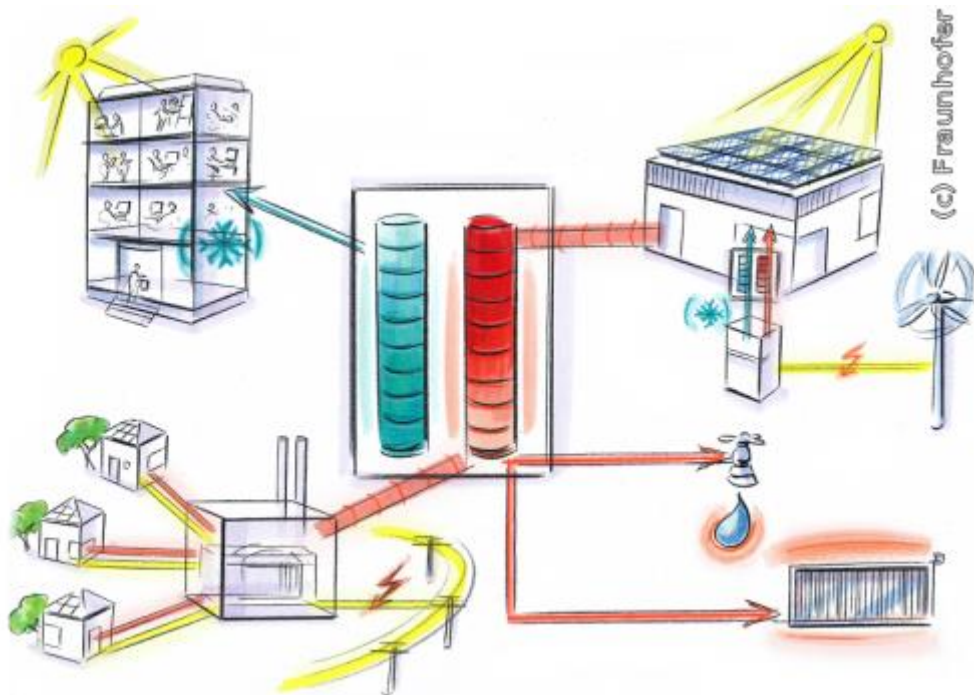




International Energy Agency

Implementing Agreement for a Programme of Research and Development on Energy Conservation through Energy Storage

Strategic Plan 2016 – 2021



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Front page image: Future vision of Fraunhofer scientists of a low exergy community using energy storage. All copyrights by Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V.

Preface

The Implementing Agreement for a Programme of Research and Development on Energy Conservation through Energy Storage (ECES) was established in 1978 with the objective of co-operative research, development, demonstration and exchange of information regarding energy storage systems.

The strategic plan of the Executive Committee of ECES outlines the scope and goals for the next 5 years, covering 2016 through 2021. This is an update on our previous strategic plan that was approved in 2011, by the Energy End-Use Working Party that prolonged ECES until February 2016. The strategic plan shall serve as the basic working document to guide the future work of the Executive Committee and shall also provide a comprehensive summary for other IEA Committees and for the IEA-Secretariat. Detailed information on ECES itself and links to publications are available on our Internet-Website (<http://www.iea-eces.org/>).

This Strategic Plan is formed by the research priorities of member countries. The results and recommendations of the `IEA Technology Roadmap – Energy Storage` of March 2014, as well as those outlined in `The Strategic Research Priorities of the Cross-cutting Technology Panel of the European Technology Platform on Renewable Heating and Cooling` have been taken into consideration in preparation of this plan.



Halime Paksoy
IEA ECES Chair
2011 - 2015

Participants in the Implementing Agreement

The 18 member countries, contracting parties, delegates and alternates to the Executive Committee are shown in alphabetical order.

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1 Background

The power sector will undergo prominent changes in the near future. The percentage of renewable energies will increase, mainly in the uses of wind, solar, and hydro-power. These variable sources shall all provide challenges for national grids. The amount of fluctuating energy - both on the supply and demand sides – compels us to control these energy flows and capacities. Grid expansion is not always the best solution from energetic and economic points of view and this option may not be possible for all parts of the world.

Many electric storage systems are currently being considered to balance the demand. Pumped-hydro plants, CAES, and various electrochemical storages have been developed. Further R&D activities shall improve the efficiency of e.g. redox flow cells and NaS-batteries as well as decrease their costs. Even thermal energy storages may be suitable for balancing the electricity grid.

Energy storage can significantly contribute to increasing overall energy efficiency in the industrial sector through the use of waste heat. This can be deduced from the fact that there exists a significant portion of industrial heat demand within the total final energy consumption.

There is a large variety of energy efficiency measures applicable to the building stock. Passive measures can reduce the heating and cooling demands of buildings. Cold storages decrease building cooling demand during summer and help to avoid black-outs. Seasonal storages can complement energy supplies, especially when used in combination with district heating and cooling systems. In buildings, energy storage bridges the gap between efficiency measures on the one hand and increases use of the renewables on the other. Solar assisted heating and cooling systems in combination with storage provide very promising solutions. Transforming surplus solar or wind energy and storing it in decentralized storages like latent heat may become very energy-efficient and economical solutions.

Energy storage technologies can overcome the temporal mismatch between electricity, thermal energy supply and demand. They are one of the major instruments used to reduce peak loads and enable load management. Storage of electricity, heat or cold, centralized or decentralized, autonomous or grid connected are becoming crucial components of energy systems of the future.

Many ways of storing energy require various technical solutions. Apart from the technical development on component and sub-system level, very efficient solutions with regard to storage are found within the overall energy system. All kind of storages have to be taken into account to find the optimum in a given supply and demand situation.

2 Strategic Direction

ECES work programme supports CERT and EUWP strategies to achieve significant increases in energy efficiency. Integration of renewables into any kind of energy system, by energy storage, encouraging development and their deployment worldwide are also encouraged. ECES has upgraded its Vision for 2016-2021, to a more precise representation of its view, and aims to align itself with CERT's Vision.

2.1 ECES Vision towards 2021

Recent scenario reports with respect to energy supply show a large discrepancy between worldwide trends and likely scenarios on one hand, and developments required (or desired) as a result of international climate policy on the other hand.

IEA Figures show a gradual increase in global primary energy use in recent decades by more than 500 EJ. While part of this growth is covered by renewables, the carbon intensity of electricity production is increased due to increased deployment of many new coal fired electricity plants. These trends arise from developments in non-OECD countries and in OECD countries there is a different trend: coal and oil are getting replaced by natural gas and renewable energy sources.

