic and Atmospheric Administration)	Top down	Multilateral		http://www.wmo.ch/web/wcrp/wcrp-home.html
The European Pathways Project (AGS flagship project 1)	This new international project has the overall aim of evaluating and proposing robust pathways, or bridging systems, towards a sustainable energy system in Europe.	Cross disciplinary	Sweden (Chalmers and Vattenfall)	USA (MIT and Ford)	Bottom up	Multilateral	2008 -	http://www.energy-pathways.org/about.htm
The Alliance for Global Sustainability at Chalmers	Facilitate research and development within complex questions about environmental science and sustainability. The alliance also includes two flagship projects.	Cross disciplinary	Sweden (Chalmers)	USA (MIT)	Bottom up	Multilateral	2007 -	http://www.ags.chalmers.se/

Appendix 2: IEA implementing Agreements[5]

IEA implementing agreements	Objective	Annexes	Participants	Website	Source
Advanced Fuel Cells	The objectives of the Implementing Agreement on Advanced Fuel Cells are to advance the state of understanding of Participants in the field of advanced fuel cells through co-operative research, technology development and system analysis on Molten Carbonate, Solid Oxide and Polymer Electrolyte Fuel Cell systems. There is a strong emphasis on information exchange through meetings, workshops and reports.	16. Polymer Electrolyte Fuel Cells, 17. MCFC Towards Demonstration, 18. Solid Oxide Fuel Cells - Making ready for Application, 19. Fuel Cells for Stationary Applications, 20. Fuel Cell Systems for Transportation, 21. Fuel Cells for Portable Applications	Australia, Austria, Belgium, **Canada, Denmark, Finland,** France, Germany, Italy, Japan, Korea, Mexico, Netherlands, **Norway, Sweden,** Switzerland, Turkey, UK and **USA.**	http://www.ieafuelcell.com	http://www.iea.org/Textbase/techno/ia.asp
Advanced Materials for Transportation	The goal of the Advanced Materials for Transportation Implementing Agreement is to promote development of new materials technologies to improve fuel economy and durability of transportation systems while maintaining environmental friendliness for emissions, recyclables, and human health and safety.	04. Integrated Engineered Surface Technology to Reduce Friction and Increase Durability, 05. Magnesium Alloy corrosion protection	Belgium, **Canada, Sweden**, **USA**	http://www.iea-ia-amt.org/	http://www.iea.org/Textbase/techno/ia.asp
Advanced Motor Fuels	The objectives of the Implementing Agreement on Advanced Motor Fuels are to: - promote understanding of alternative motor fuels, their role in energy security, relative efficiencies and environmental consequences; - facilitate understanding of impacts of economic, environmental and technical factors on the market for alternative motor fuels; - facilitate the harmonisation of legislation, standards and regulations concerning alternative motor fuels.	26. Alcohols and Ethers as Oxygenates in Diesel Fuel, 28. Information Service & AMF Website, 29. Evaluation of Duty cycles for Heavy-Duty Urban Vehicles, 30. Bio-safety Assessment: Animal Fat in Biodiesel, 31. Production and use of Synthetic Vehicle Fuels Made by Fischer-Tropsch Technique, 32. Future Fuels for Road Transport, 33. Particle Emissions of 2-S Scooters, 34. Analysis of Biodiesel Fuels	Austria, **Canada**, China, **Denmark**, **Finland**, France, Italy, Japan, Spain, **Sweden**, Switzerland, Thailand, UK, **USA**	http://www.iea-amf.vtt.fi/	http://www.iea.org/Textbase/techno/ia.asp

[5] The Nordic countries are not represented in all the following Implementing agreements. In most of the agreements where Nordic participation is absent, the European Commission is present, giving indirect representation to the Nordic countries that are part of the EU (Sweden, Denmark and Finland). The USA and Canada participate in almost all agreements. The participation in the underlying Annexes varies from annex to annex. In general, all participating countries in an implementing agreement participate in at leas one Annex under that agreement. A full list of annexes and participants is not included in this report.

