Joint Proposal for Cooperation in Energy Research
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Introduction

The transition of energy supply towards a sustainable energy system in terms of climate and environmental quality, as well as security of supply and economic competitiveness, is one of the major challenges today on a global level as well as for the individual countries. The scale of this challenge calls for both social innovation and technological innovation. Science and research are central to this process. Without scientific expertise, a new energy era is simply inconceivable.

Though starting from currently different supply portfolios, especially in the electricity sector, from a structural point of view, France and Germany share common ground regarding the requirements of energy transition. A long-standing and strong cooperation culture in energy research is reflected in numerous collaboration projects and partnerships (see annex 1). The strong and in many cases synergetic academic and research landscapes within the two countries are optimally suited to cooperate in order to meet the innovation challenges the future energy system is facing.

In concordance with the overall objectives of the 5th Franco-German Forum for Cooperation in Research, the goal of this paper is to identify common objectives and to create bilateral research activities with a strategic impact on energy transition. Based on proposals from the expert pool of the Franco-German Energy Working Group, thematic priorities within the energy research fields to be tackled by a joint Franco-German research approach have been identified as follows:

- Energy Materials
- Energy Storage
- Smart Grids at Transmission and Distribution Levels
- Nuclear Safety and Waste Management
- Socio-economic Dimensions of Energy Transition

Energy Materials

Energy technologies are dependent on suitable materials, both structural and functional. Whereas structural materials are of major importance for fossil power plants as well as wind energy, functional materials are decisive for the fields of PV, fuel cells, batteries, hydrogen production etc. In particular, they are crucial to electrochemical and catalytic processes for energy conversion. Development of suitable materials and novel catalysts (not based on critical chemical elements or noble metals) is required for the following fields:

- Next-generation fuel cells (for instance polymer electrolyte fuel cells and solid oxide fuel cells), provided that degradation mechanisms in materials and at interfaces are understood and overcome.
- Emerging co-electrolysis technology takes advantage of the thermal energy provided by power plants or industrial heat sources coupled with excess renewable electricity (power to gas as an energy carrier). Again, advanced catalysts and optimized stable electrodes are required to achieve efficient, low-cost, high-temperature electrolysers under dynamic, fluctuating operation.

- Proton exchange or ceramic-based membrane reactors are particularly interesting when using waste liquids or gases containing carbon that can result in the production of high-value chemicals at low cost. The energy and resource efficiency of chemical processes could therefore be significantly improved.

<u>Energy Storage:</u> Batteries and Electrolysers/Fuel Cells

Energy storage is a fundamental issue especially with respect to the large and rapid deployment of renewable energies within the electrical grid. It can provide various grid services such as balancing electricity demand and supply, deferring some grid investments, providing local grid support or contributing to competitive and secure electricity supply. The development of electrochemical storage systems and energy conversion, i.e. batteries and electrolysers/fuel cells, requires efficient processes for massive (e.g. redox flow batteries) as well as distributed storage for autonomous and/or isolated applications. The latter applications are considered particularly when the energy supply is obtained from a combination of intermittent renewable energy (PV and wind) generation and local storage in the form of batteries and/or hydrogen production/storage for further use with e.g. fuel cells. Such type of combination will also strengthen the concept of energy autonomy. On the other hand, the field of electrical mobility is also related to the energy storage issue, but with different challenges.

The expected scientific and technological breakthroughs deal with:

- Improvement of system components such as a new generation of battery components as well as fuel cell components.
- Improvement of energy density and cycle stability.
- Such improvements may take into account safety issues, optimizing production processes, operation management.

<u>Smart Grids at Transmission and Distribution Levels</u>

EU transmission and distribution grids are undergoing tremendous changes driven by the current concern on energy transition and the link to security of supply, sustainable development, and economic growth. As such, a large number of research challenges and scientific gaps need to be addressed with regard to smart transmission grids as well as smart distribution grids.

With respect to smart transmission grids, common research priorities include:

- Preventive and curative security tools of the interconnected grid with large renewable energy systems (RES) contributions, including storage integration.
- New tools for planning and developing infrastructures including a new generation of HVDC grids and new AC substation concepts.
- Understanding the interaction between transmission and distribution grids in the context of large distributed generation (DG) penetration with uncertain power output and demand-side management.