The recent revolution of shale gas in the United States has added a whole new dimension: In North America, coal is rapidly decreasing as a source for electricity production. This leads to lower global coal prices, which in turn makes natural gas power plants less competitive in other parts of the world. Thus more coal gets used for electricity production.

Renewable energy sources show a strong evolution both in market penetration and in technology and cost reduction. This is due to market scale and innovation in combination with strong support policies during recent decades, in Europe especially but also in other parts of the world. To illustrate this trend, the IEA expects that solar PV will cover around 16% of global energy demand by 2050. As an example, this pinpoints the significance of the changes in our energy systems.

Scenarios for the remaining part of this century, looking at these trends and the possible or likely evolutions in the field of renewable energy show a fundamental change in the dominant position of fossil fuels and the transformation to renewable energies. CO₂ emissions shall decrease drastically, reaching to zero levels according to these scenarios (Figure 1).

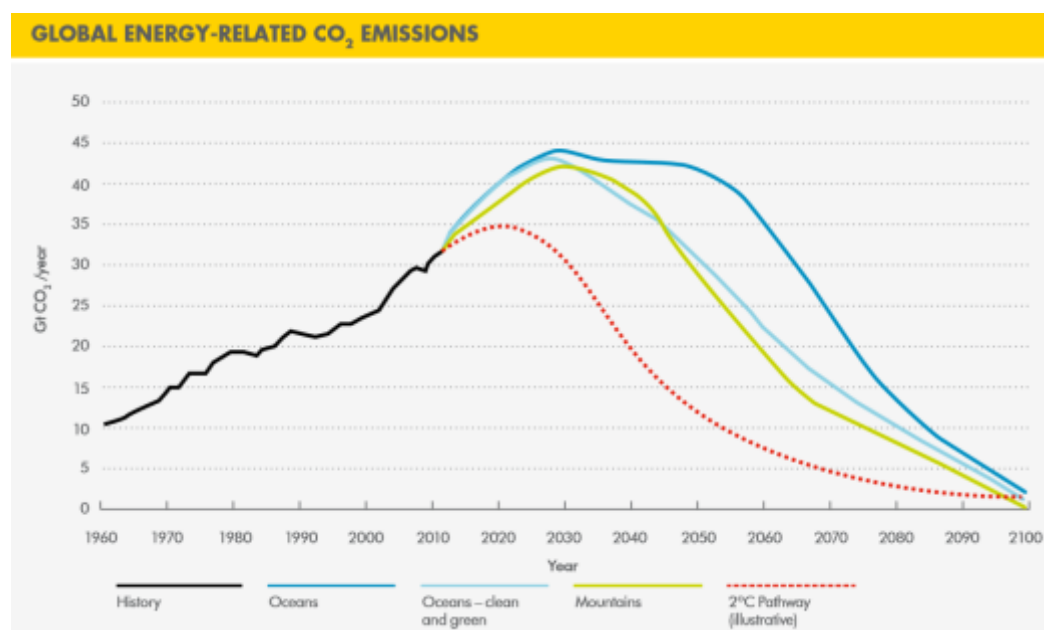


Figure 1: Global energy-related CO₂ emissions, Source: New Lens Scenarios – A shift in perspective for a world in Transition, Shell 2013

Above-mentioned analyses illustrate that on a worldwide level, we need to put more effort into policy, technology, the development and integration of sustainable and renewable energy sources in order to meet the conditions required to stay close to the IEA Energy Technology Perspectives (ETP) 2012 - “2 degrees scenario” (2DS).

Without decisive action, energy-related emissions of CO₂ will increase significantly in the coming decades. Increased fossil energy demand may amplify concerns over the security of supplies. Changing this current path requires an energy revolution. Energy efficiency, many types of renewable energy and possibly carbon capture and utilization will need widespread deployment, if we are to sharply reduce greenhouse gas emissions.

These developments mandate the need for energy storage. Generation of renewable energy, in most cases a variable contribution, will require all sorts of balancing mechanisms to match supply and demand. Energy storage will play a major role within this context.

2.1.1 Energy efficiency, heating/cooling solutions and storage

Energy efficiency offers a very broad scope of action and a large cost-effective potential, however in practice it is a challenge to activate this potential. In most countries the highest impact can be achieved in the renovation of existing buildings. Arup values this market at more than \$400 billion by 2020¹ in North Western Europe alone.

Collective solutions for energy efficiency in the built environment are more and more related to utilization of waste and renewable heat through district heating and cooling networks or individual solutions and cooling options more and more in combination with energy storage.

Heating in areas with a high density of heat demand will increasingly require the application of district heating making use of waste heat, geothermal energy, underground heat and cold storage, solar heating or biomass. Currently, this market is dominated by heat supply from fossil fuels. The transformation to a more renewable based energy source will require a strong interaction on energy system level of energy efficiency measures, renewable energy production and energy storage (in whatever form).

2.1.2 Renewable energy and its integration into the energy system

Apart from further cost reductions in renewable energy technologies, a main challenge for optimal introduction of renewables is the flexibility of the energy system. “Flexibility” will be the key feature of the future energy system.

The IEA report “Energy Technology Perspectives (ETP) 2012 – Pathways to a clean energy system” is very clear on this issue: “The future decarbonized energy system needs all flexible solutions”. Solutions for this flexibility can be found in:

- Energy storage
- Energy cluster management including flexible demand response
- “Dispatchable” power plants
- Interconnection with adjacent markets

¹ BIS RESEARCH PAPER NO. 136, The Smart City Market: Opportunities for the UK, OCTOBER 2013, <https://www.gov.uk/government/publications/smart-city-market-uk-opportunities>

To support electricity sector decarbonisation efforts in the ETP 2012 2DS, an estimated 310 GW of additional grid-connected energy storage capacity would be needed in the United States, Europe, China and India. Potential interchanges in the form of energy like power to heat or power to gas need to be incorporated in the required storage capacity. Both short (power) and long term (energy) storage solutions are required.

Depending on the different requirements of the energy system for power versus discharge duration and heating requirements, adequate solutions may range from batteries or ultra-capacitors, to pumped hydropower, power to heat, power to gas and/or chemical routes. As such the imbalance due to intermittent energy production will need to be resolved by large scale deployment of energy storage in many forms.

Furthermore, it is essential to have detailed energy system analysis including interconnection capacities and demand response elements, to make coherent predictions on the future energy storage developments. These storage solutions will also be part of larger energy clusters together with dispatchable power production and demand side response solutions.