IEA implementing agreements	Objective	Annexes	Participants	Website	Source
ASDEX-Upgrade	The IEA Implementing Agreement on 'a co-operative programme for the investigation of toroidal physics in, and plasma technologies of, tokamaks with poloidal field divertors' ('Divertor Tokamak Implementing Agreement') focuses on research on critical physics issues towards the realization of a tokamak burning plasma experiment. It enables coordination of research between the partners through programmatic discussions as well as joint research programs, including coordinated experiments between the various experimental facilities involved.	01. Investigation of Toroidal Physics & Plasma Technologies in ASDEX-Upgrade	**European Commission**, Korea, Republic of, **United States**	http://www.aug.ipp.mpg.de/iea-ia	http://www.iea.org/Textbase/techno/ia.asp
Bioenergy	IEA Bioenergy is an organisation set up in 1978 by the International Energy Agency (IEA) with the aim of improving cooperation and information exchange between countries that have national programmes in bioenergy research, development and deployment.	29. Socio-Economic Drivers in Implementing Bioenergy Projects, 30. Short Rotation Crops for Bioenergy Systems, 31. Biomass Production for Energy from Sustainable Forestry, 32. Biomass Combustion and Co-firing, 33. Thermal Gasification of Biomass, 34. Pyrolysis of Biomass, 36. Energy Recovery from Municipal Solid Waste, 37. Energy from Biogas and Landfill Gas, 38. Greenhouse Gas Balances of Biomass and Bioenergy Systems, 39. Liquid Biofuels from Biomass, 40: Sustainable International Bioenergy Trade: Securing Supply and Demand, 41. Bioenergy Systems Analysis, 42. Bio refineries: Co-production of Fuels, Chemicals, Power and Materials from Biomass	Australia, Austria, Belgium, Brazil, **Canada**, Croatia, **Denmark**, **European Commission**, **Finland**, France, Germany, Japan, Netherlands, New Zealand, **Norway**, South Africa, **Sweden**, Switzerland, UK, **USA**	http://www.ieabioenergy.com/	http://www.iea.org/Textbase/techno/ia.asp

IEA implementing agreements	Objective	Annexes	Participants	Website	Source
Buildings and Community Systems (ECBCS)	The Implementing Agreement on Energy Conservation in Buildings and Community Systems (ECBCS) focuses its work on ways to improve energy efficiency in buildings. Its programme includes developing techniques to analyse how energy use in buildings impacts on the interior, local, regional and global environments; work on the optimisation of building envelopes, advanced local energy planning, computer-aided fault detection and diagnosis, and the use of daylight in buildings (in collaboration with the Implementing Agreement on Solar Heating and Cooling); and improving the availability and use of design tools	05. Air Infiltration and Ventilation Centre, 27. Evaluation and Demonstration of Domestic Ventilation Systems, 35. Control Strategies for Hybrid Ventilation in New and Retrofitted Office Buildings, 36. Retrofitting in Educational Buildings - Energy Concept Adviser for Technical Retrofit Measures, 37. Low Energy Systems for Heating and Cooling, 38. Solar Sustainable Housing, 39. High Performance Thermal Insulation Systems (HiPTI), 40. Commissioning of Building HVAC Systems for Improving Energy Performance, 41. Whole Building Heat, Air and Moisture Response (MOIST-EN), 42. Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems (COGEN-SIM), 43. Testing and Validation of Building Energy Simulation Tools, 44. Integrating Environmentally Responsive Elements in Buildings, 45. Energy-Efficient Future Electric Lighting for Buildings, 46. Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo), 47. Cost-Effective Commissioning for Low-Energy Buildings, 48. Heat Pumping and Reversible Air Conditioning	Australia , Austria , Belgium , **Canada**, Czech Republic , **Denmark** , **Finland** , France , Germany , Greece , Israel , Italy , Japan , Republic of Korea , Netherlands , New Zealand , **Norway** , Poland , Portugal , **Sweden** , Switzerland , Turkey , UK , **USA**	http://www.ecbcs.org/	http://www.iea.org/Textbase/techno/ia.asp
Clean Coal Sciences	The key objectives of this agreement are to promote research on coal -- from the science of coal combustion, conversion and utilization to co-firing and bio-co-processing.	Investigations into Advanced Analytical Techniques and Basic and Applied Research	Australia, **Canada**, Finland, Japan, Mexico, South Africa, United Kingdom, **United States**	http://iea-ccs.fossil.energy.gov/	http://www.iea.org/Textbase/techno/ia.asp