With respect to smart distribution grids, priorities include:

- Local (distribution grids) energy loop optimization including local virtual power plant operations with the development of smart combined integration of PHEV, RES, storage and load control for optimal operation and planning.
- Investigation of embedding distributed intelligence in both MV and LV grids with high penetration of DG, including smart substations, self-healing and smart protections, new semiconductor materials (e.g. GaN and SiC) and coupled DC/AC architectures.
- Understanding the impact and the requirements of ICT technologies to manage the energy flow in the distribution system.
- Operation and planning under uncertainties.

Nuclear Safety and Waste Management

Research in the field of nuclear safety is of utmost importance for the safe operation of nuclear installations, their safe decommissioning as well as the waste disposal of high-level nuclear wastes. A major effort is needed to involve a new generation of scientists in these fields. Germany and France are aiming to support the exchange of scientists and, in particular, common research projects of young investigator groups in the field of research for nuclear safety and waste management. This approach ensures that in future both countries will have experts and sufficient knowledge to be able to assess and guarantee nuclear safety and waste management. Specific fields of research of these young investigator groups may include:

- Chemistry of actinides with respect to clay and salt environment (source term, transport, retention) based on modern state-of-the-art methods.
- Development of innovative decommissioning techniques for highly irradiated parts of nuclear installations, characterization of waste packages, tailored waste management concepts as well as a vitrification process for high-level nuclear wastes.

Socio-economic Dimensions in the Transition Towards a Sustainable Energy System

The transition to a clean energy economy requires not only technological research and innovations. The scale of this transition demands broad consensus in society. The ability to link technology issues with economic and social concerns will be central to the success of implementing new technologies. This calls for both social innovation and technological ingenuity. Energy transition and the resulting technology evolution will require socio-economic changes, accompanying policies and instruments analysis at various levels: end-user as a "*prosumer*", social acceptance of technological pathways, technology diffusion, techno-economic scenarios and prospective analysis, macro-economic assessment and new business models. The main corresponding research axes can be categorized as follows:

- Transition strategies will combine demand reduction and the supply of decarbonized electricity/energy (focus on France and Germany in a European context). Techno-economic scenarios (based on modelling) have to take into account major enablers such as: energy efficiency and demand flexibility, smart grids, transmission grids/interconnectors, decentralized renewables and storage technologies. The objective is to identify common and critical issues for both countries in cooperation and enhance the models and tools used in foresight studies.
- Assessment of energy transition scenarios focussing on macro-economic impacts (employment, growth, competitive position of industries and the social dimension) and environmental impacts, including possible externalities.

- Innovation and industrial strategies for the transition, triggered in new markets by public policy instruments and private initiatives: evaluation and design of policy options and incentive systems (tax, quotas, standards) to support an economically efficient and socially acceptable transition process.
- Methods, tools and approaches that aim to involve the public in decision-making processes and to enable scientists to incorporate central questions and the needs of stakeholders, the civil public and the economy concerning energy technology innovations from the beginning (i.e. at the basic research stage). This may focus on: i. power-generation-related technologies such as renewable sources ii. new demand technologies such as electric cars, iii. efficiency technologies for low or zero-energy buildings, efficient appliances, industrial processes iv. system innovations for smart grids and transport.

About this Proposal:

This note has been prepared by the Franco-German Working Group on Energy in preparation for the 5th Franco-German Forum for Cooperation in Research in consultation with BMBF and MESR.

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Annex:
French-German Cooperation in Energy Research – An Overview (June 2014)[1]

German and French institutions are already cooperating intensively in energy research. This is for example reflected in more than 130 projects on energy research under FP7 in which both countries were or are still participating as partners. A number of joint projects are listed hereinafter.

In the field of energy, the cooperation between Germany and France so far mainly covered the following overarching research fields:

- Efficient use of fossil energy sources
- Development and optimization of new technologies in the area of renewables, energy storage and distribution energy efficiency (including policy analysis and design for a faster penetration of these technologies)
- Increasing the safety of nuclear energy
- Making fusion energy available as a safe and clean energy source

A. Framework for cooperation in energy research (in general)

2007 **Agreement between CEA and the Helmholtz Association** on cooperation in energy and climate research

2008 Foundation of the **European Energy Research Alliance (EERA)** to accelerate the development of new energy technologies through joint research programmes (JPs). CEA and the Helmholtz Association play a leading role in this alliance. Since its foundation, 15 research programmes (e.g. JP AMPEA or JP Fuel cells and hydrogen) have been launched involving a total of 2,700 researchers from more than 150 partner organizations.[2]

German partners: DLR, FHG, HZDR, FZJ, GFZ, HZB, HZG, KIT, LIAG/Leibniz, RWTH Aachen, ZSW, University of Münster