2.1.3 Rationale for energy storage technologies within a changing energy system

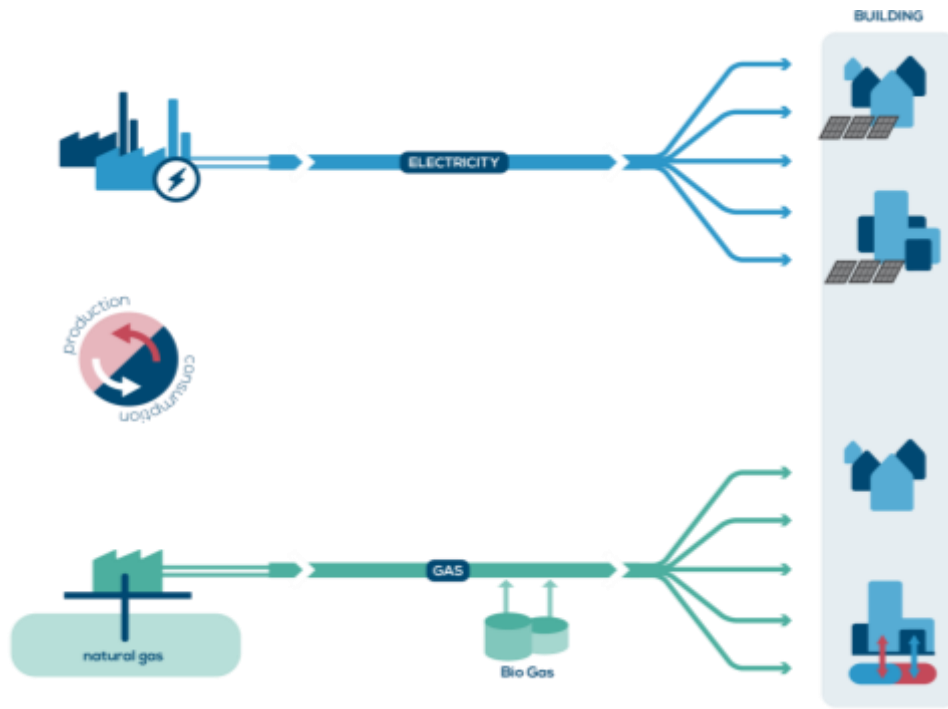
Energy storage technologies are valuable components of any energy system and could be a key component in achieving a low-carbon future. These technologies allow for the temporal decoupling of energy supply and demand, in essence providing valuable solutions to system operators. The deployment of these technologies is highly influenced by regulatory and market conditions.

Energy storage lacks a mechanism for pricing. As a result, economic boundaries and new approaches are yet to be set for large scale deployment of energy storage in our energy systems.

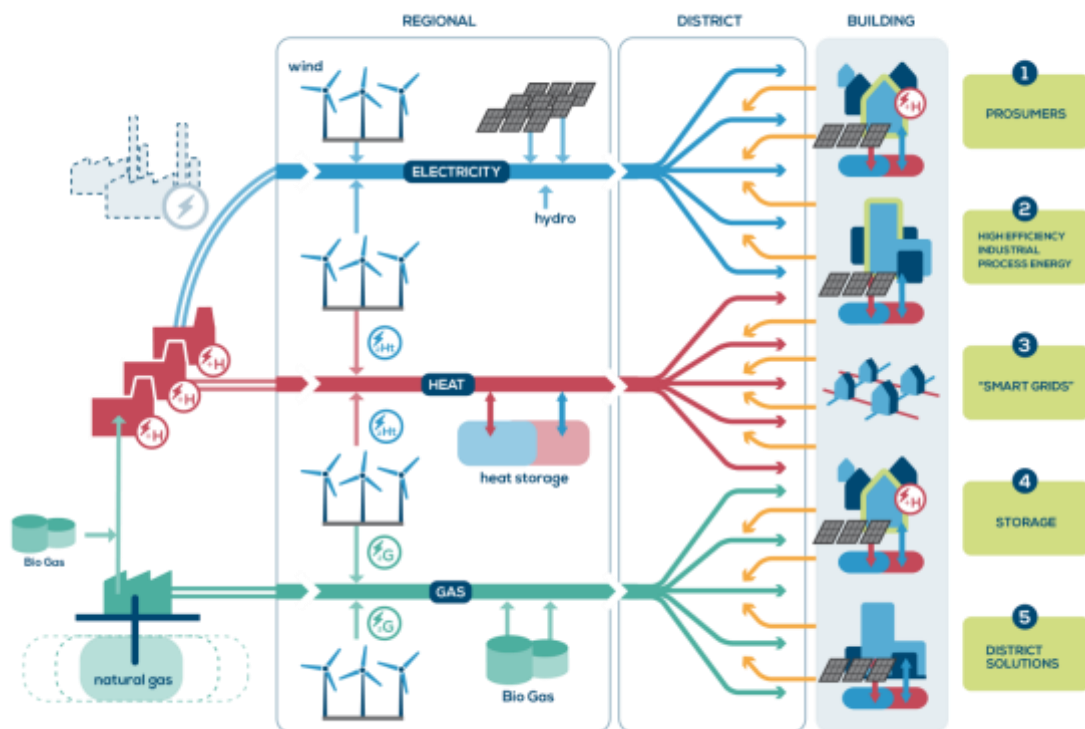
Historically, storage technologies were predominately installed as an investment that could take advantage of dispatchable supply resources and variable demand (i.e. through price arbitrage).

However, with increasing emphasis on energy system decarbonisation moving forward, storage technologies can be used to increase resource use efficiency (e.g. through increasing waste heat utilization) and to support increasing use of variable renewable energy resources. To that end, it is important that energy storage be considered from a systems point of view with a focus on the services that it can provide in bulk, small scale (e.g. off-grid) and other applications.

Our future energy system will be characterized by a complex interaction of variable (renewable) supply, changes of energy forms (i.e. transformation from gas to electricity or renewable heating) and a dominant role of energy storage (Figure 2).



(a)



(b)

Figure 2: (a) Traditional energy system whereby supply and demand could be matched by balancing the production on the supply profile (b) An impression how our energy system will evolve by depleting fossil fuel resources and increased use of (mainly decentralized) renewable energy production.

Research and development work is currently underway with the primary goals of realizing technology cost reductions and improving the performance of existing, new and emerging storage technologies. The storage technologies are to be positioned as essential facilitators for the transformation toward a renewable energy society. These technologies are the enablers.