IEA implementing agreements	Objective	Annexes	Participants	Website	Source
Climate Technology Initiative (CTI)	The Climate Technology Initiative (CTI) is a multilateral initiative, operating as an Implementing Agreement under the International Energy Agency (IEA). Its mission is to bring countries together to foster international co-operation in the accelerated development and diffusion of climate-friendly and environmentally sound technologies and practices.		Austria **Canada** **Finland** Germany Japan **Norway** Republic of Korea United Kingdom **USA**	http://www.climatetech.net	http://www.iea.org/Textbase/techno/ia.asp
Demand-Side Management	The IEA DSM Programme promotes energy efficiency and demand-side management for global sustainable development and for business opportunities. This includes a wide range of actions to reduce demand for electricity (or gas) and/or to shift demand from peak to off-peak times.	01. International Database on DSM Technologies and Programmes, 11. Energy Use, Metering and Pricing for Demand Management Delivery, 12. Co-operation on Energy Standards15. Network Driven DSM, 17. Integration of Demand Side Management, Energy Efficiency, Distributed Generation and Renewable Energy Sources, 18. Demand Side Management and Climate Change,	Austria, Belgium, **Denmark**, **European Commission**, France, Japan, Korea, Republic of, Netherlands, **Norway**, Spain, **Sweden**, **United States**	www.ieadsm.org	http://www.iea.org/Textbase/techno/ia.asp
District Heating and Cooling	The IEA Implementing Agreement on district heating and cooling including CHP recently launched a new call for proposals for Annex 8 in May 2005. The call covers eight areas of interest which are (in random order) DHC System Optimisation; District Cooling; Economy of Distribution Technologies; Small-scale DHC/CHP systems; Thermal Storage; Effect of Liberalisation, Institutional Issues; Environmental Aspects; Future trends in the built environment.	08. Several DHC/CHP projects	**Canada**, **Denmark**, **Finland**, Korea, Republic of, Netherlands, **Norway**, **Sweden**, **USA**	http://www.iea-dhc.org	http://www.iea.org/Textbase/techno/ia.asp
Efficient Electrical End-Use Equipment		Benchmarking, Standby Power, Motors, Lighting, Set-Top Boxes		www.iea-4e.org	http://www.iea.org/Textbase/techno/ia.asp

IEA implementing agreements	Objective	Annexes	Participants	Website	Source
Electricity Networks Analysis, Research & Development (ENARD)	Mission: ENARD's mission is to provide a major international forum for information exchange, in-depth research and analysis and collaborative research and development (R&D) in relation to electricity T&D networks	3. Infrastructure Asset Management, 1. Information Collation and Dissemination, 2. Distributed Generation System Integration in Distribution Networks	Austria, Belgium, **Denmark**, **Finland**, Italy, Netherlands, **Norway**, Spain, **Sweden**, Switzerland, United Kingdom, **USA**	http://www.iea-enard.org	http://www.iea.org/Textbase/techno/ia.asp
Emissions Reduction in Combustion	The goal of the Implementing Agreement on Energy Conservation and Emissions Reduction in Combustion is to accelerate the development of combustion technologies for use by industry that demonstrate reduced fuel consumption and have lower pollutant emissions. The focus on emissions is primarily concerned with toxic or noxious emissions, rather than greenhouse gases, although improved combustion efficiency will lead to a reduction in emissions of carbon dioxide.	Combustion System Modelling	**Canada**, Germany, Italy, Japan, **Norway**, **Sweden**, the United Kingdom, and **USA**.	http://ieacombustion.com/default.aspx	http://www.iea.org/Textbase/techno/ia.asp
Energy Storage	The overall objective of the Implementing Agreement on Energy Conservation through Energy Storage is to develop and demonstrate various advanced energy storage technologies for application within a variety of energy systems, and to and encourage their use as standard engineering design options.	Sustainable Cooling with Thermal Energy Storage (Annex 20), Transportation of Thermal Energy Utilizing Thermal Energy Storage Technology (Annex 18), Optimised Industrial Process Heat and Power Generation with Thermal Energy Storage (Annex 19), Thermal Response Test for Underground Thermal Energy Storages (Annex 21)	Australia, Austria, Belgium, **Canada**, **Denmark**, **Finland**, France, Germany, Greece, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, **Norway**, Portugal, Spain, **Sweden**, Switzerland, Turkey, UK, **USA**, CEC	http://www.iea-eces.org/	http://www.iea.org/Textbase/techno/ia.asp

