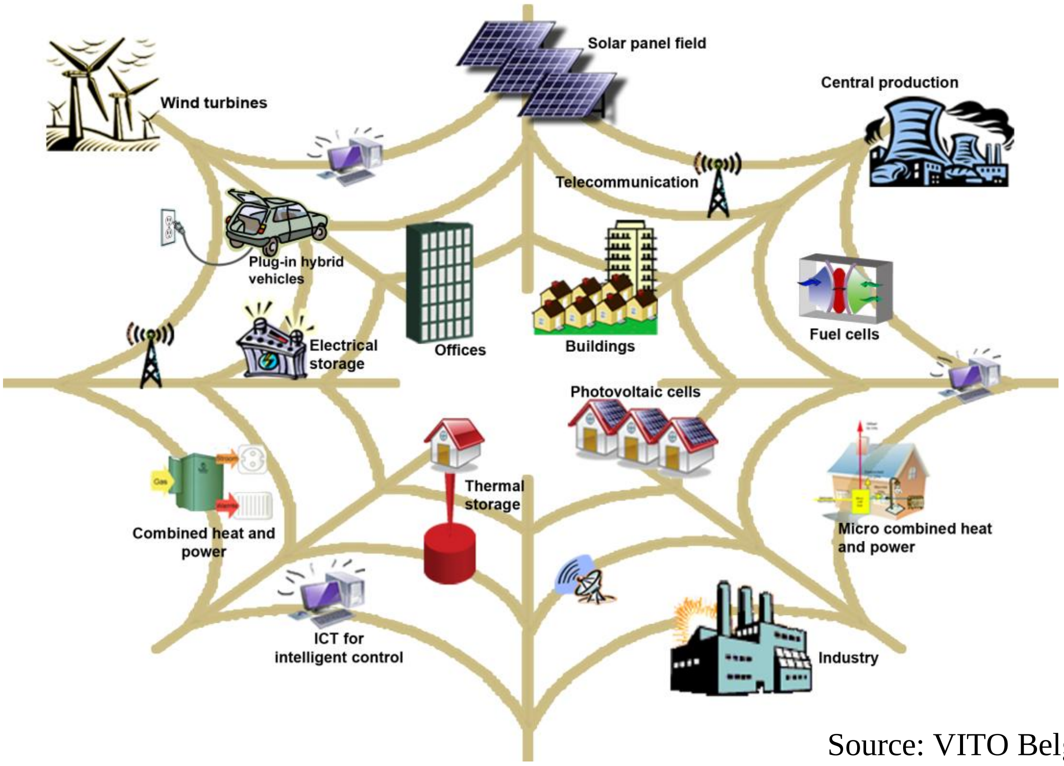
International Energy Agency
Implementing Agreement
Energy Conservation through Energy Storage

Strategic Plan
2011 – 2015



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Preface

The strategic plan of the Executive Committee of the Implementing Agreement Energy Conservation through Energy Storage (ECES) outlines the scope and goals of the IEA-Energy Storage Programme for the next term 2010 - 2014. It is an update of the previous strategic plan that was approved by the Energy End-Use Working Party in 2006 for the extension of the Energy Storage Implementing Agreement until December, 2009. The strategic plan will serve as the basic working document to guide the future work of the Executive Committee and will also provide a comprehensive summary for other Committees of the IEA and for the IEA-secretariat. More detailed information on the IEA Storage Programme itself and links to various publications are available on the Internet-Website (http://www.iea-eces.org/) of the IEA-Energy Storage Programme.

Introduction

Despite many ambitious approaches from scientists, policy makers and industry global CO_2-emissions and oil demand continue to increase significantly. Developing countries aim for the same living standards as those in developed countries. Their economies are growing rapidly - Energy Technology Perspectives 2008 (ETP 2008), projects a four-fold GDP growth worldwide and ten-fold for developing countries between now and 2050.

It would be unsophisticated to believe that this trend can be stopped. Developing countries are not accepting any lower living standard if they are able to reach a higher level – even if this leads to an irreparable damage to their environment. Similarly, developed countries themselves will not accept decreasing living standards and no policy maker will make such decisions.

Accepting these boundary conditions, one can draw at least the following conclusions with regard to the administrative and the technical level:

Facing the imbalance of the current standard of living in the world, global climate protection needs independent representatives developing roadmaps and targets on a technical level. The IEA is able to fulfill this role and each Implementing Agreement contributes with its international networks of experts. Concerning the technical level, energy efficiency measures become most important, as the increasing use of the renewables alone will not be able to solve the energy problem of the future. The global financial crisis has not stopped this development at all. Maybe the growth is decelerated. In fact, the crisis is tightening the situation: Short-term economic benefit is preferred instead of sustainability. This underlines again that economic aspects should be treated in parallel with energy questions. It is not enough to vigorously optimize energy systems, the economic benefit with respect to the payback time has to be calculated as well. Both the “green-image” and the monetary benefit are the arguments for any kind of climate protection to convince policy makers, industrial actors and the customers.

