E *H* zürich

Energy Science Center

Annual Report 2016

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Energy Science Center | Annual Report 2016

Bridging research, education and outreach across different departments and research fields to answer the energy challenges of today and tomorrow

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Dear Colleagues and Partners,

2016 has been an eventful year for the Energy Science Center (ESC) at the ETH. We are happy to report on our core activities in research, education, and outreach.

First and foremost, we would like to thank our members for their participation, collaboration and continuous support. We are also delighted to announce that five new members joined us and look forward to fruitful joint collaborations. The new ESC members are: Prof. Guillaume Habert, Prof. Maryam Kamgarpour, Prof. Melanie Zeilinger, Prof. Stefan Wiemer, and Prof. Daniel Farinotti, bringing us to a total of 70 members from 11 departments.

In research, the ESC has continued its role as a management entity of its four large interdisciplinary research projects that were initiated.

Our contribution in education has continued the success of the interdisciplinary Master programme in Energy Science and Technology (MEST), and has resulted in attracting a high number of excellent students as well as contributed to strengthening the relationships among current students.

Further, we are very pleased to see that our community is growing continuously and our international outreach is flourishing. The two largest events we organised in 2016, were "Energy Futures – Europe and North America", a joint symposium with MIT Energy Initiative, and "Energiespeicher der Zukunft", both of which had large audiences and productive discussions among the key players of the energy sector.

We are looking forward to 2017 and predict another intense year on our mission towards a sustainable energy system.

Marco Mazzotti Chair Christian Schaffner Executive Director

The Energy Science Center

A sustainable energy system is one of the are needed, relying on the expertise and most complex challenges that humankind cross-cutting research of engineering, is facing. Such an energy system must be economic and social scientists. it must also relieve the strain on the natural 2005 as an interdepartmental competence environment and not compete with the basic center to facilitate energy research and sustainability vision should be responsive and departments. to the central challenges facing the energy http://www.esc.ethz.ch \rightarrow system. These are: climate change, access The Research Center for Energy Networks to energy services, local pollutants, risks (Forschungsstelle Energienetze – FEN) is and benefits to society.

To build such a sustainable energy system http://www.fen.ethz.ch \rightarrow additional knowledge and new technologies

viable given the limited available resources; The ESC of ETH Zurich was founded in needs of the world's population. A plausible teaching activities across research fields

affiliated with the Energy Science Center.

Organisational Structure

The General Assembly, containing the ESC members, is the ESC governing body. Currently seventy professors from eleven different departments are members of the ESC.

The Managing Board is the executive body of the ESC and is composed of six members elected by the General Assembly. The managing board elects one of its members as chair.

The **Executive Office** is run by the Executive Director, who reports to the chair of the managing board.

The Advisory Board comprises representatives from industry and administration and advises the ESC on its activities.



Mission

The Energy Science Center (ESC) aims to facilitate the deployment of an environmentally friendly, reliable, low risk, economically viable and socially compatible sustainable energy system.

The ESC enhances cooperation between ETH Zurich, industry, government, and society on energy related issues, offering a platform for nourishing the exchange of information between the engineering sciences and the social sciences as well as for directing joint projects.

The ESC synergistically combines key expertise in various energy disciplines to address large-scale problems successfully and to form flagship projects.

We welcomed five new ESC members in 2016

Prof. Dr. Guillaume Habert, Sustainable Construction, D-BAUG Prof. Dr. Maryam Kamgarpour, Control Systems, D-ITET Prof. Dr. Melanie Zeilinger, Dynamic Systems and Control, D-MAVT Prof. Dr. Stefan Wiemer, Swiss Seismological Service, D-ERDW Prof. Dr. Daniel Farinotti, Glaciology, D-BAUG

Partnership Council

The Partnership Council is formed by foundations and industry partners who make substantial donations to the programme of the Center through the ETH Foundation, and who are interested in playing an active role in building joint initiatives.

The Center's Partnership Council meets biannually with the ESC Managing Board and Executive Director.

Core Activities

The ESC core activities can be categorized in Research, **Education and** Outreach

Research

Research Approach

The ESC research activities focus on large, cross-cutting themes run as inter-departmental and inter-disciplinary projects in the four strategic areas of: energy and information, integration of renewables, integrated modelling and energy-water-land nexus. The ESC identifies relevant topics in the area of energy research. This also includes participation in National Research Programs (NRP) and European Research projects (Horizon 2020).