IEA implementing agreements	Objective	Annexes	Participants	Website	Source
Energy Technology Data Exchange (ETDE)	Thanks to ETDE's partnerships with other international organizations and work with international publishers, ETDE's coverage goes far beyond just representing researchers in its member countries, making it truly a worldwide database. On the access side, too, ETDE goes beyond its membership. In support of the G8 Plan of Action, database access has been granted by ETDE's Executive Committee to over 50 developing countries around the world since 2004.		Brazil, **Canada**, **Denmark**, **Finland**, Germany, Korea, Mexico, The Netherlands, **Norway**, Portugal, Spain, **Sweden**, Switzerland, UK, **USA**.	http://www.etde.org	http://www.iea.org/Textbase/techno/ia.asp
Energy Technology Systems Analysis Programme (ETSAP)	The objective of the Implementing Agreement on Energy Technology Systems Analysis Programme (ETSAP) is to serve national governments and work in international forums by fostering and supporting the development of energy technology policy options.	10. Global Energy Systems and Common Analyses, 11. Joint Studies for New and Mitigated Energy Systems	Australia, Belgium, **Canada**, **Denmark**, **European Commission**, **Finland**, Germany, Greece, Italy, Japan, **Norway**, The Netherlands, South Korea, **Sweden**, Switzerland, UK, **USA**	http://www.etsap.org	http://www.iea.org/Textbase/techno/ia.asp
Enhanced Oil Recovery	Since 1979, the International Energy Agency has sponsored an implementing agreement on enhanced oil recovery. This group meets once per year to hold a two-day symposium and a one-day workshop. This is a task-shared agreement without an operating agent or a central budget. The meetings have migrated in the past decade from closed sessions to open sessions where the information is deemed to be in the public domain.		Australia, **Canada**, France, Venezuela, **Norway**, UK, **USA**, Russia, Austria, **Denmark**, Japan, China	http://www.iea.org/eor/	http://www.iea.org/Textbase/techno/ia.asp

IEA implementing agreements	Objective	Annexes	Participants	Website	Source
Environmental, Safety and Economic Aspects of Fusion Power	The Implementing Agreement on Environmental, Safety and Economic Aspects of Fusion Power has several areas of interest which include assessment of environmental impact and safety issues of fusion power, assessment of the cost of fusion energy and possible role in future energy scenarios.	01. Development of Environmental and Safety Models and Computer Codes for Fusion Application, 02. Environmental and Safety Analysis and Assessments for Fusion Application, 03. Fusion Power Plant Studies and Assessment of Social-economic Aspects of Fusion	**Canada**, **European Commission**, Japan, Russian Federation, **USA**		http://www.iea.org/Textbase/techno/ia.asp
Fluidized Bed Conversion	The International Energy Agency (IEA) Implementing Agreement for Cooperation in the Field of Fluidized Bed Conversion (FBC) of Fuels Applied to Clean Energy Production provides a framework for international collaboration on energy technology development and deployment.		Austria, **Canada**, France, **Finland**, Italy, Japan, Korea, Portugal, Spain, **Sweden** and United Kingdom.	http://www.iea.org/tech/fbc/index.html	http://www.iea.org/Textbase/techno/ia.asp
Fusion Materials	The objective of the Implementing Agreement on Fusion Materials is to develop and test materials suitable for fusion reactors and components.	02. Experimentation on Radiation Damage in Fusion Materials, 03. Fast Flux Neutron Irradiation of Candidate Fusion Breeder Blanket Materials	China, Japan, Russian Federation, Switzerland, **United States**	www.frascati.enea.it/ifmif	http://www.iea.org/Textbase/techno/ia.asp
Geothermal	The Implementing Agreement on Geothermal Energy commenced in March 1997.It has the objectives of exchange of information, common development of new technologies, and disseminating information on the environmental advantages of geothermal energy.	01. Environmental Impacts of Geothermal Energy Development, 03. Enhanced Geothermal Systems (EGS), 07. Advanced Geothermal Drilling Techniques. 08. Direct Use of Geothermal Energy	Australia, France, Germany, **Iceland**, Italy, Japan, Mexico, New Zealand, Republic of Korea, Switzerland, **USA**, **the European Commission**, Geodynamics Limited, Green Rock Energy Limited and ORMAT Technologies Inc.	http://www.iea-gia.org	http://www.iea.org/Textbase/techno/ia.asp

