Superconductivity and Energy

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CERN

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- Activities of Carlo as **Scientific Director** at the **Institute** for **Advanced Sustainability Studies** (**IASS,** today RIFS) in Potsdam (Germany), from 2010 till 2015
- Goal: to **develop the energy strategy for the future** and create a **new global concept for sustainable energy**
- **Earth, Energy and Environment (E^3):** exploration of innovative scientific and technological pathways for transforming the current energy system. Reconciling economic growth with the threat of climatic instability via a **coherent energy policy** based on truly **innovative scientific and technological developments.** Promote and shape societal change processes towards **sustainability**

Origin of the IASS Institute

- Idea for the creation of **IASS** born in **2007** at the **Potsdam Nobel Laureate Symposium "Global Sustainability – A Nobel Cause"**
- The symposium brought together leading researchers and decision-makers and resulted in the publication of the widely regarded **Potsdam Memorandum**, which called for a concerted effort to **tap into "all sources of ingenuity" to address the challenges of the twenty-first century.** It placed the **challenge of climate change and energy security in the context of sustainable development**
- The memorandum urged the establishment of a new **"global contract" between science and society** to bring together relevant knowledge within and beyond the science system to **meet challenges to sustainability arising in the Anthropocene**
- Better connect knowledge generation to decision-makers and the broader public, in order to **translate research findings into transformation processes**

Creation of the IASS Institute

- The Institute for Advanced Sustainability Studies (IASS) was hence created and **Carlo**, who had been one of the major players at the Symposium, was appointed as its **Scientific Director**
- The **IASS** was **legally established in 2009** and its mission defined in the course of a period of **two years**, during which the **Institute was literally built up from square zero**
- The IASS which was started with an **initial number of 20 Fellows in 2011** and has **today** a research contingency of **more than 150 Fellows** from **33 nationalities**
- **More than 40 Workshops** were organized in Carlo's E^3 Cluster

Carlo at IASS

A Wide Research Program

Earth, Energy and Environment (E^3) Cluster at IASS

1. Energy production from fossils without CO_2 emission

CH_4 cracking to separate H_2 and C: a gap bridging technology enabling use of natural gas while safeguarding the climate and facilitating the integration of a clean energy carrier

Novel reactor design proposed by Carlo and **based on liquid metal technology**. Experimental campaigns at KIT from 2012 to 2015

Innovation Prize of the German Gas Industry Association, Berlin, December 2018 for the methane pyrolysis concept which splits methane into H_2 and CO_2, thus producing environmentally friendly hydrogen. **Methane cracking: a candidate option in the portfolio of measures to transform the energy system**

KIT Karlsruher Institut für Technologie | IASS POTSDAM | KITT / IASS Producing CO_2-free hydrogen from natural gas for energy usage

The **2018 German Gas Industry Innovation Award**, the **KIT** and **IASS** team (Photo: Claudius Pflug)

A Wide Research Program

Earth, Energy and Environment (E^3) Cluster at IASS

2. Advanced concepts for **concentrating solar energy systems**

Improvement of Concentrated Solar Power technologies and development of a heat storage system to compensate for solar power's inherent intermittency. An important co-operation project was launched with Chile

3. **Recovery of CO_2** to generate a liquid substitute to oil (the methanol economy)

Recycling CO_2 for the synthesis of methanol fuel and transforming CO_2 from a liability into an asset. Combined with hydrogen from methane cracking, the whole cycle could become carbon neutral

A Wide Research Program

Earth, Energy and Environment (E^3) Cluster at IASS

4. Properties of **methane clathrates**

Clathrate: the largest **untapped reserve of natural gas** on the crust. A solid compound in which a large amount of methane is trapped within a crystal structure of water, forming a solid similar to ice

5. **Superconductivity** for energy transport **through very long distances**

Deployment of renewable electricity generation cannot occur without a **renewed investment in the transmission infrastructure**

Superconducting Transmission

- **Renewable energies** are often located **far away** from densely populated areas
- Ordinary **AC lines** at different voltage do not permit to exceed economically distances in excess of **600 - 800 km**. **Beyond these distances** the technology of **very high voltage (≈ 800 kV) DC electric lines** is increasingly used. These are massive towers covering distance of up to ~ 3000 km
- Electrical energy over extremely long distance **HVDC Superconducting Lines**: almost zero electric losses
- Use of **MgB_2 superconductor** cooled by **liquid hydrogen**

IASS Brainstorming Workshop

Kleist-Villa, Potsdam, Germany, May 2011

Collaboration Agreement CERN/IASS

Signature of the Collaboration agreement between CERN and IASS on High Current, Long Distance Superconducting Power Transmission Lines, **March 2012**

Kick-off Meeting of the Advisory Committee on Superconductivity

World-record current in a superconductor

April 2014, CERN Bulletin

20 kA @ 20 K, MgB_2

innovative transmission line for long-distance transport of green power

Nobel Laureate and IASS Scientific Director Carlo Rubbia commented on this result: "***This is really a breakthrough. For the first time****, we have a real cable which offers a* ***practical way of transporting large amounts electricity*** *over long distances, using a simple configuration and* ***cheap, widely available materials***". The experiment, which was the first of its kind, took place in the laboratories of CERN in
the framework of an **IASS-CERN collaboration**

