Position Paper of Helmholtz Association of German Research Centres on Energy Research in Horizon 2020

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HELMHOLTZ
ASSOCIATION

The Helmholtz Association of German Research Centres with its almost 33,000 employees and an annual budget of 3.3 billion euros is Germany's largest research organisation and one of the largest in Europe. The Helmholtz Association participates in many European projects – often in a coordinating role – and benefits considerably from the established instruments of the Framework Programme of the European Union for Research and Technological Development. The instruments and actions of the Framework Programme contribute significantly towards supporting networking and collaboration between the scientists of the Helmholtz Association and researchers throughout Europe. They facilitate as well activities which cannot be realised at the national level or which provide added value in the form of collaborations at the European level.

Energy research, a field of activity with significant European added value

Introduction

Given the fundamental significance of energy supply for all citizens of Europe, the issue of energy research has a particularly pronounced political dimension. In the future, a comprehensive, close-knit integration of the European energy market using cutting-edge technology will be a prerequisite for a sustainable energy supply.
It will necessitate technological collaboration in Europe throughout all phases of development, from research and prototype testing to widespread application. The current concept of an energy supply based mainly on fossil fuels is not sustainable.

Climate protection considerations and the need to maintain economically viable personal mobility are equally significant challenges whose technological bases need to be thoroughly researched. Extensive research is necessary to translate results quickly into prototype testing and industrial-scale implementation. Only in this way can living standards in Europe be maintained and further enhanced. The transition to a sustainable energy supply system is therefore one of the greatest research and industrial policy challenges of the future.
Recently, Germany decided gradually to abandon nuclear power production by 2022. This implies a radical change in German energy policy, which will only succeed if the contribution of renewable power production in Germany is drastically increased in the very near future. The requirements for integrating the management of the German power supply into a European context, as outlined in the Strategic Energy Technology (SET) Plan, is both a challenge and an opportunity.
A dedicated funding scheme for energy research is necessary to establish a new balance at the European level between climate change mitigation, the improvement and retrofitting of electricity grids, economic competitiveness and a secure and stable power supply. This goal can only be achieved through a pan-European effort.

Yet developing renewable energy sources will not be sufficient. Using such resources alters the geographical distribution of the producers and their interfaces with the consumer: While coal and gas power plants can be built close to the consumer, this is generally not possible for wind power and solar energy facilities. Only biogas plants offer greater flexibility with regard to location, as well as the additional benefit that, in principle, biogas can also be fed into the existing natural gas network.
By installing many new, small and widely distributed energy plants, a clear distinction between power consumers and power producers may no longer be feasible (Prosumer). New concepts for the integration of energy production, storage, distribution and consumption must be developed, and an adapted distribution power distribution network has to be built In areas such as energy storage and the low-loss transmission of electrical energy over long distances, there is a need for completely new solutions such as storage in geological, compressed-air reservoirs and the transmission of electricity via DC power lines. The development of these new technologies requires extensive basic research.

The Energy 2020[1] plan continues and reinforces the objectives and initiatives of the SET Plan, an EU strategy for a competitive, sustainable and secure energy supply that specifies five priorities and proposes specific actions to achieve these extremely important goals through a concerted European effort.
By implementing the SET plan, setting priorities and proposing concrete actions, the European Commission provides enhanced planning certainty for major industry and large research establishments and encourages the cooperation and inclusion of SMEs and smaller research institutes.

As a research organisation with established international connections, the Helmholtz Association very much welcomes this EU initiative and would like to make as extensive a contribution as possible towards achieving these goals within the framework of the Horizon 2020 programme. For example, the Helmholtz Association is the leading German partner in the "European Energy Research Alliance" (EERA)[2].
This is an initiative now comprising 150 European research organisations and universities with over 2000 researchers (FTE[3]) who wish to harmonise and coordinate their research projects in the area of energy research in the long term. This is an important step in coordinating national programmes efficiently and sustainably and to significantly accelerating research intensity. To translate new research findings more quickly into applications, close links and coordination with the European Industry Initiatives (EII) involving all member states are absolutely imperative.