Energy storage technologies are a central component in every energy efficient system and they are necessary for the increasing use of renewables as well. It is the challenge for the ECES Implementing Agreement to accentuate this central message, namely to make the energy systems of the future as efficient as possible and to convince the above mentioned target groups of the energy and economic benefit of this solution. Furthermore, a strong focus is necessary on the dissemination beyond scientific and economic results. Each solution needs a positive image if we want it to be accepted by the user. We have the opportunity to prove that sustainability is not a step backwards and our Implementing Agreement has to play an important role within this process.

The meaning of Energy Storage

Thermal as well as electrical energy storage technologies can overcome the temporal mismatch between energy supply and demand. Furthermore they enable the use of energy to be dispersed and used at other places thereby improving the overall efficiency of the energy system. This leads to an increase of the total efficiency, as even waste heat can be used.

From the technical point of view, energy production means a transformation of the energy form (electrical, thermal, and chemical). To decrease losses between supply source and end-user such transformations should be kept to an absolute minimum,. These requirements are also true for storage, meaning the charging and discharging process. But as mentioned before, economic boundary conditions are often the decisive factor. Therefore, the chosen storage solution depends on the total efficiency.As already pointed out, energy storage is suitable for increasing the efficiency in both the power sector and the end-use sector including industry, transport and the buildings.To define the mission and the next steps for the ECES Implementing Agreement, the meaning and the potential of different energy storage technologies are discussed.

The power sector will be subject to basic changes in future. The percentage of renewable energies is expected to increase, primarily wind power, solar energy and suitably driven µ-CHP. This means challenges and also new functions for the grids. The amount of fluctuating energy leads to a requirement of more flexibility and storage capacity. In addition, the demand itself may vary extremely. For example, though the Scandinavian countries favour a strong international transmission grid and the electrification of the transport and the building sector, these measures will not fulfill the balancing demand in the future. Furthermore, the net expansion is not the most efficient solution – from the energetic and economic point of view. Besides, it may not be possible for other parts of the world.

Currently, many electric storage technologies are available to fulfill the balancing demand. Pumped-hydro plants, CAES and even different electrochemical storages are considered. Further research and development activities will increase the efficiency of e.g. redox flow cells and NaS-batteries and decrease the specific costs. But the most efficient solution is strongly connected to the system boundaries. This means that energy supply and demand can not be judged separately – but not only in the mentioned electrification of the end use sectors. Generally speaking, all types of storages have to be taken into account to find the optimum in a given supply and demand situation. This means that even thermal energy storages are suitable for balancing the net. One example is the use of cold storages for decreasing the installed cooling capacity in buildings in summer. This helps to avoid black-outs as the electricity peak demand decreases. But even transforming surplus electrical energy and storing it e.g. in decentralized latent storages for refrigeration applications in a way that they have no electricity demand when the total demand exceeds the supply, may be energetically and economically efficient solutions.

As these examples show, storage technologies are the joining element between the supply and the demand side and in some aspects even to the distribution. The storage demand and the best storage technology are strongly connected to the system boundaries which should include the energy supply and the end user side.

But even in the narrower sense, energy storage has to play an important role for the necessary CO_2-reduction in future. Within the BLUE-map scenario in the ETP 2008, ambitious goals for the CO_2-reduction up to 2050 are described. In order to reach this, the contribution of measures to increase the energy efficiency in the end use sector is calculated to be 36%, while the percentage of the increasing use of renewable energy is 21%.

The use of waste heat in the industrial sector illustrates the possible contribution of energy storage to increase the energy efficiency. This can also be deduced from the fact that the percentage of the industrial heat demand is 70% of the total final energy consumption, whereas on the other hand a large amount of waste heat exists.

There is a big variety of energy efficiency measures in the building sector. First of all, passive measures should reduce the heating and cooling demand. After that, seasonal storage may provide an efficient energy supply, especially in combination with district heating and cooling systems. But also on a technical level, the efficiency of e.g. heating systems is strongly connected to energy storages. Within the building sector, energy storage bridges the gap between efficiency measures on the one hand and increasing use of renewables. Solar assisted heating and cooling systems, heat pumps or µ-CHP in combination with storage are very promising solutions for the future.

To sum up, energy storage technologies are necessary to increase the efficiency of energy systems in future. The amount and the storage system itself is a function of the system boundaries which may include both the supply and the demand side. Furthermore, the increasing use of renewable energies requires storage to balance the difference between energy supply and demand. Even if the technologies themselves are completely different, this storage demand is independent from the energy form.

The big variety of potential storage use – from the use of waste heat in industrial processes up to the heating and cooling demand in the building stock – requires many different technical storage based solutions. This enables an energetic and economic optimum to be reached and leads to the mission of the ECES Implementing Agreement.

Mission

To facilitate an integral research, development, implementation and integration of energy storage technologies to optimize energy efficiency of every kind of energy system and to enable the increasing use of Renewable Energy instead of Fossil Fuels.

Strategic Plan

Storage technologies are one central component in energy efficient systems. On the one hand it is a technical challenge to find the best system. However, on the other hand the whole system has to be taken into account, including its market deployment and the acceptance by the costumers. As Energy Storage is a cross cutting issue, the knowledge from experts from many disciplines (energy supply and all end-use sectors as well as distribution) has to be taken into account. To use this widespread experience efficiently and draw a benefit from the resulting synergies, high-level coordination is necessary to develop suitable working plans and research goals. ECES is predestined to fulfil this important task.