IEA implementing agreements	**Objective**	**Annexes**	**Participants**	**Website**	**Source**
Greenhouse Gas RD Programme	The aims of the IEA Greenhouse Gas R&D Programme are to evaluate technologies for reducing emissions of greenhouse gases from fossil fuel use, to disseminate information, to prepare research, development and demonstration proposals and, where appropriate, to conduct R&D projects.		Australia, Austria, **Canada**, **Denmark**, **European Commission**, **Finland**, France, Germany, India, Japan, Korea, The Netherlands, New Zealand, **Norway**, OPEC, Spain, **Sweden**, Switzerland, UK, **USA**	http://www.ieagreen.org.uk	http://www.iea.org/Textbase/techno/ia.asp
Heat Pumping Technologies	The Programme strives to achieve widespread deployment of appropriate high quality heat pumping technologies to obtain energy conservation and environmental benefits from these technologies. It serves policy makers, national and international energy and environmental agencies, utilities, manufacturers, designers and researchers.	29. Ground-Source Heat Pumps Overcoming Market and Technical Barriers, 30. Retrofit Heat Pumps for Buildings, 31. Advanced Modeling and Tools for Analysis of Energy Use in Supermarkets, 32. Economical Heating and Cooling Systems for Low Energy Houses, 33. Compact Heat Exchangers in Heat Pumping Equipment, 34. Thermally Driven Heat Pumps for Heating and Cooling	Austria, **Canada,** France, The Netherlands, **Norway**, Italy, Germany, Japan, South Korea, **Sweden**, Switzerland, **USA**.	ttp://www.heatpumpcentre.org	http://www.iea.org/Textbase/techno/ia.asp
High-Temperature Superconductivity (HTS) on the Electric Power Sector	The objectives of the Implementing Agreement on High Temperature Superconductivity are to better enable each Member to keep abreast of progress being made toward applications in the power sector, to catalyse concerted consideration of issues that have not yet been subject to definitive attention by individual participants, and to provide a network and venue that may lay the basis for future international co-operation on joint projects.	01. Impacts of High-Temperature Superconductivity in the Electric Power Sector	**Canada**, **Denmark**, **Finland**, Germany, Italy, Japan, Netherlands, **Norway**, **Sweden**, Switzerland, Turkey, United Kingdom, **USA**	www.superconductivityIEA.org	http://www.iea.org/Textbase/techno/ia.asp