The measures in Framework Programme 7 for promoting European research infrastructures (RIs) support the ESFRI process and the transnational use of RIs. Transnational access to RIs is of particular significance for realising a common European research area (ERA).
This is why widespread transnational access to relevant RIs must be expedited by means of a significant budget increase in Horizon 2020. This would benefit all EU member states because it would enhance the efficiency of the ERA and deliver significant added value for both basic and applied research and the training of young research scientists. In the field of energy research, major European research establishments are already performing very im-

1 European Commission, Communications of the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee for the Regions, „Energy 2020. A Strategy for Competitive, Sustainable and Secure Energy" COM(2010)639
2 http://www.eera-set.eu
3 Full-time equivalent

portant functions. Other initiatives such as MYHRRA[4] and EU-Solaris[5] are intended to provide European researchers in the near future with a shared infrastructure for the development of new technologies for nuclear waste reduction and "concentrated solar power "(CSP).
In addition to opening up new avenues for research, the major research establishments promote international, multidisciplinary networks through practical collaboration and the shared use of RI. A key example of this is the use of RI for investigating materials for energy technologies[6], an area of particular significance in the implementation of the SET plan.

The Helmholtz Association would like to emphasise that stable funding of nuclear fusion research is of the utmost importance to ensure a long-term, pan-European energy supply. The Helmholtz Alliance regrets the proposal of the European Commission in its draft of the Multiannual Financial Framework to discontinue EU funding for the ITER project. ITER is a key project to guarantee future energy supplies in Europe. The Helmholtz Association therefore strongly urges that funding for ITER should be continued through the EU budget.

Necessary measures

The most important measures for implementing the SET Plan and "Energy 2020" can be summarised as follows:

a. Systematic development and use of energy-saving potentiall
b. Demand-driven supply using inexpensive energy from renewable or low-CO_2 energy sources
c. Energy generation from fossil fuels in new kinds of power plants, combined with the capture and compression of CO_2 for injection into geological formations (CCS) or the recycling of CO_2 (CCR)
d. Efficient carbon-free and CO_2-neutral energy systems for mobile use
e. A shared smart European electricity supply network
f. Studies to support the preparation and implementation of measures to incorporate socioeconomic aspects as soon as possible into public consultation processes

These specific points will now be explored in more detail:

4 MYRRHA: Multi-purpose hybrid research reactor for high-tech applications http://myrrha.sckcen.be/
5 European Solar Research Infrastructure for Concentrating Solar Power, www.ctaer.com
6 European Commission, Commission Staff Working Paper „Materials Roadmap Enabling Low Carbon Energy Technologies" SEC(2011) 1609 final dated 13.12.2011

a. Systematic development and use of energy-saving potential

Regardless of the configuration of the future energy supply system, the development and exploitation of energy-saving potential is something that can be realised in a relatively short time, therefore enabling CO_2 greenhouse gas emissions to be reduced quickly and effectively. Effective solutions have to be found and widely adopted. This includes, for example retrofitting of insulation and modern heating or air-conditioning systems in residential buildings.
On the technical side, there is a need to develop flexible integration methods and new building materials and processes. From a political and economic perspective, it will be necessary to identify potential for decreasing energy use, provide a regulatory framework, created solutions for financing and organise large-scale implementation. The potential for CO_2 emission reduction is particularly high in this area because currently around 30% of the oil and gas consumed is used for heating buildings

- Exploiting the potential for energy conservation in production processes and logistics
- Realising the potential for energy saving in buildings by using high-quality building technologies combined with the production of electrical power in-house by means of photovoltaic systems or combined heat and power (CHP)
- Development of information and communications solutions (ICT) for local control of the production, storage and consumption of electrical power. This technology is sophisticated and therefore expensive, but could become cheaper through large-volume application and thus help to reduce transmission losses. Only by offering a usable, standardised concept over as much of Europe as possible can a critical mass be achieved for cost-efficient production.