The strategic plan of ECES has to reflect both aspects. Therefore, ECES has to fill out its neutral and leading position in energy storage in a coordinative and cooperative way. The collaboration with experts on the demand and distribution side has to be strengthened significantly.

Taking into account all these aspects, the strategy can be divided as follows:

1. **Research Activities**
   a. Strategies for scientific research and development
   b. Strategies for dissemination
   c. Strategies for market and deployment

2. **Coordination Activities**
   a. Aims
   b. Adminstrative Matters

1. Research Activities

a. Strategies for scientific research and development

In order to make any energy system as efficient as possible, the whole environment has to be taken into account – including both supply and demand. This requires detailed information about the limitations and advantages of the different storage systems concerning thermal and electrical energy storages. Furthermore, a detailed roadmap should be developed including the state of the art, short and long term perspectives of each storage system. This means also a discussion of the physical and economical limits of each system and the storage materials themselves.

In addition, a detailed analysis of the energy saving potential within the different end-use sectors is necessary. This has to be carried out by experts in their countries to identify possible synergies. These examinations are the basis for the further steps: Demonstration projects as the result of material research, system engineering and case studies. To realize these projects, the dialogue with national funding organisations is very important and should be considered by the involved experts.

b. Strategies for dissemination

In order to bring storage based solutions to the market and to increase the efficiency of existing and future energy systems, scientific results has to be translated into the language of the different audiences. This requires a detailed analysis of the target groups.
However, any simplified message has to be based on fundamental scientific results developed as described before. The most successful way to convince policy makers, end-consumers and the industry is to show success-stories and demonstration projects, accompanied by figures concerning e.g. the energy saving potential or the pay-back time.

To increase the visibility of the scientific results and the success stories, information platforms in each country and within the IEA have to be identified. This may include for example publications, scientific journals, roadmaps or conferences.
The introduction and the just mentioned strategies clearly show, that even the scientific results can not be reached by experts from one discipline only. The collaboration of many disciplines in a very well-structured and headed process leads to the described success. Particular attention has to be paid to the intersections of educational programmes and relevant institutions. The future experts have to be involved in this interdisciplinary as early as possible.

c. Strategies for market and deployment

Demonstration projects address many different target groups. Presented in a suitable way they are best positioned to start collaborations with the relevant companies. Demonstration projects have to be the beginning of a fruitful cooperation between science and industry until and even after the components have reached their break-even point. To shorten up this process, within the international cooperation of the experts, standardisation questions have to play an important role. This enables the national industries to enter foreign markets. Well-planned and therefore successful demonstration plants have to trigger a chain reaction: Each realisation is the successful acquisition of the next cooperation project between industry and science.

But even successful demonstration projects and well-funded numbers may not suffer to bring storage solutions to the market. Also soft factors have to be taken into account, not only if end-consumers are addressed, even the dialogue with companies may effort the knowledge of their way of thinking and their aims.

2. Coordination Activities

a. Aims

Within the IEA-Framework, about 20 Implementing Agreements are related to energy storage questions. Any kind of future energy system needs energy storage to maximize the overall energy efficiency in an economic way. The big variety concerning the scientific and technical background of the involved experts in the Implementing Agreements dealing with energy storage aspects offer a great potential resulting in proposing solutions for future energy systems. However, it is quite impossible on expert level to cooperate with all relevant storage experts to find the optimum solution as there are too many players. In addition, joint research activities in the meaning of joint Annexes are not always the most efficient way of collaboration if more than three different Implementing Agreements have to be involved. In fact, coordinated working plans and a coordinated exchange of results delivered from parallel Annexes in a number of Implementing Agreements may be the best solution in such a case.

The development and heading of work plans and its delegation to the experts requires less detailed knowledge about specific aspects – e.g. energy-supply-, end-use technologies or distribution. Rather a more general approach is necessary.
ECES is experienced in this role as identifying an optimal storage solution always requires to take the whole energy system into account.

b. Administrative Matters

ECES has already started this process leading to more cooperation in the field of energy storage. As pointed out before, a coordination platform above the different Implementing Agreements is necessary. Furthermore, energy storage is not limited to one Working Party: Even though the Renewable Energy and the End-Use Working Party are both involved a close contact to the Expert Group on Science for Energy (EGSE) is still necessary.
Representatives from all these groups have to be addressed by the storage coordination group to develop working plans, pointing out research goals, exchanging information between the different players and finally draw the conclusions from the work.
These results as an outcome of well-coordinated activities increase the visibility of the storage-based solutions significantly. They may influence both roadmaps and reports (like the Energy Technology Report) within the IEA as well as programmes and decisions of national policy makers and stakeholders.
To add weight to the idea of a storage coordination platform, ECES organized a first workshop in Bad Tölz, Germany from Sept. 30 to Oct. 2 in 2009. The outcome was an agreement of the participating Implementing Agreement to continue in this way of installing a kind of coordination group. Therefore, ECES has organized a second workshop in July 2010, to develop a number of research goals and the suitable way of cooperation for each case: Experts Workshops, Joint Annexes but also as an exchange platform coordinating the different activities and develop further steps and aims.
ECES will continue this process and present the results within the IEA to the relevant groups.