IEA implementing agreements	Objective	Annexes	Participants	Website	Source
Hybrid and Electric Vehicles	The objective of the Implementing Agreement on Hybrid and Electric Vehicles is to help hybrid and electric vehicle technologies reach their full market potential, with attendant advantages for diversification of energy supplies and environmental protection.	01. Information Exchange on EV Technologies and Programmes, 07. Hybrid Vehicles Information Exchange, 10. Electrochemical Power Sources and Energy Storage Systems for Electric and Hybrid Vehicles, 11. Annex on Electric Two Wheelers, 12. Heavy Duty Hybrid Vehicles, 13. Fuel Cells for Vehicles, 14. Market Deployment of Hybrid & Electric Vehicles: Lessons Learned	Austria, Belgium, **Canada**, **Denmark**, France, Italy, The Netherlands, **Sweden**, Switzerland, Turkey, **USA**	http://www.ieahev.org	http://www.iea.org/Textbase/techno/ia.asp
Hydrogen	The vision of the IEA Implementing Agreement on Hydrogen Production and Utilisation is one of clean sustainable energy supply of global proportions that plays a key role in all sectors of the economy. To achieve this vision, the work of the Agreement is directed towards the development of advanced technologies, including direct solar production systems and low-temperature metal hydrides and room-temperature carbon nanostructures for storage.	Task 18: Integrated Systems Evaluation, Task 20: Hydrogen from Waterphotolysis, Task 22: Fundamental and Applied Hydrogen Storage Materials, Task 23: Small-Scale Reformers for on-Site Hydrogen Supply (SSR for Hydrogen), Task 24: Wind Energy and Hydrogen Integration, Task 25: High Temperature Production of Hydrogen,	Australia, **Canada**, **Denmark**, **European Commission**, **Finland**, France, Germany, Greece, **Iceland**, Italy, Japan, Korea, Lithuania, New Zealand, **Norway**, Spain, **Sweden**, Switzerland, **USA**	http://www.ieahia.org	http://www.iea.org/Textbase/techno/ia.asp
Hydropower	The IEA Hydropower Agreement is a working group of governments and industry which intends to provide objective, balanced information about the advantages and disadvantages of hydropower.	02. Small Scale Hydropower, 08. Hydropower Good Practices	Brazil, **Canada**, China, **Finland**, France, Japan, **Norway**	http://www.ieahydro.org	http://www.iea.org/Textbase/techno/ia.asp
IEA Clean Coal Centre	The world's foremost provider of information on efficient coal supply and use, IEA Coal Research - The Clean Coal Centre enhances innovation and continued development of coal as a clean source of energy.		Austria, **Canada**, **European Commission**, Germany, Italy, Japan, Korea, Spain, UK, **USA**	http://www.iea-coal.org.uk	http://www.iea.org/Textbase/techno/ia.asp

IEA implementing agreements	**Objective**	**Annexes**	**Participants**	**Website**	**Source**
Industrial Energy-Related Technologies and Systems	The objective of IETS is to allow OECD Member countries and OECD non-Member countries to work together to foster international co-operation for accelerated research and technology development of industrial energy-related technologies and systems with main focus on end-use technologies, also taking into account other relevant IEA activities.	05. Energy Systems Integration between Society and Industry including Cogeneration Systems and Power Plants, 06. Gasification of Black Liquor and Biomass, 07. Analysis and Policy, 08. Technologies, Systems and Networking, 09. Separation Technologies, 10. Energy Efficient Drying and Dewatering Technologies, 11. Industry-Based Bio refineries	Brazil, Belgium, **Canada**, **Denmark**, **Finland**, **Norway**, Korea, Mexico, Portugal, **Sweden**, **USA**, The Netherlands	http://www.iea-iets.org	http://www.iea.org/Textbase/techno/ia.asp
Large Tokamaks	The Implementing Agreement promotes collaboration among the large tokamak facilities and enables teams from each tokamak facility to co-ordinate their research activities to accelerate scientific and technological advances. Focus of the collaboration is the physics of high performance plasmas.	Large Tokamaks	**European Commission**, Japan, **USA**	http://www-jt60.naka.jaea.go.jp/	http://www.iea.org/Textbase/techno/ia.asp
Multiphase Flow Sciences	Aims to promote the exchange of information between researchers in member countries to improve the efficiency of multiphase flow systems regarding energy utilisation and emission reduction.			http://www.etsu.com/	http://www.iea.org/Textbase/techno/ia.asp
Nuclear Technology of Fusion Reactors	The Implementing Agreement on Nuclear Technology of Fusion Reactors deals with the technology of such components for tritium production and processing, energy extraction, and radiation shielding. The Agreement focuses on the first wall, blanket, shield and plasma-facing components of the fusion reactors.	01. Tritium Breeding Blanket, Radiation Shielding & Tritium Processing Systems of Fusion Reactors, 02. Plasma-Facing Components for Fusion Reactors,	**Canada**, **European Commission**, Japan, Russian Federation, **USA**		http://www.iea.org/Textbase/techno/ia.asp