b. Demand-driven supply using inexpensive energy from renewable or low-CO_2 energy sources

- Wind power

Wind power technology is highly advanced and is on the verge of a steep increase in capacity through the construction of off-shore wind parks. Ensuing disadvantages such as distance from consumers and lack of base load capability can be partially offset by refining storage technology and establishing modified supply grids.
In addition, there are many locations where wind power can also be generated close to consumers, although this option is subject to stricter constraints owing to the disruptive effects for those living nearby. The widespread use of wind power will require new developments in materials, s for example lightweight construction for wind turbines, as well as the development of high-performance storage technology.

- Photovoltaics

In recent years, great advances have also been made in photovoltaics. Across much of Europe, the cost of locally produced solar power is already equivalent to residential tariffs, making it attractive for private individuals to install solar panels, particularly in new residential buildings (even without government subsidies). In this context, it is also important to develop aesthetically pleasing solutions. This is where thin-film solar technology can make an important contribution, as it offers better opportunities for aesthetically pleasing integration in house facades.

However, the efficiency of thin-film solar panels is currently lower than that of crystalline cells. Thanks to intensive research efforts in recent years, it has been possible to reduce the gap between the two panel variants, and this gap will be eliminated altogether in the next few years as a result of on-going, intensive basic research. Solar power systems with the same output as wind power plants are still more expensive than the latter, although solar power systems are ideal for use close to consumers, and at certain times of day they can meet demand in the summer months. This makes them almost complementary to wind power.

To achieve widespread use of solar energy to meet domestic energy requirements, however, cheaper, simple, space-saving storage systems must still be developed for household use. Photovoltaics offer great potential for reducing costs, which is currently being exploited through the refinement of production technology. In the medium and long term, however, it will be necessary to further develop photovoltaic materials and device technology to reduce costs even more.

- Concentrated Solar Power

The CSP system is better suited to large solar power plants. In a CSP power plant, the electricity is generated by a steam turbine, as in a conventional power plant. The steam is generated by heating a medium through solar radiation. The heat thus generated can be stored temporarily in a large reservoir of molten salt, thus allowing for operations supplying base load. This technology is highly efficient and in no way inferior to that of conventional coal or oil-fired power plants.

Nevertheless, it does require intense solar radiation and the kind of large, flat land areas available in Mediterranean regions of Europe. International cooperation is therefore an indispensable prerequisite for exploiting solar energy in the arid regions of Europe for the benefit of the entire continent. This must be complemented by the development of technologies, particularly long-distance grids, to supply Europe's industrial centres and conurbations without transmission loss. To achieve this, research in the field of superconductors is important. The increased deployment of superconducting elements is a key method for reducing electrical distribution losses in the grid.

- Geothermal energy

In principle, geothermal energy plants could be built in wide areas of Europe and thus make an important contribution to local energy supply throughout Europe. The insights gained with this method to date must be tested and optimised in a pilot application in formations that are geologically as representative of Europe as possible. For the development of systems technologies, research on materials is important, for example because of the process-engineering requirements of handling large volumes of highly concentrated salt solutions.

To achieve wider use of geothermal technology in Europe, it is important to verify and, if necessary adapt the know-how gained across Europe in relevant geological formations. The aim is to reduce costs by means of standardised solutions and widespread application. Previous experience has shown that each individual initiative requires a detailed geological survey to evaluate the risks.

- Bioenergy

The upgrading of biomass into chemical energy is another option for a CO_2-neutral energy supply. During combustion, the same amount of CO_2 is released as that which the plants comprising the biomass originally consumed from the atmosphere through photosynthesis during growth. One of the challenges of this process is the efficient collection and transport of biomass to the reactor.