After presenting the objectives for the future, the barriers and drivers within the processes mentioned in section 1. and 2. have to be reflected upon.

Barriers

The consciousness of energy efficiency beyond technical aspects is hard to teach, therefore engaged pioneers and a strong connection to universities and education centre in general are essential. We have already started this process, but increased efforts are still necessary.
This general statement is also true for energy storage itself as storage experts have to be on a par with system experts and material experts in the ideal case, having also the economic benefits in mind. But in the case of storages, additional difficulties occur. Storages are in most cases not visible within an energy system, they have to be regarded as a passive component. Solar thermal systems in the building sector are a good example: End-consumers discuss the advantages of vacuum tubes against flat plate collectors as active components, but they disregard the meaning of the storage, the gains of the collector array can be counted in kWh from the control unit, the effect of a better storage is hardly observable for them, least of all not in numbers. This is also a central topic for the funding of, for example, solar systems in the building sector. In most cases, requirements for the collector performance exist (based on standardised tests), but there is no pendant for the storage.

As in the strategies mentioned, state of the art reports do not currently exist. Many demonstration projects have been realized which do not reach the proposed aims. In many cases, mistakes concerning the future demand or general planning mistakes are responsible. These negative examples have unfortunately increased the reservation against similar ideas. In recent times the financial crisis has also reduced the financial possibilities of many smaller companies.

Drivers

On the one hand, the global financial crisis has impacted many companies, but on the other hand it has also increased the pressure for innovation to sustain market position.
Even if energy prices have decreased in the last year, the prior developments have drawn attention to the limitation of fossil fuels. Energy efficiency measures are more and more accepted and the pay-back has already been reduced in comparison to the situation a few years ago.

Driven by ambitious climate protection goals throughout the world, in many parts of the world electro-mobility has become a new keyword, which is obviously strongly connected to electrical storages, namely Li-ion-batteries. Another very popular topic is the increasing use of renewable energies. This discussion has also highlighted the need for energy storages. Though most people have only electrical storage in mind, these circumstances offer the chance to extend the view on energy storage technologies in general.

The funding situation at least for electrical approaches is quite good, so many experts are attracted. To sum up, the actual situation offers a high potential to broaden the view to the meaning of energy storage in general. This is also a very good starting point for the described activities concerning the coordination activities.

Strengths and Limitations of ECES

Limitations

As pointed out before, there are many positive signals at the moment and even difficult circumstances may offer new opportunities and lead to a change toward more energy efficiency in future.

ECES has to redefine its role within this rapidly changing world. In the last several years, ECES has had a strong focus on thermal storages. Electrical storages have not played any role at all. Furthermore, ECES has not fully developed the necessary general approach to find the best storage solution and to increase the overall energy efficiency as much as possible.

These points are not structural problems . In fact the market deployment is more difficult to reach as too few industries are sponsors. Further approach is necessary to start at least collaboration in different areas. In order to influence the economical development in developing countries, more of them have to be attracted to join the ECES. This is also a very important topic for the coming years.

Strengths
Within the ECES-ExCo scientist of many disciplines, representatives from funding organisations and even companies are active. Therefore interdisciplinary research and development activities in the described way can be initiated. ECES has established a well-accepted network for R&D on thermal energy storages and is able to extend it to system analyses, respectively potential studies, and even to electrical storages. ECES has the expertise or at least the contact to experts to publish the results in scientific journals and to produce more visible messages for policy makers and other consumers on a national basis.
The already started coordination activities will have a positive effect. Increasing the visibility and the meaning of energy storage in general, enables ECES to attract more experts for the R&D-activities. In addition, this leads to a broader awareness of ECES within the other Implementing Agreements, therefore it will also facilitate the implementation of joint research activities.

Collaborations

Even before ECES started the process of a coordination platform on energy storage issues in general, there has been a close cooperation concerning building related activities.
Therefore the Executive Committee has intensified cooperation with other
Building Related Implementing Agreements (BRIA´S):
- Solar Heating and Cooling
- District Heating and Cooling
- Energy Conservation in Buildings and Community Systems
- Heat Pumps
- Photovoltaic Power Systems
- Demand Side Management (DSM)

Joint workshops and an annual 2-day meeting of the Building Coordination Group (BCG) are employed to share information, to transfer knowledge for implementation of new concepts and technologies and to identify new cooperative activities.
Beyond this, ECES is in contact with other Implementing Agreements, that will be described later on (section ***Achievements in 2009***).

In addition to the building related activities, ECES also participates in the Electricity Coordination Group.

Furthermore ECES was involved for the first time in the scientific organisation of the Eurosun 2010, the European conference on solar thermal energy of ISES and the IEA-Solar Heating and Cooling Programme. A similar participation is planned for the ISES Solar World Congress 2011.

Work and Achievement from 2006-2010

Throughout the whole period:

- ECES attended actively the annual meetings of the Building Coordination Group, BCG, and the Future Building Forum.
- Attendance at the annual meeting of the Electricity Coordination Group since 2009.

Achievements in 2006

- ECES and the Richard Stockton College of New Jersey, US, organized the Ecostock 2006, the 10th International Conference on Thermal Energy Storage. About 200 participants from 31 countries participated in the conference. The "Stock" Conference has never had so many countries represented.

