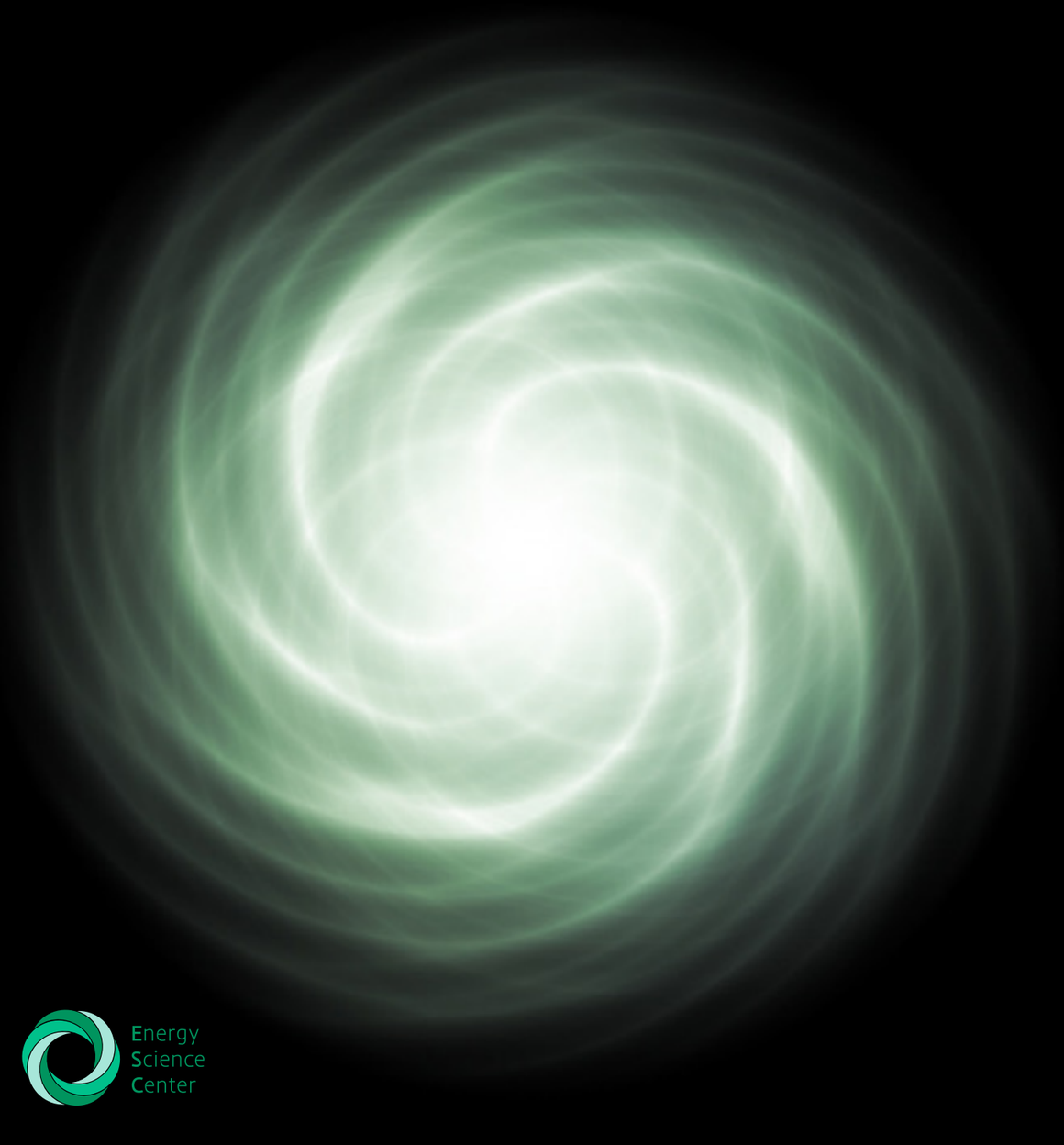
ETH zürich

Energy Science Center

Annual Report 2015



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Content	**Energy Science Center**
Layout	**Lisa Bettoni**
Cover Image	
Photos	**p. 11 Alessandro Della Bella, ETH Zürich; p.12/1-2-3 Pino Covino, Swissgrid/ESC; p.13/1-2 Pino Covino, Swissgrid/ESC; p.13/3 focusTerra, ETH Zürich/Jon Etter, 2015; p.13/4-5-6-7 Lisa Bettoni, ESC.**

Energy
Science
Center

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

Table of Contents

Dear Colleagues and Partners,

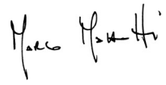
2015 has been another successful year for the Energy Science Center (ESC) at ETH Zurich and we are happy to report on our activities. We warmly welcomed seven new members: Prof. Nicolas Noiray (D-MAVT), Prof. Lygeros (D-ITET), Prof. Patrick Jenny (D-MAVT), Prof. Florian Dörfler (D-ITET), Prof. Ulrike Grossner (D-ITET) and Dr. Evelina Trutnevyte (D-USYS), bringing us to a total of 66 members from 11 departments.

In research, the ESC continued the large cross-departmental research projects launched earlier. Also, initial works to launch a platform for energy system modelling were conducted. In addition, the ESC has organised another call for energy related seed projects. Six projects were selected for funding, receiving an overall total of 600'000 CHF from the Energy Fund of ETH Zurich Foundation. The four focus areas for this call were energy storage, energy systems, building technologies and the "internet of things". The full list of recipients is in the annex.

The ESC's educational responsibility towards the Master in Energy Science and Technology (MEST) continues with this successful programme, which draws smart students from around the world, keen to engage in the diversity of knowledge required to prepare themselves for building a future sustainable energy system.

