Major opportunities in the Research Field Energy in Europe

Position paper by the Helmholtz Association

a) Introduction

The availability of energy is central for healthy living conditions and economic development. Globally, one of the most important challenges of today and tomorrow is to provide safe, reliable, affordable, and environmentally friendly energy, as well as highly efficient technologies for its conversion and storage.

Climate change is the reason for the great urgency in rethinking the energy supply system and making it secure for the future. By burning fossil resources and implementing global deforestation, humankind has raised the CO2 level in the atmosphere by 45% compared to pre-industrial levels. To achieve the climate goals the industrialized countries in particular have to drastically reduce their CO2 emissions within the next 30 years, and renewable energy technologies have to be implemented globally. Therefore, international and especially European cooperation in energy research is a prerequisite for the future EU leadership in renewables as well as for a holistic, system integrational approach that should be integrated in FP9. The Helmholtz Association transfers this societal challenge into its research agenda and takes into account the whole value chain as well as societal acceptance.

b) Future Directions

The following four future Helmholtz research topics tackle grand challenges to ensure a secure energy system which should play an important role in the forthcoming European Research Framework Programme:

Energy System Design

deals with the energy system as a whole and covers those system aspects which connect the actors and energy carriers. This includes physical and IT connections, their struc-ture, and their operational behavior. The Helmholtz activities take also into account interfaces of the energy system with its environment, economy and society. Scientific questions from multi-dimen-sional assessment of energy technologies & energy systems, future of the energy supply and transformation processes on different scales, management of resource flows from primary resources to holistic recycling (“Circular Economy”), digitization of energy systems (Energy 4.0), grid structures and sector coupling, virtual & real research platforms, and safety & security aspects will be addressed.

Materials and Technologies for the Energy Transition

includes a variety of technological options, ranging from the scientific basics of disruptive innovations to the fast introduction of new techno-logies. Core activities will be on both the environmentally friendly production and the highly efficient storage of energy, simultaneously considering the economic feasibility of the energy supply. Questions related to material sciences are at the center of this technological development and allow innovative leaps in the respective energy technologies. The activities will have the following clusters: methods and fundamentals of materials science (computer-aided design, synthesis, and charac-terization), solar and wind energy technologies, electrochemical conversion and storage, chemical energy carriers and processes, high-temperature technologies and thermal storage, grid technolo-gies and superconductivity, energy and resource efficient technologies for a circular economy.

Fusion

has the potential to significantly contribute to meeting the globally rising demand for energy safely and without CO2 emissions. The central projects of international fusion research are ITER and Wendelstein 7-X. The ITER Tokamak will realize the world’s first burning fusion plasma. The Tokamak experiment ASDEX Upgrade in

Garching contributes to this aim with important developments. Wendelstein 7-X, the biggest and most important Stellarator in the world, has already gone into operation at Greifswald. The Fusion activities cover physics aspects, the development of new technology and materials, and building and operating fusion experiments. The planned Helmholtz topics are Tokamak physics, stellarator research, technologies & materials and plasma–wall interactions.

Nuclear Safety

Safety and security in terms of nuclear reactors, the management of nuclear waste incl. its deep geological disposal and the dismantling of nuclear facilities as well as the protection of the population constitute essential elements of the energy transition. The Helmholtz research approach in this field includes fundamental and applied research on safe nuclear disposal in deep geological repositories and contributes to the search and characterization of possible repositories with its expertise in radio-geochemistry and biogeochemistry. It investigates innovative disposal strategies for the decommissioning of nuclear facilities in Germany. Additionally, Helmholtz contributes to the advancement of the safety assessment for German and foreign nuclear power plants including new reactor concepts currently being developed. The considered research areas are reactor safety, repository research, safe decommissioning, waste treatment and conditioning, and long-term interim storage (pre-disposal research).

c) Missions for FP9 and new applications for materials in the SET-Plan

The Helmholtz Research Field Energy has identified two proposals for missions which we are convinced would have the potential to bring important benefits to citizens in terms of a European Energy transition. These missions have already been sent to the European Commission in 11/2017 and refer to the UN Sustainability Development Goals:

- *"Affordable, sustainable and clean energy supply"*
- *"Pan European Carbon-Neutral Energy System Design and Operation"*

(For further details please see our mission paper, updated March 2018.)

Further, the Helmholtz Research Field Energy suggests the preparation of an extension of the SET-plan with new material applications by means of EERA, e.g. energy efficient IT and quantum materials.

Activities are pursued at 8 Helmholtz Centres: *the Forschungszentrum Jülich (FZJ), German Aerospace Center (DLR), German Research Centre for Geosciences (GFZ), the Helmholtz Centre for Environmental Research (UFZ), Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Helmholtz-Zentrum Berlin für Materialien und Energie (HZB), Max Planck Institute for Plasma Physics (IPP) and the Karlsruhe Institute of Technology (KIT).*

Brief portrait of the Helmholtz Association

The Helmholtz Association contributes to solving major challenges facing society, science and the economy with top scientific achievements in six research fields: Energy; Earth and Environment; Health; Key Technologies; Matter; and Aeronautics, Space and Transport. With some 39,000 employees in 18 research centres and an annual budget of more than €4,5 billion, the Helmholtz Association is Germany's largest scientific organisation. Its work follows in the tradition of the great natural scientist Hermann von Helmholtz (1821-1894).

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