The ESC research activities consist of:

- Taking a proactive role in the energy research activities of ETH Zurich and supporting its strategic goals in all areas of action (efficiency, grids, storage, provision, economy, geothermal and more);
- Supporting the professors and institutes active in these fields by leveraging its network inside ETH Zurich with other universities and industry;
- Gathering opinions and open questions within the energy sector internally and externally, synthesising and disseminating them amongst researchers of ETH Zurich;

- Hosting researchers for specific projects in order to facilitate inter-departmental research projects;
- Promoting flagship programmes in the area of energy research.

www.esc.ethz.ch/research.html \rightarrow

Research Focus

Clean, affordable and reliably available energy is of paramount importance to the well-being of modern societies. Developing future environmentally friendly energy systems requires research in a large number of scientific disciplines. Most of these are cultivated at ETH Zurich, which has a bright tradition in energy-related research.



Research Projects

Renewables Management and Real-time Control Platform (ReMaP)

The aim of the project "Renewables Management and Energy Strategy 2050. Real-time Control Platform" (ReMaP) is to design, build AFEM analyses the design of the electricity market in and deploy an advanced technology platform of both na-Switzerland and Europe today, identifies shortcomings tional and international relevance that will contribute to of the existing market setup and investigates the possible the understanding of future energy supply systems by: addition of capacity markets or capacity payments. AFEM 1. providing academic and industrial researchers with a is developing new models to analyse the specific behavtest bed infrastructure to assess the performance, risks iour of future electricity supply systems and their energy and general issues associated with a volatile supply from network structure in which renewable energy sources renewable energies embedded within smart grids exare likely to be deployed on a large scale. ploiting advanced real-time measurement and control solutions;

2. providing experimental facilities for education of students in decentralized energy systems;

3. supplying a high-visibility demonstration platform for the benefit of the various societal actors and stakeholders, especially the

4. municipal/cantonal/federal/regulatory authorities and the general public.

It will stand out to become a prominent ambassador of the strategic focus area "Energy" of the ETH domain within public society and the scientific community. It should become operative in 2018, integrating existing research platforms at the sites at Empa (in Dübendorf) and PSI (in Villigen).

Integration of sustainable Multi-Energy-hub Systems at neighbourhood scale (IMES)

IMES aims at developing an holistic analysis of decenpolitical sciences, economics and risk management is tralized energy systems where renewable sources, gasin the unique position to develop such a comprehensive based micro-cogeneration and energy storage systems platform. are integrated together. IMES will develop and provide a While the platform will enable studying a wide range comprehensive simulation approach for such power proof questions, the first case study will focus on the role duction scheme by tackling at the same time technical, of flexibility providers in the future electricity system, economic and social issues. Multiple test cases reprei.e. what level of flexibility will be needed and who can senting different neighbourhood environments will be provide it in a scenario where nuclear energy is phased used to formulate techno-economic decision guidelines out and the penetration of variable renewable energy for current and future implementation of decentralized resources has increased significantly. These and other power. Bringing together all the required expertise, from questions are directly linked to the needs and consethe thermodynamic to the economic and social point of quences of realizing the Energy Strategy 2050. Hence, view, IMES will permit to clearly assess the potential role of decentralized multi-energy systems. 9

Assessing Future Electricity Markets (AFEM)

AFEM is a research project with the objective to identify and evaluate the performance of alternative designs for future electricity markets, including a continuation of the current market setting, in terms of their ability to meet the challenges created by the targets set in the Swiss

Integrated Energy Systems Modelling Platform (Nexus)

The objective of the Nexus project is to develop a platform which enables the study of complex and interdisciplinary questions about the impact of technical, socio-economic and political decisions on the performance of the future energy system.

The analysis of how the energy system will and should evolve and the study of what the consequences of far-reaching decisions in the energy sector are of high national importance. In academia, administration and industry there is a need for a comprehensive and transparent platform which enables studies that provide a holistic view including top-down and bottom-up models taking into account the physical properties as well as the socio-economic and policy related aspects of the system. ETH Zurich with expertise in energy in the domains of electrical engineering, building technologies,

Education

Master in Energy Science and Technology (MEST)

The ESC coordinates the interdisciplinary Master's degree programme Master in Energy Science and Technology (MEST) at ETH Zurich, a world-class master programme for energy engineers. This specialised programme is of a unique type, enabling study across a wide range of energy-related courses offered by ETH Zurich and provides students with the academic skills required by the energy marketplace.

For entry in autumn 2016, the MEST admission committee received more than 140 applications from all over the world, of which 56 high-calibre students were offered a place.

www.master-energy.ethz.ch \rightarrow





Master in Integrated Building Systems (MBS)

The ESC supports the interdisciplinary Master's degree programme in Integrated Building Systems (MBS) at ETH Zurich.