French partners: CEA, BRGM, CNRS, IFPEN, IFREMER, INRA, University of Lorraine

2009 Creation of **KIC InnoEnergy**, a Knowledge and Innovation Community for energy research that was created under the leadership of the European Institute of Innovation and Technology (EIT). KIC InnoEnergy unites 27 shareholders.[3]

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[1] Basis of this document: German Federal Ministry of Education and Research (BMBF) and French Ministry of Higher Education and Research (MESR), March 2013: "50 Jahre Deutsch-Französische Zusammenarbeit in Forschung, Technologie und Innovation" (50 years of German-French cooperation in research, technology, and innovation), pp. 130–139.
and http://cordis.europa.eu/fp7/projects_en.html

[2] http://www.eera-set.eu

[3] http://eit.europa.eu/eit-community/kic-innoenergy and http://www.kic-innoenergy.com

German partners: ENBW, University of Stuttgart, Karlsruhe Institute of Technology (KIT), in cooperation with FhG, Steinbeis-Europa-Zentrum

French partners: AREVA, CEA, Grenoble INP, Grenoble Ecole de Management

In 2014, 5 EERA Integrated Research Programmes (IRPs) will be launched under the Seventh Framework Agreement. Germany and France are partners in the following four: ELECTRA, CHEETAH, STAGE-STE and MATISSE (for details, see cooperation by topic).

B. Cooperation classified by topic

1. Renewable energies

- **Alpha Ventus** pilot projects (launched in 2009): German and French companies develop offshore wind farms (Fraunhofer IWES, Ifremer)[4].
- **BioTfuel** collaboration (2010–2020): Companies ThyssenKrupp Uhde, Axens, Sofiprotéol, IFP Energies Nouvelles, and Total collaborate with CEA on second-generation fuels from biomass.[5]
- **CORE-JetFuel**: Coordinating research and innovation of jet and other sustainable aviation fuel (FP7-Transport, 2013–2016)

German partners: Fachagentur Nachwachsende Rohstoffe e.V., Bauhaus Luftfahrt e.V., Wirtschaft und Infrastruktur GmbH & Co Planungs KG

French partners: IFPEN, EADS

- **SoPhia**: PhotoVoltaic European Research Infrastructure (FP7-Infrastructures, 2011–2014): 20 European partners jointly develop new technologies and materials for solar cells.[6]

German partners: Fraunhofer ISE and IWES, HZB, FZJ

French partners: CEA-INES

- **STAGE-STE (CSP)**: Scientific and Technological Alliance for Guaranteeing the European Excellence in Concentrating Solar Thermal Energy (based on JP Concentrated Solar Power, FP7-Energy, EERA-IRP, 2014–2018)[7]

German partners: Fraunhofer ISE, DLR, SCHOTT SOLAR CSP GMBH

French partners: CNRS, CEA

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4 http://rave.iwes.fraunhofer.de/rave/pages/welcome

5 http://total.com/en/energies-expertise/renewable-energies/biomass/projects-achievements/biotfuel

6 http://www.sophia-ri.eu/home/
7 http://www.stage-ste.eu/index.php

- **CHEETAH**: Cost-reduction through material optimization and Higher EnErgy outpuT of solAr pHotovoltaic modules – joining Europe's research and development efforts in support of its PV industry (FP7-Energy, EERA-IRP, 2014-2017)

German Partner: Fraunhofer ISE, FZJ, HZB, ZSW

French partners: CEA

- **European Alliance SolLab** (2004–2013, extended by 4 years in 2014): CIEMAT (Spain), ETH (Switzerland), and PSI (Switzerland) work together with CNRS-PROMES and DLR on optimizing the construction of and components for solar thermal plants and thermal storage systems.[8]
- **Geothermal electricity generation in Soultz-sous-Forêts** (test operation since 2008): German and French partners built a demonstration plant in Soultz-sous-Forêts to generate electricity from geothermal heat by means of deep drilling.

German partners: BMU, BGR, ENBW, Steag, Pfalzwerke, Bestec, KIT, EIFER, GTC

French partners: ADEME, EIE, University of Strasbourg, CNRS, BRGM, EDF, and Électricité de Strasbourg

- **CO2GeoNet and GEISER project**: Research projects on CO_2 storage at a demonstration plant in Ketzin (CO2GeoNet, FP6-SUSTDEV, 2004–2009, non-profit scientific association since 2008)[9] and on seismic activities associated with deep geothermal drilling such as the GEISER project (Geothermal engineering integrating mitigation of induced seismicity in reservoirs, FP7-Energy, 2010–2013)[10] were conducted on a joint basis.