One solution proposed is an initial decentralised process stage to compact and reduce the weight of the biomass prior to transport to the large-scale plant. In addition to using energy crops, it is important to develop or make more efficient use of other material flows, such as waste and residues, for energy generation, as well as to use biomass both as an energy source and as a feedstock for base chemicals (polygeneration). A holistic approach in the interests of a bio-based economy should not only incorporate the technological aspects of efficiency improvement, but also consider the ecological and socioeconomic impacts of biomass as an energy source on a global scale.

Apart from the engineering aspects of optimising specific systems, there needs to be a sound understanding of the biochemical processes underpinning conversion. Further optimisation potential can be realised by applying microbiological insights to the process design and control of biogas facilities. In this context, the biogenic supply of electricity and bio methane represents a particular challenge, demanding both specific engineering and microbiological approaches in process design. Other interesting research approaches involve the recovery of energy and materials from microalgae in the field of synthetic biology and photobiological fuel production.

- Storage technologies

Important renewable energy sources such as wind and sun are only available under specific weather conditions or at specific times of the day and therefore do not lend themselves to base load.

It is therefore absolutely essential to develop various storage technologies to allow energy to be converted and stored at different time scales, with as little loss as possible, to ensure the include super capacitors or stationary battery storage, while over longer periods a suitable solution could be to convert to an energy carrier like hydrogen that is recovered by electrolysis through electricity produced from renewable sources. The move to renewable energy sources therefore calls for the development of innovative and inexpensive storage and conversion systems with high power density, high efficiency and high levels of reliability and security.

c. Energy generation from fossil fuels in new kinds of power plants, combined with the capture and compression of CO_2 for injection into geological formations (CCS) or the recycling of CO_2 (CCR)

For a transitional period it will still be necessary to generate electricity from fossil fuels. However, to protect the climate, the combustion product CO_2, generated during energy production will in future have to be filtered out of exhaust gases and isolated permanently from the atmosphere. The key steps required for this concept are the removal of the CO_2 from exhaust gases, followed by capture and transport, then sequestration in deep geological formations.
It will be necessary to investigate to what extent it is possible, from the point of view of energy and cost efficiency, to develop industrial-scale processes to recycle CO_2 (CCR). All steps involved call for extensive research and development, the results of which must be scalable for use in large power plants. Even the first stage, the separation of CO_2 from combustion products, can no longer be integrated economically by retrofitting existing power plants.
New processes have been developed and need to be integrated into new large-scale power plants and evaluated. Power plant technology and the introduction of CO_2 into geological formations are thus mutually dependent, industrial-scale technologies.
This huge development effort can only succeed if scientists and engineers from all European countries act together. A small pilot plant to inject CO_2 into deep geological formations is already operating in Germany. Apart from Germany, there are still comparatively extensive coal reserves particularly in east European countries. Collaboration, primarily with the countries in Eastern Europe, will be necessary to achieve these objectives and can be taken as an opportunity to accelerate their integration into the European Research Area (ERA).

d. Efficient carbon-free and CO_2-neutral energy systems for mobile use

Hydrocarbons supply an extremely high energy yield in relation to their net weight during combustion and are easy and safe to handle. This makes them an ideal energy source for mobile applications.
However, because of the shortage of hydrocarbon resources and the formation of CO_2 during combustion, this fuel should be replaced or produced using renewable energies, particularly if current levels of mass mobility and private transport are to be maintained. Three main approaches are currently being pursued:

- Storing energy recovered from sustainable energy sources in high-capacity lightweight batteries (lithium ion batteries
- Making electrical energy recovered from sustainable energy sources more readily transportable and usable by converting it to hydrogen via electrolysis. In a second step, using fuel cells to convert back to electricity on demand on board the vehicle
- Producing higher hydrocarbons through hydration of CO_2 using hydrogen (recovered from renewable energy sources) by means of innovative and highly efficient catalysts

The first method is especially suited to small vehicles with a shorter range, e.g. for use in cities. The second method based on hydrogen technology is especially suitable for heavy vehicles and long distances.
The further development of fuel cells calls for in-depth materials research to increase efficiency, reliability and duration of use to levels necessary for mass deployment (comparable with current vehicle technology).