This programme provides a science-based education in building systems and technologies with a strong emphasis on the energy performance and the environmental impact of buildings. The emphasis is on the integration of sustainable energy technologies at both the building and the urban level.

www.master-buildingsystems.ethz.ch \rightarrow

Frontiers in Energy Research

Frontiers in Energy Research is a series of lectures given by Ph.D. students for Ph.D. students of their energy-related research work.

It aims to disseminate knowledge of ETH Zurich energy-related research activities throughout the research community. The "Frontiers in Energy Research" gives students the opportunity to present and discuss their energy-related research activity to the broader ETH research community and learn more about other pertinent projects.

The presenters are doctoral students who take this opportunity to present their research. The weekly presentations are open to the public, free and do not require registration. The Frontiers series has been running successfully since the spring semester in 2012.

The spring semester 2015 hosted 14 seminars and the presenters were coming from 9 different ETH departments (included EMPA and PSI).

www.esc.ethz.ch/events/frontiers-in-energy-research.html \rightarrow



Alumni Support and Career Development

Alongside the MEST academic studies, the ESC plays a role in developing an Alumni Network for career support and development. Regular social events bring together past and present students to help strengthen the MEST students' network.

Outreach

Our outreach activities includes the organisation of public events, collaboration with energy related associations and organisations, regular workshops with industry partners and the representation of the ETH Zurich in energy-related topics towards policymakers and institutions.

ESC Events & Collaborations

Energy Futures – Europe and North America

A joint symposium: MIT energy initiative and ETH Zurich

June 6, 2016

This joint event by the ESC and the MIT Energy Initiative (MITei), explored the approaches being taken in Europe and North America to secure the energy futures of both regions given the urgent need to act on climate change, and brought together around 460 attendees. Dynamics relating to the power grid's evolution, the use of fossil fuels, the role of nuclear power and the changes in mobility were discussed by a panel of experts from both sides of the Atlantic. Lessons learned from past policy and regulatory actions, along with existing efforts to support technology development and deployment were covered. Emphasis was placed on identifying effective mechanisms to hasten the development, deployment and implementation of energy efficiency and low-carbon energy technologies.

http://www.esc.ethz.ch/events/esc-mitei-symposium.html \rightarrow

Die Zukunft der Energiespeicher

Trends und offene Fragen

December 14, 2016

The purpose of this ESC event was to bring key players in energy storage together to discuss the future role of energy storage in Switzerland. Reaching an audience of more than 450 attendees, showed the big interest as well as importance of this topic. Storage has always played an significant role in the energy supply system. While the storage of fossil fuels can be easily achieved for example for oil, coal, and to a certain extent for natural gas, direct storage of electricity is not possible. However, indirect storage - today mainly in the form of water storage facilities - plays a central role in the electricity system, since production and consumption must be balanced at all times.

http://www.esc.ethz.ch/events/zukunft-der-energiespeicher.html →



Swiss Energy and Climate Summit (SwissECS)

10th Anniversary

September 13/14, 2016

Also for the 10th anniversary of the SwissECS, Switzerland's leading conference for energy and climate issues, the Energy Science Center took part at the two-day event. Together with the Swiss startup Battrion AG - an ETH Zurich spin-off that develops innovative fabrication technologies for lithium ion batteries aimed at increasing the charging speed of high energy density cells, the ESC represented the ETH Zurich at the summit where over 800 decision-makers from industry, the energy, finance, insurance and construction sectors as well as representatives of NGOs, and the Swiss government, took part.

www.swissecs.ch \rightarrow

Klimarunde 2016

Globalized climate change: How does it affect us?

November 8, 2016

Towards the end of the year, the ESC supported the C2SM (Center for Climate Systems Modeling) in the organisation and successful realisation of the Klimarunde 2016 with over 420 attendees, where top climate researchers discussed how weather and climate extremes influence our globally networked world.