Apart from the technological developments, the deployment of energy storage also depends on identifying and solving the non-technical barriers to deployment.

Looking forward, the most important drivers for increasing use of energy storage will be:

- Efficiency in the use in energy system
- Increasing use of variable renewable generation resources
- Self-production and consumption of energy (electricity, heat/cold)
- Increasing energy access (e.g. via off grid electrification)
- Electricity grid stability, reliability and resilience
- Changes in (electrical) mobility
- Increased end-use sector electrification

Summary: the main position of energy storage within a “smart”, reliable and renewable energy system is to:

- **Facilitate energy grid stability**
- **Optimize renewable energy production to match specific demand**
- **Create flexibility in energy form (i.e. electricity vs gas or heat and cold)**

2.2 Mission

ECES stimulates and facilitates collaboration of international research aimed at discovery, development, deployment and demonstration of energy storage systems as part of the transformation from a fossil fuel based energy system to an energy system based on renewable energy sources.

3 Scope and Objectives

The scope of the work in ECES is:

- Research and dissemination activities on both thermal as well as electrical storage technologies
- Storage technologies as a main driver for the transformation of the energy system toward a renewable based supply
- The international collaboration is to be carried out within a framework of typical IEA countries in combination with developing and transition countries

The objectives of ECES are:

1. To stimulate and facilitate collaboration of international (fundamental) research, development, deployment and demonstration of energy storage systems
2. To increase the awareness and visibility of energy storage technologies as being the essential part of the transformation of the overall energy system

3. To create an open and accessible platform to exchange the latest development and experiences in the field of research and deployment of energy storage systems

3.1. High Priority Research and Innovation Topics

The research and innovation activities are determined based on the priorities of ECES member countries and the outcomes of the recent IEA Technology Roadmap on Energy Storage. Furthermore, the strategic research agenda of the Cross-Cutting Panel of the European Technology Platform on Renewable Heating and Cooling is also taken as reference.

Some of the suggested key actions for the next 10 years indicated by IEA Technology Roadmap on Energy Storage² are compiling datasets, eliminating price distortions, supporting demonstration projects, sharing information on lessons learned and providing incentives.

In the near future, energy storage applications, both electrical and thermal, will be needed in order to balance the energy system, to allow for optimal transformation between energy commodities like electricity and heat or cold and to increase the optimal use of renewable energy.

This development will require evaluating the financial cost and benefits of energy storage. The cost of storage needs to be considered in a wider perspective of the total energy system. This can be both on the demand side and elsewhere in the energy system. Cost assessment is a parameter which needs much more elaboration. It will relate to avoided cost, stand still cost of power plants, and system benefits. New methodologies need to be established in order to assess the economic impact of energy storage in comparison with other flexibility mechanisms.

The objectives of ECES can be reached if the competitiveness of energy storage systems are significantly increased through cost reduction and improved performance and reliability based on an overall integrated system approach. To achieve this further RD&D is needed in the following topics:

- Development of energy storage for energy savings and efficient use of energy in buildings and industry
 - High temperature heat storage for industrial purpose
 - Storage in buildings for efficiency improvement
 - Effective storage solutions for heating and cooling in Smart Cities / Regions
 - Mobile storage options for surplus heat utilization
 - Stationary batteries
- Cold storage development
 - Distributed storage in district cooling systems
 - Local storage for free (night-time) cooling of buildings

² IEA Technology Roadmap on Energy Storage

<https://www.iea.org/publications/freepublications/publication/technology-roadmap-energy-storage-.html>

Overall, the result of the research work on these topics must lead to a more stable energy system in which the variations between (renewable energy) supply and demand are better balanced in such a way that fossil fuel based back-up resources will gradually be made obsolete.

Table 1 gives a matrix showing the RD&D topics with links to recently completed and current annexes. The areas that ECES has covered already are mostly thermal storage and recently more emphasis on electric storage and interchangeable/hybrid options are covered. The white spots in the matrix given in Table 1 indicate what is missing in our portfolio and areas that can be covered in future annexes.

Table 1: Matrix showing R-D&D topics in energy storage applications with links to recently completed annexes (blue), current annexes (dashed) and both completed and current annexes (blue and dashed). White spots are identified gaps in the Annexes.

| | | Urban Systems / Building related Applications | Industrial Applications | Integrated System Related Applications |
|------------------------------------|--|---|----------------------------|---|
| Pure Electrical Storage | Large scale- such as pumped hydro, CAES | | | |
| | Small scale- in various forms of batteries | | | |
| Pure Thermal Storage | Thermo-chemical / thermo-physical | | | |
| | Phase Change Materials (PCM) | | | |
| | Cold storage | | | |
| | Sensible Thermal Energy Storage | | | |
| Interchangeable /Hybrid Options | Power to Gas | | | |
| | Power to Heat | | | |
| | Power to Chemicals | | | |
| Cross- Cutting Issues | | | | |

Cross-cutting issues that will increase the penetration of storage technologies into market should accompany these topics. These include:

- Database on all kinds of realized storage projects
- Development of standards and guidelines for evaluation and successful implementation of storage technologies
- Economic evaluation with a wider perspective including avoided costs, system benefits, etc.
- Addressing social acceptance of storage technologies

Research and innovation topics needed for the development of a wide range of storage technologies for electricity, heat and other energy sources for increasing energy efficiency and integration of renewables are prioritized in Figure 3.