German partners: GFZ

French partners: BRGM, IFPEN (CO2GeoNet), ARMINES (GEISER)

2. Hydrogen

- **SOLARH2**: European solar-fuel initiative – renewable hydrogen from sun and water; science linking molecular biomimetics and genetics (FP7-Energy, 2008–2012)[11]

German partners: MPIBAC, FU Berlin, Ruhr-Universität Bochum, Bielefeld University

French partners: CEA Saclay, CEA Cadarache, CNRS

- **Fuel Cells and Hydrogen Joint Technology Initiative** (JTI, FP7, 2008–2017): Public research institutions such as DLR and CEA work with partners from industry (Air Liquide, Daimler) in a joint technology initiative to advance the development of hydrogen technologies and fuel cells. Although a number of countries are involved in this partnership, Germany and France were the driving force behind its creation.[12]

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8 http://www.sollab.eu/index.html
9 http://www.co2geonet.com/Default.aspx?section=265
10 http://www.geiser-fp7.fr
11 http://www.fotomol.uu.se/Forskning/Biomimetics/solarh2/Solarh2.shtm
12 http://www.fch-ju.eu

- Furthermore, researchers from DLR and CNRS have developed nanocomposites for hydrogen storage. DLR, CEA, and industry are working on key components for hydrogen production as well as on fuel cells.

3. Nuclear safety

- Germany and France have collaborated on a European level on **fourth-generation nuclear reactors** (**ESFR, HPLWR, LEADER, GoFastR**), on **severe accident research (SARNET2, SAFEST),** on **materials research** (**GETMAT, MATTER**), on **nuclear incidents** (**PWR, ARNET**), on the **conversion (transmutation) of long-lived radioactive waste** (**EUROTRANS**), and on **actinide science (ACTINET, SACSESS**).
- **MATISSE**: Materials, Innovations for a Safe and Sustainable nuclear in Europe (Joint Programme on Nuclear Materials (JPNM), EERA-IRP, 2013-2017).
- German partners: University Stuttgart, KIT, FZJ, HZDR
- French partners: CEA, CRNS, EDF
- KIT and CEA conduct formalized joint research on reactor safety and waste management under a Framework Cooperation Agreement.
- FZJ and CEA, in conjunction with France's National Radioactive Waste Management Agency (ANDRA), work on methods of detecting toxic elements in radioactive waste as well as on concepts for safe waste management.

In 2013, a framework agreement between FZJ and CEA was extended by a further five years. Cooperation activities cover a wide range of topics. The cooperation between Dr. Mauerhofer (FZJ) and Dr. Perot and Dr. Carasco (both CEA) on "radioactive waste characterization by neutron activation" warrants special mention here.

- Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) in Germany and IRSN in France collaborate in the area of reactor safety.
- Helmholtz-Zentrum Dresden-Rossendorf operates the TOPFLOW research facility (Transient Two Phase Flow Test Facility) with the aim of investigating flow phenomena in collaboration with partners from France and Switzerland.

4. Nuclear fusion

- Cooperation between CEA and the Helmholtz centres (IPP, FZJ, KIT) is primarily associated with large-scale experiments such as **Tore Supra** in Cadarache or **ASDEX-U** at IPP in Garching.

In the course of the past ten years, the two countries were involved in the joint decision to construct the **ITER** experimental reactor in Cadarache. In addition, CEA was involved in the construction of the superconducting stellarator **Wendelstein 7-X** at IPP in Greifswald.

- **FUSION-CA**: Fusion Energy Materials Science – Coordination Action (FP7-EURATOM-FUSION, 2008–2011). 27 European institutions have joined together in the FEMaS-CA to advance fusion materials science in Europe and in close cooperation with EFDA, the European Fusion Development Agreement.[13]

[13] http://www.femas-ca.eu/main/main.php

German partners: MPG, TU München, FZJ, HZB, KIT

French partners: CEA, Installation européenne de rayonnement synchrotron

5. CO_2 capture and storage technologies

- **SUCCESS**: Industrial steam generation with 100% carbon capture and insignificant efficiency penalty – Scale-Up of oxygen Carrier for Chemical-looping combustion using Environmentally SuStainable materials (FP7-Energy, 2013–2017)

German partners: TU Darmstadt

French partners: IFPEN, Institut Nat. Polytechnique Toulouse, EDF, Total

- **FORUM-AE**: FORUM on Aviation and Emissions (FP7-Transport, 2013–2017). The FORUM-AE coordination action will create a technical specialists European network with all relevant competencies, including academic and industrial partners, linked to key environmental technical issues on aviation emissions.