Achievements in 2007:

- ECES was engaged in the biennial IEA ministerial meeting in Paris (14.-15.5.2007). The ministerial gathering was the occasion to present a rich array of publications and papers drawing attention to the work of the IEA Secretariat and its international energy technology network. The ministerial meeting featured a technology fair showcasing the work of the Implementing Agreements. The fair illustrated with stands the potential of different technologies and steps that governments, businesses and consumers need to take to put them into practice. The picture shows the ECES exhibit at the meeting, which was explaining a mobile sorption storage system for the utilization of industrial waste heat.

- The NEET workshop in Brazil, organized by the IEA and the Ministry of Mines and Energy MME of Brazil was attended. ECES presented its activities with special focus on the following topics:
  - Peak shaving: Avoiding electricity peak caused by air conditioning by the implementation of thermal energy storages (TES).
  - Industrial Application: Utilization of „waste cold“ at the re-gasification of liquefies natural gas (LNG) or after transportation in a pipeline.
  - Cold storage in remote sites (in combination with solar cooling)
  - Avoiding electricity peak caused by use of electric shower heads by TES

Achievements in 2008:

- Attendance of the AHGSET-workshop (May, 6-7). ECES gave an overview on its activities with special focus on the planned Symposium on “Material Development for Thermal Energy Storage”.
- ECES and the Bavarian Center of Applied Energy Research organised the Symposium on “Material Development for Thermal Energy Storage”. The goal of this Symposium was to define needs for research and to establish teams for further activities, which included material science and Thermal Energy Storage application expertise. The scattered international activities in material research and development for thermal energy storage should become more structured and better coordinated. About 80 participants from 11 countries attended the Symposium. The Symposium was focused on Phase Change materials and Chemical reactions. Its major outcome was that the participants saw the gap between fundamental material science, applied research and industrial interests and that the different parties talked to each other. By doing that, they started to learn each others “languages” and to overcome obstacles in the development of these technologies. The event was an excellent start for joint Annex/Task activities with other Implementing Agreements.
- Presentation of the ECES-activities at the NEET workshop in Russia, organized by the IEA and the The Federal Agency for Science and Innovation, FASI.
- ECES participated on invitation in the workshop on “Long-term Technology Perspectives in the End-Use Sector” in Germany, organized by the End-Use Working Party. The Workshop was intended to foster the discussion on future end-use technologies for energy efficiency, energy security and greenhouse-gas reduction, on consequences for future R&D strategies and on the role of international cooperation in the IEA´s End-Use Working Party.

Achievements in 2009:

- ECES attended on invitation the first meeting of the IEA coordination group on “Electricity Grids”.
- The Swedish Energy Agency and ECES organized the 11th international Stock-Conference in Stockholm: The Effstock 2009 – Thermal Energy Storage for Energy Efficiency and Sustainability. The official host organisation was Swedvac, the Swedish Society of HVAC Engineers. 170 scientific papers from 31 countries were presented, covering both, theoretical investigations and experimental research on latent, sensible and thermo-chemical Thermal Energy Storage (TES). Success stories were also reported about sensible underground systems and other large water tanks: Furthermore impressive results were achieved with solar-assisted and geothermal systems. More than 350 participants attended the conference, which also offered a business exhibition with 29 exhibitors.
- ECES presented its joint activities with the SHC Implementing Agreement at the SolarPaces Conference in Berlin, Germany. ECES attended the conference with about 800 participants. Thermal Energy Storage (TES) is becoming a big issue in the field of Concentrated Solar Power (CSP). Storage might be the big advantage of this technology in comparison to Photovoltaics. This invitation was a great opportunity to learn about the potential of energy storage in this application.
- ECES presented its activities at the ENARD workshop in Fredericia, Denmark on “Balancing the Variability in Renewable Electricity Supplies: - New challenges and opportunities”. On the invitation of ENARD, ECES made a presentation about the important role energy storage will play in the future, when aiming to balance the grid. Within the presentation it was shown, that even thermal energy storage may be an

optimal solution having both aspects of economic and energetic reasons in mind. The workshop offered the great possibility for an exchange between different Implementing Agreements as well as important representatives from industry.

- ECES attended on invitation the workshop on "Future Transport Systems", organized by the End-Use Technology Working Party in September in Stockholm. The workshop was intended to foster the discussion on:
    - future energy-efficient transport solutions
    - consequences for future R&D strategies
    - the role of international cooperation in the IEA´s End Use Working Party.

  ECES gave an overview of the potential of energy storage in this context.
  The workshop enabled very fruitful discussions among different Implementing Agreements like AFC, DSM, HEV and ENARD together with the experts from the EUWP.