In addition to the development of vehicles and components, providing the necessary infrastructure (battery changing and charging stations, hydrogen fuelling stations) will require extensive efforts and the rapid establishment of standards that can be quickly achieved only through pan-European cooperation.
In contrast, the use of biofuels or fuels recovered from CO_2 hydration allows the use of conventional combustion engines and the already available infrastructure for fuel supply.

e. A shared smart European electricity supply network

The European energy supply of the future will require the use of wind, solar, bio and geothermal energy as well as tidal power plants. These energy sources are not or not easily -as in case of bioenergy- transportable. This means that European geography and meteorology will have a major impact on the energy system of the future.
However, because of the fluctuations and locational constraints associated with wind and solar power, a stable energy supply will not be possible until there is a modified, trans-European network.
For example, in case of wind power oversupply, excessive power has to be stored in Norwegian pumped storage hydropower stations whereas in the case of no wind or little sun during the day, idling gas power plants have to be available. It is especially apparent here that many development opportunities can be exploited only through European collaboration and will remain beyond the reach of a single country, no matter how highly developed its technology.
For example, solar power from southern Europe and wind power from northern Europe are intended to be stored in northern Europe in huge reservoirs and supplied to the industrial centres of central Europe. New grids with integrated sensors and control functions (smart networks) must be built, while existing, reusable networks need to be upgraded. Ultimately, the low-loss, long-distance transmission of energy requires highly efficient DC power

lines across all of Europe. However, new methods of recovering and distributing energy will also create new economic and political opportunities for underdeveloped regions. For example, energy-intensive industries could ideally be concentrated in the future in the Mediterranean region near centres of solar power.

The restructuring of the European energy supply system towards the use of renewable energies reduces the current reliance of European countries on suppliers outside Europe and will replace these instead with a network of intra-Europe interdependencies. The production, storage and consumption of energy are distributed throughout all of Europe as a result of geographical and socioeconomic factors. Besides technical and scientific aspects, there are significant sociopolitical factors to be considered.
Europe's citizens will need to be informed and involved in political decision-making processes at an early stage. From an economic perspective, the development of markets must be supported by stable framework conditions for producers and consumers (also with respect to international patent law and liability issues, etc.).
To realise a European energy supply system from renewable energy sources, cooperation at international and pan-European level will always be necessary. It is in the interest of all nations to accelerate research and technological development as well as standardisation and market penetration of the solutions found. These are a prerequisite to achieving globally accepted climate policy objectives.

f. Studies to support the preparation and implementation of measures to incorporate socioeconomic aspects as soon as possible into public consultation processes

The Energy 2020 plan is highly challenging for research and technology. In addition to promoting cutting-edge RTD, implementation measures will have to cope with legal and political issues. Large-scale energy facilities like high-power transmission lines, wind parks, CCS facilities etc. will affect the daily life of citizens living in the vicinity. The realisation of a pan-European energy system depends not only on energy research and energy technologies, but also on the further development of key enabling technologies like materials research and nanoscience.
In addition, socioeconomic factors like demographic change, economic demand for and societal acceptance of new technologies will play an important role. To achieve a comprehensive view along the entire chain of energy production and consumption, all steps starting from exploration, exploitation, production, and storage to distribution to consumers must be studied in detail and in an appropriate context.
This is the only way to reach firm judgements on the ecological, economic, political, social and ethical effects of new technologies. Comprehensive scientific studies of these aspects will make a substantial contribution to political and economic decision-making processes.

The implementation of a new European energy system will require transparent, science-based judgements to achieve broad public acceptance. Engineers and economists will need to work together with social and political scientists using interdisciplinary approaches.
Experts from the Helmholtz Association have the necessary expertise and have already been carrying out complex studies for many years on the socioeconomic impacts of the proposed energy supply measures. The Helmholtz Association would like to continue to support public discussion on these issues with facts and figures in the future.