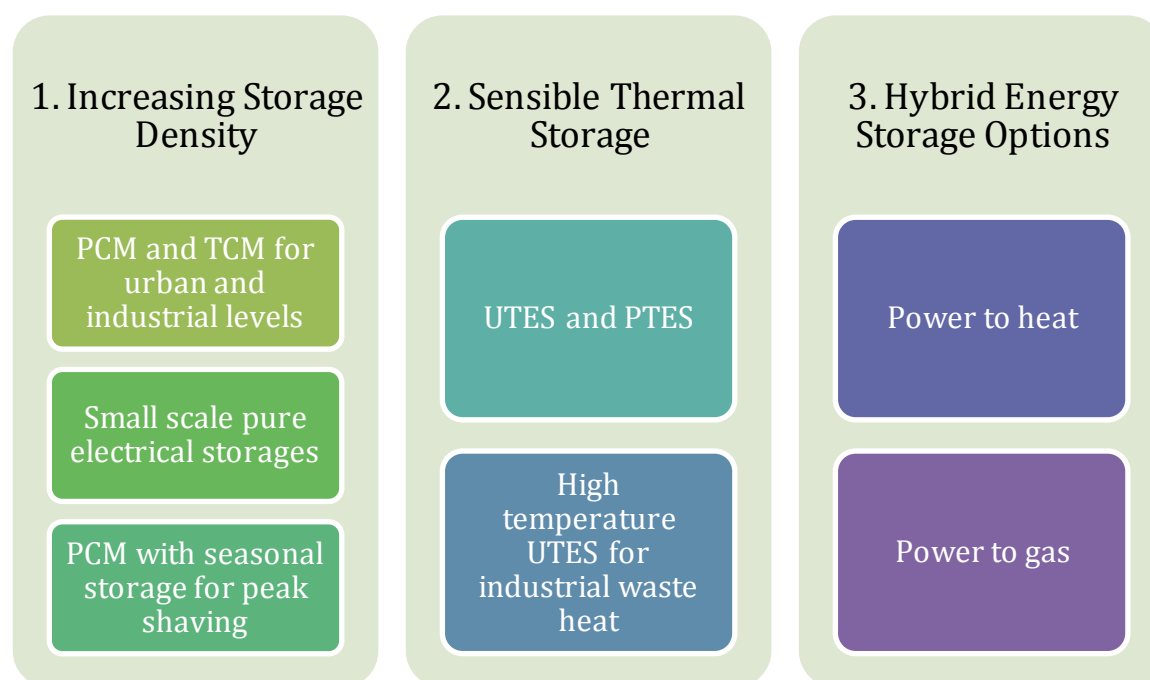


Figure 3: Research and innovation topics with highest priority

3.2 Strategy implementation

Bottom-up approach for flow of information from Annexes to higher bodies in the IEA and also governments is needed for a successful strategy implementation. This approach starts with the discussion of a new idea suggested by one or more of ECES countries during ExCo meetings. Table 1 and Figure 3 are used as guidance in determining high priority topics of common interest. A workshop that will bring the industrial representatives and experts working in the together to determine the scope meetings gaps in the strategy plan and new annex ideas are discussed. A new idea can be developed into an Annex starting with a task definition workshop addressing experts, industrial representatives and decision makers.

ECES will continue efforts to implement its strategic objectives within context of the following current and planned Annexes. The R-D&D topics covered by these annexes are shown as dashed cells in Table 1.

- Current
 - Annex 28 “Distributed Energy Storages for the Integration of Renewable Energies”
 - Annex 29 “Material Research & Development for Improved TES Systems”
 - Annex 30 “TES for Cost Effective Energy Management and CO₂ Mitigation”
 - Annex 31 “Energy Storage with Energy Efficient Buildings and Districts: Optimization and Automation”
- Planned
 - Annex 27 “Quality Management in Design, Construction and Operation of Borehole Thermal Energy Storage Systems” – planned to start in 2015

New ideas that started to be discussed by the ECES ExCo are:

- Modeling of Energy Storages
- Energy Storage Contribution in Building Renovation
- Electric Storage Demonstration Project Database
- Standards for Energy Storage
- Advanced TES – Material Development and System Integration

Current and future joint activities (annexes, workshops, etc.) with following IAs are also important to create synergies and avoid duplication of research topics:

- Current
 - Solar heating and Cooling (SHC) – Annex 29
 - International Smart Grid Action Network (ISGAN) – Annex 28
 - Hybrid Electric Vehicles (HEV) – Annex 28
- Future
 - Heat Pump Program (HPP) – Annex 27
 - Solar Power and Chemical Energy Systems (SolarPACES) – Annex 30
 - Industrial Energy-Related Technologies and Systems (IETS) – Annex 30
 - Energy for Buildings and Communities (EBC) – Annex 31

4 Contractual and Management Requirements

4.1 ECES Management

ECES will continue to be managed according to the requirements of IEA. The Executive Committee (ExCo) consists of one voting Member from each Member Country and Sponsor, with an Alternate appointed who may serve on the ExCo if the designated Member is unable to do so. The ExCo meets twice a year and Members and/or their Alternates are strongly encouraged to attend. The minutes and documents of the meeting are placed on the password protected site of the website and made available to all the delegates. The ExCo Chair and one or more Vice-Chairs are elected by the ExCo for a term of one year. The management of the individual Annexes is the responsibility of Operating Agents. The definition of a new Annex, the subsequent progress reports and the final report needs to be approved by the Executive Committee. In the coming period the ExCo will annually update its activities and review them to be in line with this strategic plan.

4.2 ECES IA Text

The last review of the ECES legal has been made on December 10th, 2004. The legal text will be reviewed prior to the start of the new term and make any necessary changes to ensure that the provisions remain consistent with the new Strategic Plan.

4.3 Annual Report

The ECES Annual Report is compiled under the responsibility of the ExCo chair and edited by the Secretary. This is a major publication of ECES to disseminate information on the progress, plans and achievements of the work programme. The operating agents of Annexes provide the data to be included in the report by the end of the year. The official approval of the report is realized in the following year's spring ExCo meeting. This timing leads to a delayed publication. In the new term the scheduling of annual report will be changed for a faster publication. The format of the annual report has also been updated as a result of the discussion in the Spring 2014 meeting. All Annual Reports are provided in the public area of the ECES website.

5 Contribution to Technology Evolution / Progress

More integration of renewables with low carbon economic technologies and providing secure energy are common topics in energy policy of many countries to meet the targets of challenging CO₂ mitigation. The main challenge is to meet the variable renewable energy supply with variable energy demand.

5.1 Participating Countries

The results of ECES work have been providing solutions to existing energy problem with developing storage technologies. Examples of such contributions to technology progress in participating countries are:

- Denmark: New concept of energy infrastructure utilizing storage of renewables, pit thermal energy storage in distributed energy systems
- Finland: Energy storages and micro-grid concepts
- Germany: Technology development and demonstration for electrochemical, compressed air, fly wheel and thermal energy storage; higher-level energy storage topics like underground storage potential, numerical modelling of storage potential and systems and demand side management in buildings, industry and local district heating systems
- Japan: Further technology development of latent heat storage materials and vehicle TES, TES integrated within the energy efficient building
- Korea: Increase current energy storage capacity of 100MW as of 2013 to 300 MW in households, industry and power generation and transmission by 2020
- Netherlands: Compact thermal energy storage developments to facilitate the electrification of heating demand; distribution and UTES on district level
- Slovenia: Intelligent electrical energy storage networks including energy storage
- Spain: Molten salts storage in solar power plants; increase of buildings energy efficiency with the use of compact thermal energy storage and other storage systems; development of electrical storage for smart grids
- Sweden: Material characterization methods enhancement, use of active and passive TES in building sector for indoor temperature/humidity control, energy efficiency improvement and peak load alleviation, mobile TES for industrial surplus heat reutilization, development of UTES to be used commonly and commercially
- Turkey: Energy storage for increasing energy efficiency in buildings, industry and appliances, thermal energy storage material development

Successful climate change mitigation strategies require combined efforts in all sectors. In response, ECES has recently completed Annex 25 “Surplus Heat Management using Advanced TES for CO₂ mitigation”. The final report identified many successful examples of installed energy storages and determined the CO₂ mitigation potential of these technologies. This activity will be continued in the new term with Annex 30 “TES for Cost Effective Energy Management and CO₂ Mitigation”. In addition to these Annexes, with an attempt to expand electrical storage activities ECES started the new Annex 28.