- ECES organized the workshop „The Role of Energy Storage in Future Energy Systems" in October in Bad Tölz, Germany. All storage related Implementing Agreements were invited, as well as representatives from the End Use Working Party, the Renewable Energy Party, the IEA Office and CERT. The scope of the workshop can be described as follows: Energy storages are central components of many energy systems. Looking at the "Energy Technology Perspective 2008", the reduction of CO_2 emissions until 2050 can only be achieved by introducing a lot more renewable energies and substantially increasing the overall energy efficiency. Both measures are closely connected to the development of innovative storage technologies. Energy storage is explicitly mentioned in several of the "Energy Technology Roadmaps" (e.g. Wind Energy, Solar Heating and Domestic Hot water, Electric and Plug-in Vehicles and Solar Concentrated Power). In addition to that, at the last workshop of the Experts Group on Science for Energy (EGSE) energy storage was defined as one of the key energy technology challenges. The organization of the workshop was supported by the Committee for Energy Research & Technologies CERT, the End Use Working Party EUWP and the Renewable Energy Working Party REWP. Peter Cunz, Chair of CERT, Hermann Halozan, Chair of EUWP and Andreas Indinger, Vice Chair of REWP were participating the meeting. The following Implementing Agreements sent their representative to the workshop:
    - Solar Heating and Cooling (SHC)
    - Buildings and Community Systems (ECBCS)
    - Energy Conservation through Energy Storage (ECES)
    - Electricity Networks Analysis, R&D (ENARD)
    - Heat Pump Program
    - High Temperature Superconductors (HTS)
    - Hydrogen (HIA)
    - Solar Power and Chemical Energy Systems (SolarPACES)
    - Advanced Fuel Cells (AFC)
    - ETSAP

  The IA on District Heating and cooling (DHC) sent a presentation on their current activities on energy storage. One representative of a German energy utility (e.on) also participated.
  All participants agreed on the need of substantial innovations for storage technologies and that future cooperation and coordination in the field of energy storages might be very fruitful. Furthermore, a state of the art report and joined summer schools from different Implementing Agreements were also judged as very helpful in increasing the visibility of energy storage and initiating collaborations on experts' level.

- ECES attended workshops with Japan Industries and researchers about storage demand and suitable storage solutions
- ECES assisted in the organisation of an ETP2010-workshop for storage contribution

Annexes to be completed by the end of 2010

- Annex 18: Transportation of Thermal Energy Utilizing Thermal Energy Storage Technology
  A key component in a sustainable energy system is to be able to use thermal energy from various sources at a consumer located at a distance from theses sources. For this purpose, the thermal energy has to be transported from one place to another. This could be achieved by using thermal energy storage technology (TES). Depending on the distance, the storage medium could either be pumped through pipelines or for longer distances the TES itself could be transported on a truck or a train. The crucial properties of the TES for the technical and economical feasibility are the storage capacity per volume and weight and the possible charging and discharging power, which affects the possible number of storage cycles per time.
- Annex 19: Optimised Industrial Process Heat and Power Generation with Thermal Energy Storage
  Previous activities in the IEA Implementing Agreement "Energy Conservation through Energy Storage" has achieved significant progress in thermal energy storage technologies for energy savings and for reduction of peak demand of energy in buildings and in advancing the prospects of cooling with TES technologies. The potential for thermal energy storage and regenerative heat transfer for the industrial process heat sector for efficient energy utilisation, heat recovery and storage of high temperature waste heat as well as the need for energy storage for power generation based on new conversion techniques and renewable energy resources (RES) is a concern of several national and international research strategies. Both areas are directed to applications and processes at high temperature. In this context "High Temperature" is defined to be higher than 120 °C as required for comfort heating and where water cannot be applied as heat transfer fluid.
- Annex 20: Sustainable Cooling with Thermal Energy Storage
  Renewable and natural energy sources, main components of sustainable energy systems, can only be made continuously available to users through thermal energy storage (TES). In addition to heating TES provides several flexible alternatives for cooling systems. Recent discussions on topics like global warming and heat waves have brought attention once again to energy efficient cooling systems utilizing renewable energy sources. Cooling demand has been increasing due to the evolving comfort expectations and technological development around the world. Climate change has brought additional challenges for cooling systems designers. New cooling systems must use less and less electricity generated by fossil fuel based systems and still be able to meet the ever increasing and varying demand.

Ongoing Annexes

- Annex 21: Thermal Response Test for Underground Thermal Energy Storages
  Thermal Response Test (TRT) is a measurement method to determine the heat transfer properties of a borehole heat exchanger and its surrounding ground in order to predict the thermal performance of a ground-source energy system. The two most vital parameters are the effective thermal conductivity of the ground and thermal resistance within the borehole. These measurement results are important for proper BTES design

but also for commissioning and failure analysis. This method has significantly supported the rapid spreading of BTES systems and the introduction of this technology in "new" countries.
The overall objectives of Annex 21 are to compile TRT experiences worldwide in order to identify problems, carry out further research and development, disseminate gained knowledge, and promote the technology. Based on the overview, a TRT state of the art, new developments and further work are studied.