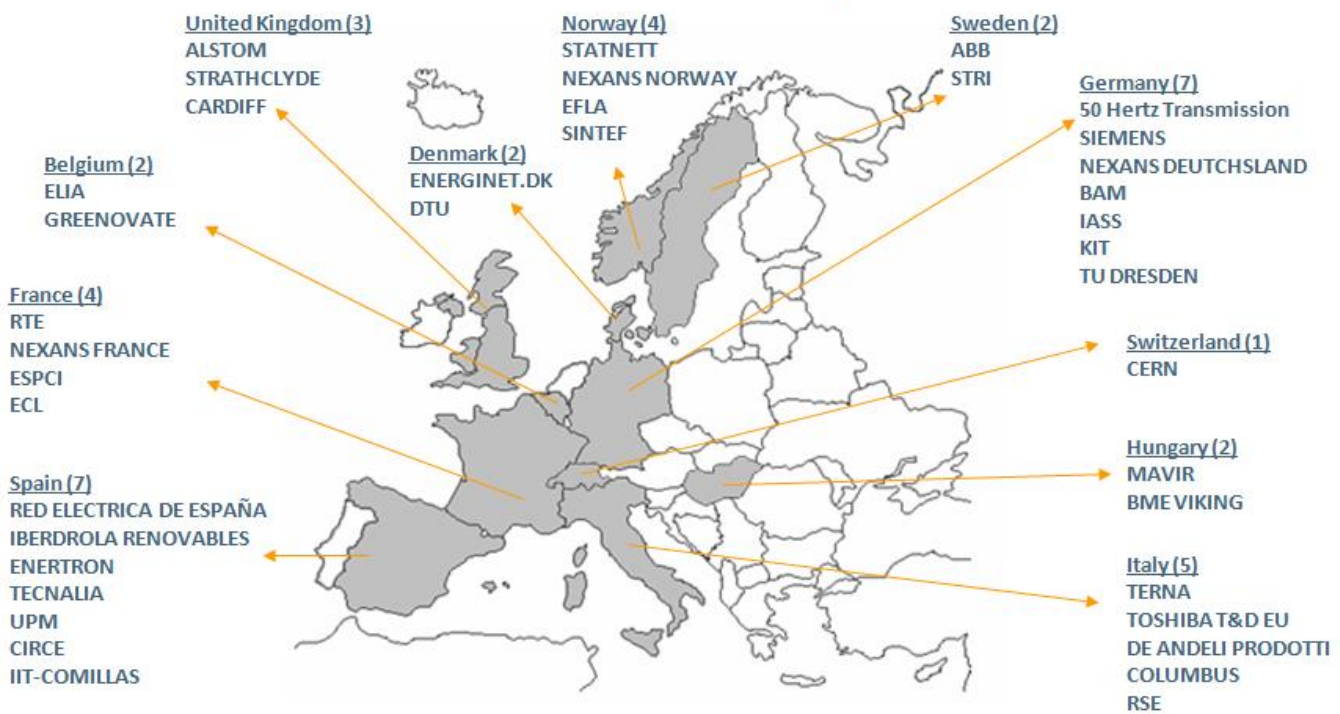
Synergy with Transmission Line development for HL-LHC

https://cds.cern.ch/journal/CERNBulletin/2014/16/News%20Articles/1693853

The BestPaths EU Project

BEyond **S**tate-of-the-art **T**echnologies for re**P**owering **a**c corridors and multi-**T**erminal **H**VDC **S**ystems

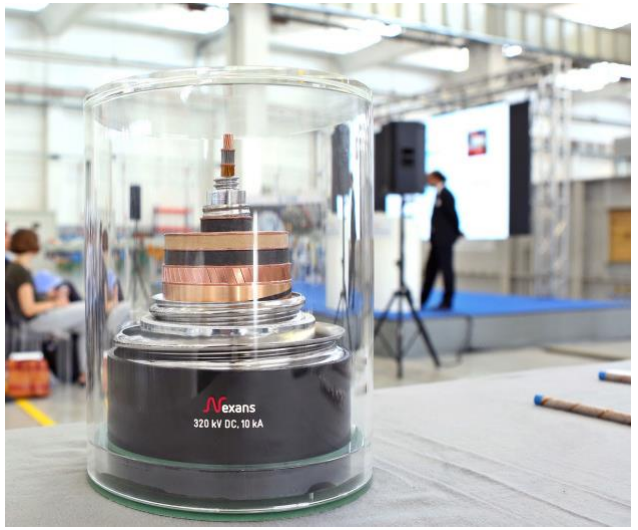
Best TRANSMISSION FOR SUSTAINABILITY Paths



The BestPaths Project

10 kA @ 20 K, 320 kV, MgB_2 monopole cable, 3.2

Together with **transmission system operators**, [GW]**ners from industry and science** presented the results of ground-breaking research on a superconducting cable system at an International Workshop in La Spezia, Italy



July 2016, La Spezia, Italy

RTE - France's Transmission System Operator

IASS Scientific Director Prof. Carlo Rubbia and Olivier Grabette, R&D and Innovation Director RTE

RTE's strategic objectives include integrating **40% of renewable energy** into the system and finding the **technological breakthroughs that will shape the electricity grid of the future**. In this respect, a broad identity of views was reached regarding the future prospects of superconducting lines. Superconducting lines: transport of an **enormous amount of electrical energy** in remarkably **narrows corridor**

50 years of French-German scientific cooperation

French-German conference themed "Technology for the Future", organized by KIT to celebrate the 50th anniversary of the Élysée Treaty between France and Germany. Guest speakers Prof. Rubbia, Prof. Joachim Sauer from Humboldt University, and Prof. Gabriel Chardin from the French National Center for Scientific Research (CNRS)

Even higher current: 120 kA DC

CERN HL-LHC Recent Achievement

MgB_2, 120 kA @ 20 K

Complete System Solution

The Team

“Only with dreams we can develop the way of the future”

“Fatti non foste a viver come Bruti
Ma per seguir virtude e conoscenza”