IEA implementing agreements	**Objective**	**Annexes**	**Participants**	**Website**	**Source**
Ocean Energy Systems	The Implementing Agreement on Ocean Energy Systems commenced in October 2001. The Agreement's mission is to facilitate and co-ordinate ocean energy research, development and demonstration through international co-operation and information exchange, leading to the deployment and commercialisation of sustainable, efficient, reliable, cost-competitive and environmentally sound ocean energy technologies.	Task I. Review, Exchange and Dissemination of Information on Ocean Energy Systems, Task II. Development of Recommended Practices for Testing and Evaluating Ocean Energy, Task III. Integration of Ocean Energy Plants into Distribution and Transmission Electrical Grids	**Denmark**, Portugal, UK, Ireland, Japan, **Canada**, **European Commission**, **USA**, Belgium, Germany, Mexico, **Norway**, Italy, New Zealand, Spain	http://www.iea-oceans.org	http://www.iea.org/Textbase/techno/ia.asp
Photovoltaic Power Systems	The mission of the PVPS programme is "To enhance the international collaboration efforts through which photovoltaic solar energy becomes a significant renewable energy source in the near future."	Task 01. Exchange and Dissemination of Information on PV Power Systems, Task 02. Performance, Reliability and Analysis of Photovoltaics Systems, Task 08. Study on Very Large Scale Photovoltaics Power Generation Systems, Task 09. Photovoltaic Services for Developing Countries, Task 11. PV Hybrid Systems within Mini-Grids, 12. Environmental Health and Safety Issues of PV, 13. PV Performance and Reliability	Australia, Austria, **Canada**, **Denmark**, **European Union**, **Finland**, France, Germany, Israel, Italy, Japan, Korea, Mexico, The Netherlands, **Norway**, Portugal, **Sweden**, Switzerland, United Kingdom and **USA**	http://www.iea-pvps.org	http://www.iea.org/Textbase/techno/ia.asp
Plasma Wall Interaction in TEXTOR	The objective of the Implementing Agreement on Plasma Wall Interaction in TEXTOR is to study these processes, to evaluate their relative importance and to develop methods for their control. This includes the development of novel specific diagnostics and of methods to condition the wall, to structure the wall and the magnetic field and to influence the transport features of the confined plasma.	Plasma Wall Interaction in TEXTOR	**Canada**, **European Commission**, Japan, **USA**	www.fz-juelich.de/ief/ief-4/en	http://www.iea.org/Textbase/techno/ia.asp