- Annex 22: Thermal Energy Storage Applications in Closed Greenhouses
  Increasing attention is being paid to thermal energy storage (TES) in greenhouse systems as a means of enhancing crop production while reducing primary energy (fossil fuel) use and operational impacts to soil, water and air. TES leads to the 'closed or nearly closed' greenhouse concept, which subsequently allows for active environmental control, avoiding the need to control of environmental variables by opening and closing windows – an act which also unintentionally releases CO2.
  Thermal energy storage has an important contribution to make to the viability and sustainability of horticultural greenhouse systems because it allows for a renewable, continuous, and adaptable supply of heating, cooling, and dehumidification. The nature of this contribution is cardinal in light of concerns of increasing fossil fuel expenses and climate change.
  The industries which provide us with food and plants (i.e. potted plants, flowers, sod, trees) strive to maximize the outputs of their greenhouse system while simultaneously minimizing their inputs. They do this to meet ever-increasing demands for competitive pricing as well as product quality and security assurances. There are three key ways in which the integration of TES simultaneously addresses the system's outputs and inputs:
    - Energy Savings
    - Controlled CO_2 and humidity
    - Fewer chemicals
- Annex 23: Applying Energy Storage in Ultra-low Energy Buildings
  Sustainable buildings will need to be energy efficient well beyond current levels of energy use. They will need to take advantage of renewable and waste energy to approach ultra-low energy buildings. Such buildings will need to apply thermal and electrical energy storage techniques customized for smaller loads, more distributed electrical sources and community based thermal sources. Lower exergy heating and cooling sources will be more common. This will require that energy storage be intimately integrated into sustainable building design. Many past applications simply responded to conventional heating and cooling loads. Recent results from low energy demonstrations, distributed generation trials and results from other Annexes and IAs such as Annex 37 of the ECBCS IA, Low Exergy Systems for Heating and Cooling need to be evaluated. Although the ECES IA has treated energy storage in the earth, in groundwater, with and without heat pumps and storing waste and naturally occurring energy sources, it is still not clear how these can best be integrated into ultra-low energy buildings capable of being replicated generally in a variety of climates and technical capabilities.
  Energy storage has often been applied in standard buildings that happened to be available. The objective was to demonstrate that the energy storage techniques could be successfully applied rather than to optimize the building performance. Indeed the design of the building and the design of the energy storage were often not coordinated and energy storage simply supplied the building demand whatever it might be.
- Annex24/42 (joint Annex with SHC): Material Development for Improved Thermal Energy Storage Systems

For the performance of thermal energy storage systems their thermal energy and power density are crucial. Both criteria are strongly dependant, along with other factors, on the materials used in the systems. This can be the storage medium itself, but also materials responsible for the heat (and mass) transfer or for the insulation of the storage container.
After a number of thermal energy storage technologies have reached the state of prototypes or demonstration systems a further improvement is necessary to bring theses systems into the market. The development of improved materials for TES systems is an appropriate way to achieve this. The material solutions have to be cost effective at the same time. Otherwise the state of the existing technologies can not be brought closer to the market.
The worldwide R&D activities on novel materials for TES applications are not sufficiently linked at the moment. A lot of projects are focusing on the material problems related to their special application and not towards a wider approach for TES in general. The proposed Annex should help to bundle the ongoing R&D activities in the different TES technologies.

Planned Annexes

- Annex 25: Surplus Heat Management using Advanced TES for CO_2 mitigation
  The world's total energy supply is 136500 TWh/year whereas the energy use is approximately 94000 TWh/year (IEA Key Statistics, 2008). By inspecting these figures, one can see that close to 1/3 of the world's energy supply is "wasted" in energy conversion. In reality, the number is even larger, perhaps as much as 50%, since for example the tank-to-wheel efficiency of engine driven transportation is only 20%, and boiler efficiencies seldom are above 90%. From a sustainability perspective, increasing the efficiency in many energy conversion processes is crucial. As the demand for energy increases in all sectors, and all over the world, waste heat management will be a cost-effective way of securing the supply of energy and power while mitigating the emissions of CO_2. Such management is most effectively done in cases where the waste heat flow are large, like industrial processes, or in cases where the value of increases waste heat utilization is large, like in the vehicles and transporting goods sector. Recent advances in compact thermal energy storage has encouraged this initiative to explore solutions where waste heat management can be enhanced, facilitated and even enabled by integrating thermal energy storage technology.
  The general objective of this Annex is to **identify and demonstrate cost-effective strategies for waste heat management** using advanced TES. New knowledge will be generated with regards to:

  1. The potential for advanced TES to minimize process waste heat through better process integration, enabling the use of waste heat for internal heating demands or cooling demands (via heat driven cooling).
  2. The potential for advanced TES to cost-effectively increase waste heat driven power generation in industrial applications.
  3. The potential for advanced TES to enable external use of heat from industrial-scale processes through effective thermal energy distribution.
  4. The potential for advanced TES to increase the utilization of waste heat in vehicles like on-board cooling and minimization of cold-start.

5. The potential for advanced TES to increase the use of waste cooling (e.g., the large cooling potential associated with LNG regasification) and free cooling for comfort cooling applications.

Thus, a sub-goal of this proposed annex is to really dig into the waste heat utilization issue from a very broad perspective, and show the great potential for using advanced TES towards reaching a resource efficient energy system where waste heat (and cold) is minimized. This has a good potential for attracting a large number of participants from a variety of disciplines and levels of R&D (basic research to commercial systems).