5.2 Success Stories

Selected success stories from ECES member countries are summarized here. These are also included in the End of Term Report.

In Belgium, implementation of underground heat and cold storage systems has increased and will continue to increase. So far, 87 aquifer thermal energy storages (ATES) and 214 borehole energy storages (BTES) have been implemented, with plans for an additional 25 ATES and 55 BTES projects in the very near future. Furthermore, several phase change material (PCM) concepts in the temperature range between 40°C and 70°C have been measured and compared, leading to new research on multistage PCM concepts, involving multiple PCM's with different melting temperatures in the same storage unit. For electric energy storage, work in the annexes has resulted in a handbook on future (electric) energy storage demands.

In Denmark PTES (Pit Thermal Energy Storage) has been developed to extend the solar fraction in district heating systems. Water storages of 75,000 m³ and 60,000 m³ were implemented in 2012 and 2013 and two new water storages of 117,000 m³ and 200,000 m³ will be opened in 2015. The solar storages combined with heat pumps offer power to heat services. The storage concept can also utilize excess heat from waste incineration, industrial processes and CHP production.

The German government announced 211 a joint RD&D Initiative on Energy Storage Technologies. Currently, there are 273 projects running with approved public funding of €196 million and the same amount of industrial RD&D expenditures.

Energiepark Mainz is a combined wind–hydrogen project, where a power-to-gas (PtG) facility is situated adjacent to an existing 8 MW wind park in Mainz. The project partners are Stadtwerke Mainz, Linde, Siemens, and Hochschule Rhein-Main. The main objectives are to implement peak-shaving in distribution grids; demonstrate ways to avoid grid expansion by producing, storing, and using hydrogen in different ways; to bridge the gap between existing small-scale electrolyzers (100 kW) to large-scale devices (100 MW); and to develop a large-scale ionic compressor as well as conduct accompanying research activities.

Smart Region Pellworm is another funded project example, studying the use of batteries in distribution grid. The project involves a hybrid power plant: 772 kW photovoltaic and a 300 kW wind power system. The coordinator of the project is E.ON Hanse AG. Research focuses on developing a hybrid storage system and an energy management system, developing business cases, and fostering customer interaction and technology acceptance.

Mobile energy storage systems working with zeolite in an open sorption system can utilize industrial waste heat in cases where a pipeline bound connection is not cost-effective. A demonstration plant was built, operated and monitored over one year which uses extraction

steam from a waste incineration plant to charge the storage with 130 °C hot air and deliver to an industrial drying process customer 7 km away from the charging station. The storage contains 14 tons of zeolite and at the discharging station uses exhaust air from the dryer with 60 °C and 0.09 kg/kg humidity to realize a storage capacity of 2.3 MWh. This saves 616 kg carbon dioxide per cycle and shows no degradation within accuracy of the measuring equipment. Maldistribution through the packed bed of zeolite prohibits the desired power output. The prime energy costs can be reduced down to 73 €/MWh transported energy, considering a small-scale mass production. This is about twice as expensive as natural gas for an industrial customer in Germany. Project partners are ZAE Bayern, Hoffmeier Industrieanlagen, waste incineration facility in Hamm and Jäckering.

In Japan TES has been installed in over 30,000 buildings such as offices, shopping centres, hospitals, factories etc. and total peak shift capacity by TES is estimated to be 1.94GW as of 2013. Nowadays it has become popular to install TES in huge buildings/DHC. One of the innovative projects is the Tokyo Denki University's new campus. The TES system in this project installed vertically connected ice/water TES tanks, which has been operational since 2005 to enable a heat source system to minimize the transportation energy for the pumps. Another interesting project is Harumi DHC plant, which has been operating since 2001 with a largest TES capacity in the country (Total water volume: 19,060 m³). The COP for primary energy conservation has fluctuated slightly from year to year with the highest value (1.25) occurring in 2009; the average value over 10 years is 1.25. This DHC plant has shown the importance of plant commissioning. Last but not least TES has been receiving more attention due to the high recognition toward BCP (Business continuity planning) with the function that the water stored in the storage tank could be utilized for daily life water or firefighting water when an emergency occurs.

In the Netherlands major new developments in commercial real estate now use state of the art underground heat and cold storage systems (UTES) for their heating and cooling requirements. The soil conditions allow the use of heat and cold storage. New legislation has been adapted to regulate the balance between heat/cold extraction and return to the underground storage. With an expected change and transformation in heating the existing building stock (from natural gas to district heating and electrification) the role of heat storage will increase.

In Sweden, the number of ATES is steadily growing, even more so for BTES applications supported by ECES activities. All together, some 5 600 MW of shallow geothermal energy systems are installed extracting at least 15 TWh of heat from the underground (in some cases stored in ATES and BTES systems). This represents some 15 % of total heat demand in Sweden. In later years, further development and marketing of GSHP and UTES has been strengthened by forming a "Geo-Energy Centre" in which experiences are collected and education to the market is given."

In Turkey, the first ATES plant in the Mediterranean climate was successfully demonstrated for a greenhouse. With a new approach surplus heat in the greenhouse from summer was stored underground to provide heating during winter.

6 Contribution to Technology Deployment / Market Facilitation

ECES recognizes the importance of a higher interaction with industrial companies that have strong production links to their relevant sectors. Within this next term, the activities that are planned by ECES to expand the contributions to technology deployment and/or market facilitation are grouped as follows:

1. Demonstration Projects
2. Industrial Participation
3. Standards and Guidelines

6.1 Demonstration Projects

Demonstration projects have to be the beginning of a fruitful cooperation between science and industry until and even beyond when the components have reached their break-even points. Well-planned and successful demonstrations need to start a chain reaction: each realization is the successful acquisition of the next cooperation project between industry and science. The demo shall ignite the first spark that is intended to grow into win/win situation for both parties.