Brief profile of the Research Field ENERGY

The Helmholtz Association of German Research Centres is Germany's largest research organisation. The Helmholtz Association's strategic programmes in the research field Energy pool the expertise of eight major German research centres (German Aerospace Centre (DLR), Forschungszentrum Jülich, Helmholtz-Zentrum Berlin für Materialien und Energie, Karlsruhe Institute of Technology, Helmholtz-Zentrum Dresden-Rossendorf, Helmholtz Centre for Environmental Research - UFZ, Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, and the Max Planck Institute for Plasma Physics).
This collaboration makes use of large-scale research facilities to carry out multidisciplinary research, both basic and applied, as well as partnerships with industry partners, who thereby gain access to large-scale research infrastructures. Researchers from the Helmholtz centres have been working on strategic research programmes for many years in multi-disciplinary teams involving different institutions. This allows them not only to explore individual issues in depth, but also to develop comprehensive solutions for complex problems.
At the national level, synergies are realised through long-standing co-operations amongst the centres taking part in the Helmholtz research programmes. Some of these collaborations are complemented by specific projects or long-term collaborations with universities and industry.
Researchers in the Helmholtz Association investigate the entire chain of energy-related processes, taking into account conditions and side effects relating to climate change and ecological issues as well as issues surrounding public acceptance of research and technology. Interdisciplinary research in related fields such as resource technology, construction engineering and mobility engineering is another strong focus.
The Helmholtz energy research programmes target industrial applications and are therefore strongly linked to industrial activities and seeks to support German industry so that it can play a key role in the global refurbishment of the energy system. There is also a long tradition of European cooperation in the Helmholtz Association.
The Association is therefore seeking to continue its active participation in future European research programmes.

BRIEF PORTRAIT OF THE HELMHOLTZ ASSOCIATION

In the Helmholtz Association, 18 German research centres have joined forces to share their resources in strategically oriented programmes to investigate complex questions of societal, scientific and technological relevance.

They concentrate on six major research areas: energy; earth and environment; health; aeronautics, space and transport; key technologies and structure of matter. The scientists work closely together across the centres on these issues.

The Helmholtz Association provides the necessary resources, a framework for long-term planning, a high concentration of scientific competence and an outstanding scientific infrastructure with major projects, some of which are unique worldwide.

The research objectives of the Helmholtz Association are set by the funding bodies after discussions with the Helmholtz centres and the Helmholtz Senate and Assembly of Members. Within this framework, the scientists of the Helmholtz centres determine the themes of their research through strategic programmes in the six research areas across centres.

(Source: “Strategy of the Helmholtz Association,” Berlin 2009, updated 2012)

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Helmholtz Centres

- Alfred Wegener Institute for Polar und Marine Research
- Deutsches Elektronen-Synchrotron DESY
- German Cancer Research Center
- Deutsches Zentrum für Luft- und Raumfahrt
- Deutsches Zentrum für Neurodegenerative Erkrankungen
- Forschungszentrum Jülich
- GEOMAR | Helmholtz Centre for Ocean Research Kiel
- GSI Helmholtz Centre for Heavy Ion Research
- Helmholtz Centre Potsdam GFZ, German Research Centre for Geosciences
- Helmholtz Centre for Environmental Research – UFZ
- Helmholtz Centre for Infection Research
- Helmholtz-Zentrum Berlin für Materialien und Energie
- Helmholtz-Zentrum Dresden-Rossendorf (HZDR)
- Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research
- Helmholtz Zentrum München, German Research Center for Environmental Health
- Karlsruhe Institute of Technology
- Max Delbrueck Center for Molecular Medicine (MDC) Berlin-Buch
- Max Planck Institute for Plasma Physics (associated member)

This paper presents a consensus of the views
of the Helmholtz Association and its centres.

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