The event showed risks and opportunities for Switzerland: What impact does a strong El Niño have on Swiss chocolate? How does extreme weather affect the supply of smartphones in Asia? Why does purchasing soap and suncream influence climate change?

http://www.c2sm.ethz.ch/events/eth-klimarunde-2016.html \rightarrow



Security of Supply in the Swiss and the EU Electricity Market

Ownership Structures, Political Responsibility, and Cross Border Cooperation

September 29, 2016

This event, organized by Avenir Swiss and the CSS (Center for Security Studies), was supported by the ESC. The event discussed the responsibilities, ownership structures and cooperations between Switzerland and the EU to ensure security of energy supply.

http://www.css.ethz.ch/en/think-tank/ events/versorgungssicherheit-imstrommarkt.html →

Energy Startup Day

December 1, 2016

In a collaboration with the ZHAW School of Management and Law, the ESC organized the Energy Startup Day, bringing 200 participants from the energy sector together, in 2016. The main goal of the energy startup day is to initiate collaboration for knowledge exchange between startups, incumbents and new actors in the energy and cleantech sector. The focus goes beyond financial investments to foster collaborative development.

www.energy-startup-day.ch \rightarrow

Annex

Active Members (as of 31.12.2016)

D-ARCH

Prof. Dr. Jan Carmeliet Prof. Dr. Kees Christiaanse Prof. Dr. Andrea Deplazes Prof. Dr. Hansjürg Leibundgut Prof. Dr. Arno Schlüter

D-BAUG

Prof. Dr. Robert Boes Prof. Dr. Paolo Burlando Prof. Dr. Eleni Chatzi Prof. Dr. Daniel Farinotti Prof. Dr. Guillaume Habert Prof. Dr. Stefanie Hellweg Prof. Dr. Martin Raubal

D-CHAB

Prof. Dr. Christian Copéret Prof. Dr. Konrad Hungerbühler Prof. Dr. Maksym Kovalenko Prof. Dr. Reinhard Nesper Prof. Dr. Javier Pérez-Ramirez Prof. Dr. Thomas Schmidt Prof. Dr. Alexander Wokaun

D-ERDW

Prof. Dr. Fredrick Evans Prof. Dr. Domenico Giardini Prof. Dr. Christoph A. Heinrich Prof. Dr. Johan Robertsson Prof. Dr. Martin Saar Prof. Dr. Stefan Wiemer

D-GESS

Prof. Dr. Renate Schubert Prof. Dr. Tobias Schmidt Prof. Dr. Andreas Wenger

D-INFK Prof. Dr. Friedemann Mattern

D-ITET

Prof. Dr. Göran Andersson Prof. Dr. Jürgen Biela Prof. Dr. Florian Dörfler Prof. Dr. Christian Franck Prof. Dr. Ulrike Grossner Prof. Dr. Gabriela Hug Prof. Dr. Maryam Kamgarpour Prof. Dr. Johann Walter Kolar Prof. Dr. John Lygeros Prof. Dr. Ayodhya Nath Tiwari Prof. Dr. Vanessa Wood

D-MATL

Prof. Dr. Jennifer Rupp

D-MAVT

Prof. Dr. Reza S. Abhari Prof. Dr. Konstantinos Boulouchos Prof. Dr. Paolo Ermanni Prof. Dr. Lino Guzzella Prof. Dr. Petros Koumoutsakos Prof. Dr. Wolfgang Kröger Prof. Dr. Edoardo Mazza

Prof. Dr. Marco Mazzotti Prof. Dr. Christoph Müller Prof. Dr. Nicolas Noiray Prof. Dr. David Norris Prof. Dr. Hyung Gyu Park Prof. Dr. Patrick Jenny Prof. Dr. Dimos Poulikakos Prof. Dr. Horst-Michael Prasser Prof. Dr. Philipp Rudolf von Rohr

Prof. Dr. Giovanni Sansavini Prof. Dr. Aldo Steinfeld Prof. Dr. Melanie Zeilinger

D-MTEC

Prof. Dr. Lucas Bretschger Prof. Dr. Massimo Filippini Prof. Dr. Elgar Fleisch Prof. Dr. Volker Hoffmann Prof. Dr. Sebastian Rausch

D-USYS

Prof. Dr. Reto Knutti Dr. Evelina Trutnevyte Prof. Dr. Anthony Patt Prof. Dr. Michael Stauffacher Prof. Dr. Bernard Wehrli

Total: 70 members

Managing Board (as of 31.12.2016)

Prof. Dr. Marco Mazzotti (Chair) Prof. Dr. Reza S. Abhari Prof. Dr. Robert Boes Prof. Dr. Jan Carmeliet Prof. Dr. Massimo Filippini Prof. Dr. Volker Hoffmann Prof. Dr. Gabriela Hug

Executive Office (as of 31.12.2016)

Dr. Christian Schaffner – Executive Director **Deborah Hufton - Education** Lisa Bettoni/Susanne Keller - PR and Communications Dr. Pedro Crespo del Granado – Post-doctoral Fellow

Members Partnership Council

ABB Schweiz Alpiq Alstom Axpo BKW CKW EKZ ewz Repower Shell swisselectric