IEA implementing agreements	**Objective**	**Annexes**	**Participants**	**Website**	**Source**
Renewable Energy Technology Deployment	The Implementing Agreement for Renewable Energy Technology Deployment (RETD) engages in collaborative activities seeking to advance renewable energy technology improvement and cost reduction for all renewable energy technologies by facilitating international deployment efforts. RETD Vision Significantly higher utilisation of renewable energy technologies will result from international cooperation encouraging more rapid and efficient deployment.		**Canada**, **Denmark**, France, Germany, Ireland, Italy, Japan, Netherlands, **Norway**, United Kingdom,	http://www.iea-retd.org	http://www.iea.org/Textbase/techno/ia.asp
Reversed Field Pinches	Reversed Field Pinches (RFPs) are one of the possible magnetic confinement alternatives to the tokamak concept, which is the main fusion magnetic confinement option. The RFP concept is less developed than the tokamak but offers potential advantages. The RFP requires a much weaker magnetic field, which may result in a significant advantage for fusion reactors. However, the reduced magnetic field also reduces plasma stability and confinement. Improvement of confinement is one of the major objectives of on-going research.	01. Co-ordination of R&D Work on Reversed Field Pinches, 02. Joint Work on the Investigation of Plasma Confinement Physics and Technology in RFX	**European Commission**, Japan, **USA**		http://www.iea.org/Textbase/techno/ia.asp
Solar Heating and Cooling	The Solar Heating and Cooling Implementing Agreement was one of the first collaborative R&D programmes to be established within the IEA, and since 1977 its participants have been conducting joint projects on advance active solar, passive solar, day lighting and the application of these technologies in buildings and other areas, such as agriculture and industry.	32. Advanced Storage Concepts for Solar Thermal Systems in Low Energy Buildings, 33. Solar Heat for Industrial Process, 34. Testing and Validation of Building Energy Analysis Tools, 35. PV/Thermal Solar Systems, 36. Solar Resource Knowledge Management, 37. Advanced Housing Renovation with Solar & Conservation, 38. Solar Air Conditioning and Refrigeration, 39. Polymeric Materials for Solar Thermal Applications	Australia, Austria, Belgium, **Canada**, **Denmark**, **Finland**, France, Germany, Italy, Mexico, The Netherlands, New Zealand, **Norway**, Portugal, Spain, **Sweden**, Switzerland, **USA**.	http://www.iea-shc.org/	http://www.iea.org/Textbase/techno/ia.asp

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SolarPACES	Concentrated Solar Power (CPS) technologies use large, sun-tracking mirrors to concentrate solar radiation. However, the final steps of generating electricity using CSP systems is similar to conventional electricity generation - the ultimate energy conversion process depends on the use of steam or gas to rotate turbines, or move a piston in a Stirling engine. In a CSP system, however, steam or hot gas is produced by the concentrated solar radiation.	01. Concentrating Solar Electric Power Systems, 02. Solar Chemistry Research, 03. Concentrating Solar Technology and Applications, 04. SHIP Solar Heat for Industrial Processes, 05. Solar Resource Knowledge Management	Australia, Brazil, Egypt, **European Commission** , France, Germany, Israel, Mexico, Russia, South Africa, Spain, Switzerland, United Kingdom and **USA**	http://www.solarpaces.org/	http://www.iea.org/Textbase/techno/ia.asp
Spherical Tori	The spherical torus (ST) machine has recently emerged as an innovative example of fusion confinement that could allow progress to be made in fusion energy development. For example, experiments are conducted with spherical tori to establish the physics principles of the low aspect ratio.				http://www.iea.org/Textbase/techno/ia.asp
Stellarator Concept	The Implementing Agreement provides mechanisms to jointly investigate the properties of different Stellarator approaches and to compare them with the tokamak concept. The Implementing Agreement co-ordinates all the ongoing Stellarator activities around the world in one co-ordinated programme.	Research & Planning for the Development of the Stellarator Concept	Australia, **European Commission**, Germany, Japan, Russian Federation, Spain, Ukraine, **USA**		http://www.iea.org/Textbase/techno/ia.asp

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Wind Energy Systems	The Wind Energy Systems Implementing Agreement vision and mission aim to directly contribute to those of the IEA Committee on Energy Research and Technology (CERT), by enabling deployment through reducing costs and overcoming barriers to encourage a diverse, secure and sustainable energy supply.	11. Base Technology Information Exchange, 19. Wind Energy in Cold Climates, 20. HAWT Aerodynamics and Models from Wind Tunnels Tests and measurements, 21. Dynamic models of Wind Farms Power System studies, 23. Offshore Wind Energy Technology Deployment, 24. Integration of Wind and Hydropower Systems, 25. Design and Operation of Power Systems with Large Amounts of Wind Power, 26. Cost of Wind Energy, Analysis of the Cost of Energy from Wind Systems, 28. Social Acceptance of Wind Energy Projects	Australia, Austria, **Canada**, **Denmark**, **European Commission**, EWA, **Finland**, Germanu, Greece, Ireland, Italy, Japan, Korea, Mexico, The Netherlands, **Norway**, Portugal, Spain, **Sweden**, Switzerland, UK, **USA**,	http://www.ieawind.org	http://www.iea.org/Textbase/techno/ia.asp