- Annex 26: Electric Energy Storage: Future Energy Storage Demand
  The future of electricity network involves a massive penetration of unpredictable renewable energies. For insuring network stability as well as for maximizing the energy efficiency of such networks, storage is a key issue. Up to now, the integration of renewable energies did not take into account the demand side and was performed in a "fit and forget" way. The optimum evolution from an economical point of view, is to have an integration in the future that is respecting the needs. One solution – beneath demand side management and grid extension – is the use of energy storages. The main purpose of adding energy storage systems in the electricity grid is to collect and store overproduced, unused energy and be able to reuse it during times when it is actually needed. Essentially the system will balance the disparity between energy supply and energy demand. Worldwide between 2% and 7% of the installed power plants are backed up by energy storage systems (99% pumped hydro systems). The future demand of energy storage devices is actually unknown. Only the main influence factors on this demand are known.
  The overall objective of this task is to develop a method or approach to calculate the regional energy balancing demand and to derive regional storage demand rasterizing the area and taking into account that there are competitive technical solutions. This objective can be subdivided into ten specific objectives:

  - to rasterize the whole area to typical small self-similar elements,
  - to identify and characterize typical fluctuating energy demand for different elements which stands for different regions and grid situations (e.g. intermeshing),
  - to identify and characterize typical fluctuating energy production (wind, PV) for different elements which stand for different regions and renewable energy potential (e.g. wind velocity),
  - to identify and characterize typical conventional energy production (gas turbine, nuclear power plant) for different elements which stand for different regions and conventional energy production,
  - to reduce different grid structures to a fistful of typical systems and to simulate their inner intermeshing and their exterior connectivity (transport, import, export),
  - to derive balancing demand for each typical region,
  - to derive energy storage demand as a share of the total balancing demand, taken into account that the most successful economic solution will be realized,
  - to develop a method or model to transfer these results to other countries and regions,
  - to assess the technical and economical impact of energy storages on the performance of the energy system, and
  - to disseminate the knowledge and experience acquired in this task.

A secondary objective of this task is to create an active and effective research network in which researchers and industry working in the field of electric energy storage can collaborate.

Planned activities 2011-2015

The main aims for the new period can be described as follows:

1. Strenghtening of the collaboration in energy storage between all relevant players within the IEA Framework
2. Intensifying the research activities on both thermal and electrical storages
3. Increasing the visibility of the meaning of energy storage for CO_2-reduction

1. Strenghtening of the collaboration in energy storage between all relevant players within the IEA Framework

ECES aims to establish a kind of coordination platform in the field of energy storage until the end of 2012. On the basis of the outcome of the workshop "Energy Storage – Matching the supply and the demand in future" in July 2010, further biannual or annual expert workshops on special aspects will follow. In addition, an annual coordination meeting is favorised.
These activities will lead to different ways of cooperation. On the one hand, joint Annexes may be a suitable way of collaboration if only a small number of Implementing Agreements are involved. On the other hand, the coordination group might develop a working plan, resulting in separate Annexes within different Implementing Agreements. The coordination group would establish the scientific exchange between the related Implementing Agreements and would develop new research and demonstration aims if necessary. Furthermore, the coordination group would be responsible for publishing the results in IEA-reports, in scientific magazines as well as on conferences. They would also be responsible for reporting the progress to e.g. CERT or other parties within the IEA.

2. Intensifying the research activities on both thermal and electrical storages

A further outcome of the above mentioned workshops is also the update of the R&D-goals in the field of energy storages. Depending on the practical needs, further research activities on new storage materials (incl. batteries) respectively their optimisation regarding lifetime, cycle-stability and costs will be started.
Special focus will be placed on standardisation and evaluation of test procedures for batteries for stationary and mobile applications. Even if there are no concrete Annexes in preparation, there are already several discussions on this topic which will lead to Annex activities in the medium term.

3. Increasing the visibility of the meaning of energy storage for CO_2-reduction

ECES is also going to increase the visibility of the results from 1. and 2. in addition to the publications mentioned in 1 by further collaborations. A cooperation with ETSAP is planned. ECES will review their technology briefs and will ask the storage experts to contribute to technology briefs on different energy storage technologies. Furthermore, a contribution to the Energy Technologies Perspectives from the IEA is planned. This kind of cooperation has already started in 2009.
To increase the practical relevance of R&D-results, demonstration projects are also very important to prepare a market entrance for storage technologies. Therefore, a close contact to industrial players is very important. ECES has already started to intensify contact with relevant industries in different countries and will continue this exchange.
The attendance of conferences on national and international level will also be important to increase the visibility.

In addition special attention will be drawn to the education of young scientists. Therefore, summer schools offer a large potential to broaden the view related to the meaning of energy storage in energy systems, as this is in general not done at university. Furthermore, summer schools are also very helpful to create networks. Especially joint summer schools with other Implementing Agreements are aimed for.

Therefore, the overall planned activities from ECES can be summarized as follows:

- Establishing a Storage CoordinationGroup within the IEA
- Carrying out research activities in joint Annexes with other Implementing Agreements
- Organizing summer schools, also together with other Implementing Agreements
- Attending Conferences like e.g. the Eurosun, the Solar World Congress and continue organizing storage conferences ("Stock"-Conferences)
- Contribute to IEA-publications, reports and roadmaps as well as to workshops to attract developing and threshold countries in particular
- Participating at further IEA-coordination groups (building and electricity coordination groups)
- Publishing own R&D-results in own brochures as well as in scientific journals
- Intensifying the contact to relevant industries and policy makers

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