We shall focus more on technology readiness levels - TRL (5-7) in developing demonstration projects in the new term. Well-planned demonstration projects of energy storage technologies that are ready to be transferred to the market shall be carried out more. Two new annexes, namely Annex 30 and 31, have both begun their activities in demonstration plans targeting different sectors:

- Annex 30 “TES for Cost Effective Energy Management and CO2 Mitigation”
 - Industrial processes
 - Power and co-generation plants
 - Non-residential buildings
 - Vehicles
- Annex 31 “Integration of Energy Storage with Energy Efficient Buildings and Districts: Optimization and Automation”
 - Buildings
 - Districts

Best practices and demonstration projects will be exposed to a wider audience from industry, policy makers and other research groups. Therefore one of the key strategic objectives for the coming period is to more actively encourage dissemination activities through existing communication channels.

We will form a database of current energy storage projects that cover various technological sectors. The current database by DOE includes only storage projects that are connected to the grid and data on some of the projects needs to be updated. ECES shall make an effort to build its new database through an interactive Internet application. This will be a new Annex or a task in a new Annex. ECES will also provide a showcase of solutions that grew from laboratories to marketable products that our annexes have already achieved.

6.2 Industry Participation

We will address different industrial groups through our demonstration projects. Some successful demonstration projects with well-funded budgets may still face problems in bringing storage solutions to the market. Increasing the dialogue with companies and understanding their goals to share these solutions is important as demonstrating cost-effective and low carbon alternatives will simplify their penetration to markets. Expectations from different industrial sectors on pay-back times may be different and this will be addressed when facilitating new and relevant areas.

Higher industry involvement in the ExCo and Annex levels needs to have realistic approaches. We will practice mutual understanding. ECES has two sponsor members, which come from academia currently. They have strong links with industry through joint projects and other means of cooperation. We aim to increase the sponsor members from industry and enhance the interaction with our current sponsor members as well as continue to organize workshops focusing on special industrial sectors in parallel with ExCo and Annex meetings. Workshops addressing industrial representatives in new and potential member countries are also considered very important. Such a workshop was organized in Slovenia to increase industrial involvement. More participation in special conferences organized by industrial organizations will be realized to increase the interaction with industry, and prove both the short and long term benefits achieved through energy storage.

We will invite an obligation for the new annexes to show business opportunities for industries and include special targeted actions for industry involvement. Annex final reports shall each include a special chapter on industry's involvement. In this chapter, the opportunities created for industries, products that have been developed for the market within each annex, and any barriers and suggestions to overcome these will be included. Conclusions shall recommend aspects that need to be studied further.

6.3 Standards and Guidelines

To achieve successful and accelerated deployment of technology, it is important first to address standardization within a global context. In the past, the first guidelines on underground energy storage technologies were written in Germany through the collaborative efforts in ECES. These guidelines have been transferred and adapted in different countries like Canada and Japan. In the new term, we will identify priorities for international standards and make an effort to work with the IEC, CEN and ISO, as well as industries; to ensure what test and performance standards are applicable. This would not only enable the national industries to enter foreign markets, but also ensure technical innovation through our projects. A workshop that brings standardization organizations, industries and energy storage experts together to determine the standardization priorities will be organized in parallel to ExCo meeting.

With an increasing awareness on the need for energy storage, the interest from the industry to participate in the work is increasing as well. Research leads to new technological concepts and ideas which eventually lead to new products, systems and services. Where the IEA research projects in Annexes in many cases addresses the lower Technology Readiness Levels (TRL), the results of the work become increasingly interesting for the industry to develop further to products and services.

Apart from the awareness of the potential technological opportunities, the industry also is highly sensitive for overall market conditions as they may derive from government policies, market conditions and competitive options.

7 Policy Relevance

ECES focuses on energy storage technologies that allow transition to a low-carbon, energy secure economy in consistent with the 2011 IEA Ministerial Communique and Action Plan.

ECES chairman continues to report summarized results of actual work regularly to the EUWP and IEA, in a format and structure proposed by IEA Secretariat. ECES fosters the use of its findings in IEA analysis such as Energy Technology Roadmap and Energy Technology Perspectives.

The European Commission is a contracting party of ECES, but has been inactive. In the next term, we will seek to renew this collaboration and further improve this connection to feed our results to the European Commission. ECES will continue collaboration with the European Energy Research Alliance (EERA) in the new term.

ECES delegates are responsible to transfer the work of ECES to policy makers of their countries. They can report twice a year, after each ExCo meeting and if necessary, also even more to contact persons in the national governments. For more efficient interaction ExCo, EUWP and CERT delegates should have an active contact. Participating countries are encouraged to plan annual “National ECES implementing agreement days” to improve the coordination and dissemination between national delegates, local experts, policy makers in order to disseminate the results from ECES Annexes.

To improve policy relevance of ECES, ExCo has realized that key performance indicators (KPI) need to be described for the different applications. In the next term we will develop KPI for several highlighting applications including different storage technologies.

8 Contribution to Environmental Protection

The main technologies in realizing the 2D scenario³ – a vision of a sustainable energy system of reduced greenhouse gas emissions – are those increasing the end use fuel and energy efficiency (42%) and integrating renewables (21%). Energy storage is an enabling technology to maximize energy efficiency and integration of renewables in any kind of energy system. It is determined as one of the key technologies to decarbonize the power sector and also heating and cooling demand in buildings and industry.

At least 50% of the world’s primary energy supply is “wasted” in energy conversion. Waste heat is not fully harvested, because the quantity and quality of both heat resources and demands are not fully known. Thermal energy storage increases the potential of waste heat utilization by matching supply and demand in time and space and temperature by allowing use of heat pump technologies. Annex 30 that has started in 2015 will address these topics for further exploiting the waste heat potential in industry.

³ IEA Energy Technology Perspectives 2012

To maximize cost-effective contribution of energy storage to environmental protection in the transition to a low-carbon energy system, new tools are necessary. In the new term, an annex on modeling tools to include environmental aspects is planned. A stronger relation to policy makers is also needed to eliminate price distortions.

ECES work plan has been dedicated to developing cost effective energy storage solutions to protect the environment. This strong focus will continue with increased effort within the next term through the current and planned annexes.

9 Contribution to Information Dissemination

ECES will continue to strengthen its dissemination activities to expand promotion of our results to various stakeholder groups and to feed into promotional efforts of the IEA Secretariat.