German partners: DLR, Deutsche Lufthansa AG, Rolls Royce Deutschland

French partners: IFPEN, SNECMA, Airbus, ONREA

6. Smart energy networks

- **ELECTRA**: European Liaison on Electricity Committed Towards long-term Research Activity (FP7, EERA-IRP, 2014–2017): The ELECTRA Integrated Research Programme on Smart Grids brings together the partners of the EERA Joint Programme on Smart Grids (JP SG) to reinforce and accelerate Europe's medium- to long-term research cooperation in this area.[14]

German partners: Fraunhofer IWES

French partners: CEA

- **DREAM**: **Distributed Renewable resources Exploitation in electric grids through Advanced heterarchical Management (FP7-Energy, 2013–2016)**

German partners: University Kassel

French partners: Institut Polytechnique de Grenoble, Electricité de Strasbourg

- **evolvDSO**: Development of methodologies and tools for new and evolving DSO (distribution system operator) roles for efficient DRES (distributed renewable energy sources) integration in distribution networks (FP7-Energy, 2013–2016)

German partners: RWE Deutschland Aktiengesellschaft, RWTH Aachen

French partners: Institut Polytechnique de Grenoble, Energy Pool Développement SAS, Electricité Réseau Distribution France, RTE Réseau de Transport d'Electricité SA

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[14] http://www.electrairp.eu/index.php

- **ELECON**: Electricity Consumption Analysis to Promote Energy Efficiency Considering Demand Response and Non-technical Losses (FP7-People-2012-IRSES, 2012–2016)

German partners: Otto-von-Guericke-Universität Magdeburg

French partners: Institut polytechnique de Grenoble

- **AlpEnergy**: Virtual Power Systems as an Instrument to Promote Transnational Cooperation and Sustainable Energy Supply in the Alpine Space (2007–2011)

German partners: Allgäu Initiative GbR, B.A.U.M. Consult GmbH

French partners: Grenoble INP/G2ELAB, Rhônalpénergie-Environnement

- **FINESCE**: Future INternEt Smart Utility ServiCEs (FP7-ICT, 2013–2015)

German partners: Ericsson GmbH, RWTH Aachen, Forschungsinstitut für Rationalisierung, B.A.U.M. Consult GmbH, Alcatel-Lucent Deutschland AG, QSC AG

French partners: Institut Polytechnique de Grenoble

- **FINSENY**: Future INternet for Smart ENergY (FP7-ICT, 2011–2013)

German partners: Nokia Siemens Networks GmbH & Co KG, Ericsson GmbH, Forschungsinstitut für Rationalisierung, Siemens AG, ABB AG, Alcatel-Lucent Deutschland AG, Stadtwerke Aachen Aktiengesellschaft, RWTH Aachen, B.A.U.M. Consult GmbH, SAP AG, VDE Verband der Elektrotechnik Elektronik Informationstechnik e.V.

French partners: France Telecom SA, Thales Communications & Security SA, Electricité de France S.A., Institut Polytechnique de Grenoble

- **eHighway 2050:** Modular development plan of the Pan-European transmission system at the 2050 time horizon (FP7-Energy, 2012-2015)

German partners: Amprion, DENA (Deutsche Energie-Agentur), 50Hertz, TU Berlin

French partners: RTE Réseau de Transport d'Electricité SA, Technofi

7. Energy Policy, Innovation research

- **Odyssee-MURE project**: Monitoring tools for European energy efficiency developments and policies in all European Member States and Norway (FP7-Energy, 2013–2015) see www.odyssee-mure.eu

German partner: FHG ISI (Technical coordinator)

French partners: ADEME (Project coordinator)

- **PACT project** (Pathways to Carbon Transition): The project investigated energy demand, and how this should evolve towards post-carbon concept, from the infrastructures viewpoint, in relation to urbanisation and land-use schemes, and that of the life-styles and behaviours, in relation to the available technologies. (FP7-Energy, 2008–2011) see www.pact-carbon-transition.org

German partner: FHG ISI, MPG Institute for Plasma Physics

French partners: ENERDATA (Project coordinator), EDDEN/UPMF Grenoble, Arcelor Mittal

- **European Techno-Economic Policy Support Network (ETEPS), previously European Science and Technology Observatory ESTO**: Network of research organisations in the field of policy support. (IPTS, three framework contracts since 2006) see www.eteps.net

German partner: FHG ISI, KIT ITAS, VDI Technologiezentrum

French partners: Technopolis, INRA GAEL