Within IEA, ECES will continue to take part in collaborative groups (Building Coordination Group, Transportation Contact Group, Industrial Experts' Group) to enhance collaboration and share information for dissemination. ECES is also supporting the work of IEA Secretariat through contribution to publications such as ETI, ETP and most recently to Technology Roadmap on Energy Storage. We are also contributing to the IEA workshops, most recently Experts' Group on R&D Priority Setting and Evaluation and ETP 2016. ECES plans to use the OPEN Bulletin more to promote our results and activities.

Collaborating with other IAs is important to determine mutual topics of interest, start new joint activities and also to avoid duplication of R&D efforts. New collaborations with IAs can be foreseen with Annex 27 and HPP, Annex 30 and SolarPACES and IETS, and Annex 31 and EBC.

The main publications of ECES are the annual reports and brochure, which are available from the webpage. The final annex reports are published on the webpage. Resources are limited for printing high quality dissemination materials. Therefore, webpage has an important role in dissemination of information. We plan to update the webpage structure to make easy access to publications, to include selected publications from Annexes, and to have an interactive database management platform.

ECES is organizing tri-annual "Stock" conferences since 1985. In the next term the 14th Stock Conference will be organized in 2018 in Turkey. This conference is a very important event to disseminate and promote our results. Together with the conference four different awards shall be given to individuals, companies, or private/public institutions that have shown outstanding leadership or achievements in the field of energy storage, and that supports the work of ECES.

Furthermore, ECES will continue contributing to scientific organisation of the Eurosun, the European conference on solar thermal energy and Solar World Congress of International Solar Energy Society and the Solar Heating and Cooling Conference of IEA-SHC IA and other conferences and workshops related to energy storage, that the ExCo finds adequate. ECES started being one of the supporting organizations of the annual event Energy Storage Europe since 2015. The delegates of the ExCo and experts of Annexes are giving presentations on energy storage as keynote speakers at these and other conferences and forums.

In addition to these conferences, ECES will organize workshops in parallel to ExCo and Annex meetings with different focused themes. There are several scientific papers published as a result of the works in annexes. ExCo will encourage new annexes to continue publishing joint research. Special editions on energy storage in distinguished journals are published with the joint efforts of the experts in different annexes.

The delegates and experts of ECES are also supporting education and training activities and exchange programs through joint projects. Such activities for young professionals and early scientists will be continued to enhance the network and quality of research and practice in this field.

10 Outreach to IEA Non-Member Countries

We have participated in EUWP meetings and workshops, Expert Group on R&D Priority-Setting and Evaluation Workshop and NEET Workshops to strengthen international cooperation and enhance outreach of ECES in the past. Currently, ECES has members from Europe, North America, and Asia. There are two sponsor members. We have China as an IEA non-member country coming from n countries. Chile and India have shown interest to join ECES. Chile has already sent an observer to our meetings. From the IEA member countries, we have interests from Australia, Austria, New Zealand and Switzerland. In the next term, ECES will continue efforts to involve new members with the support from IEA Secretariat and CERT and EUWP delegates.

11 Added Value

11.1 Collaboration within IEA

The selection of the topics in the Annexes is based on the ambition to share research activities and collectively collaborate. In this way, it avoids duplication of work and uses national research funds more effectively. This approach creates strong international relations among research groups, institutes and industry. Network established leads to new joint activities in other forums as well. Important advantage for this approach is that researches are exposed to more and new ideas. These boost the level and excellence of R&D on energy storage.

On the national level, each ECES country will be encouraged to organize IEA IA days to strengthen the links among different stakeholders – ExCo delegates, government representatives, experts from research and industry. Presentations at national workshops with special focus are also recommended as activities to increase collaboration. An example for this can be given from Germany. In 2015, we presented IEA and ECES at the second workshop of the German joint RD&D Initiative on Energy Storage Technologies.

Some of the other IEA IAs tie in nicely with the work of ECES. Where possible ECES seeks to establish cross cutting activities such as currently done with the SHC program. Other cross cutting initiatives may be expected with IEA EBC, HPP, SolarPACES and ISGAN. ECES will continue to participate in IEA coordination groups such as BCG, TCG and ISG and workshops organized by different bodies of IEA. One such recent event was EGRD workshop on energy storage in Berlin. ECES represented its aims and strategies and results of Annex 26, Electric Energy Storage: Future Energy Storage Demand at this workshop.

11.2 Collaboration outside IEA

There are a number of other organisational structures, which develop outside the direct scope of IEA work such as EU programmes. These programmes are closely monitored and collaboration is sought for as much as possible and feasible. In the next term a representative from EC will be invited to give a presentation on EU programmes relevant to ECES. Another such organization is European Association for Storage of Energy –EASE, which was founded in 2012. The operating agent of Annex 26 represents ECES in EASE. ECES will continue the dialogue with EASE.

In 2014, we started information exchange with the joint programme on energy storage of European Energy Research Alliance (EERA). We will continue this collaboration in the new term.

Acronyms and Abbreviations

| | |
|------------|--|
| 2DS | 2 Degrees Scenario |
| BRICS | Brazil Russia India China South Africa |
| BVES | German Energy Storage Association |
| CERT | Committee on Energy Research and Technology |
| HEV | Hybrid Electric Vehicles |
| HPP | Heat Pump Programme |
| IA | Implementing Agreement |
| IEA | International Energy Agency |
| IEC | International Standardization Technical Committee |
| IETS | Industrial Energy-Related Technologies and Systems |
| ISO | International Standardization Organization |
| ISG | Industry Strategy Group |
| CEN | European Committee for Standardization |
| ECES | Energy Conservation Through Energy Storage |
| EERA | European Energy Research Alliance |
| EGRD | Expert Group on R&D |
| ETP | Energy Technology Perspectives |
| EUWP | End Use Working Party |
| ExCo | Executive Committee |
| RD&D | Research Development and Deployment |
| ISGAN | International Smart Grid Action Network |
| EBC | Energy in Buildings and Communities |
| EC | European Commission |
| KPI | Key Performance Indicators |
| NEET | Networks of Expertise in Energy Technology |
| PCM | Phase Change Materials |
| SHC | Solar Heating and Cooling |
| SolarPACES | Solar Power and Chemical Energy Systems |
| TCM | Thermochemical Materials |
| TES | Thermal Energy Storage |
| TRL | Technology Readiness Level |
| UTES | Underground Thermal Energy Storage |