Building on its large and active community both within and outside ETH Zurich, the ESC organised many events in 2015. The two largest of these were "Das Stromnetz der Zukunft" together with the "Grid Expo" exhibition, and "Klimarunde 2015", co-organised with the Center for Climate Systems Modeling (C2SM), with each event attracting well over 400 participants.

In 2016 we will be fostering our relationships with industry, government and the public in order to jointly face, discuss and find solutions for the global energy challenges we are facing. We aim to bring researchers from different disciplines together for a more holistic approach towards a sustainable energy system.



Marco Mazzotti
Chair

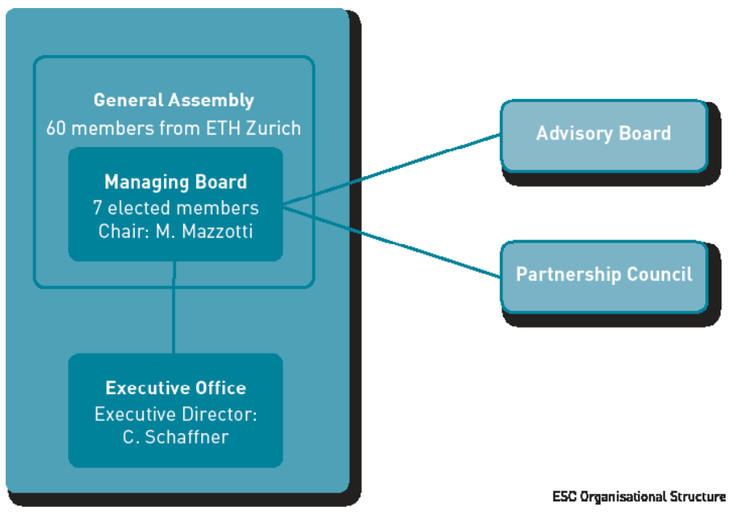
Christian Schaffner
Executive Director

The Energy Science Center

A sustainable energy system is one of the most complex challenges that humankind is facing. Such an energy system must be viable given the limited available resources; it must also relieve the strain on the natural environment and not compete with the basic needs of the world' s population.
A plausible sustainability vision should be responsive to the central challenges facing the energy system. These are: climate change, access to energy services, local pollutants, risks and benefits to society.
To build such a sustainable energy system additional knowledge and new technologies are needed, relying on the expertise and cross-cutting research of engineering, economic and social scientists.

The ESC of ETH Zurich was founded in 2005 as an interdepartmental competence center to facilitate energy research and teaching activities across research fields and departments.
The ESC contributes significantly to the integration of specialists and disciplines and aims to be one of the most influential centers in energy research with national and international visibility.
www.esc.ethz.ch →

The Research Center for Energy Networks (Forschungsstelle Energienetze – FEN) is affiliated to the Energy Science Center.
www.fen.ethz.ch →



ESC Organisational Structure

The Energy Science Center welcomed 7 new members in 2015

Professor Nicolas Noiray, Combustion and Acoustics for Power Systems, D-MAVT
Professor John Lygeros, Automatic Control Laboratory, D-ITET
Professor Patrick Jenny, Fluid Dynamics, D-MAVT
Professor Florian Dörfler, Complex Systems Control, D-ITET
Professor Gabriela Hug, Power System, D-ITET
Professor Ulrike Grossner, Advanced Power Semiconductor Laboratory, D-ITET
Doctor Evelyna Trutnevyte, Senior Researcher, D-USYS TdLab

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. These programmes will be large, financially intensive projects that have a visibility far beyond ETH Zurich and should promote energy research to a large extent.

Organisational Structure

The General Assembly, containing the ESC members, is the ESC governing body. Currently sixty professors from eleven different departments are members of the ESC.
The **Managing Board** is the executive body of the ESC and is composed of five 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.
The **Partnership Council** is formed by foundations and industry partners who make substantial donations to the programme of the Center through the ETH Foundation.

Partnership Council

The Center's Partnership Council meets biannually with the ESC Managing Board and Executive Director.
Members represent foundations and industry partners who provide significant financial support for projects and programme through the ETH Foundation and who are interested in playing an active role in building joint initiatives

Core Activities

According to the ESC Mission, the ESC activities can be categorized in three main areas: Research, Education and Outreach.

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 →

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.

Energy Fund of ETH Zurich Foundation

Seed Projects

The Energy Fund of the ETH Zurich Foundation funds seed projects,in close cooperation with the Energy Science Center (ESC). The following thematic priority areas have been selected in 2015:

- Energy storage (Electricity, Heat, Chemicals);
- Energy systems, business models, energy policy, environmental solutions;
- Building technologies (efficiency, control, metering);
- "Internet of things" (applications in power generation, transmission or distribution).

This funding opportunity for post-doctoral projects of up to one year is financed with a maximum budget of 100'000 CHF per project from thematic funds of the ETH Zurich Foundation. 6 seed projects were financed in 2015 (see Annex).

www.esc.ethz.ch/research/seed-projects.html →

Research Projects

Below is a list of inter-departmental and inter-disciplinary projects tackling cross-cutting themes currently under the co-ordination of the ESC.

IMES

Integration of sustainable Multi-Energy-hub Systems at neighbourhood scale

IMES aims at developing an holistic analysis of decentralized energy systems where renewable sources, gas-based micro-cogeneration and energy storage systems are integrated together. IMES will develop and provide a comprehensive simulation approach for such power production scheme by tackling at the same time technical, economic and social issues. Multiple test cases representing different neighbourhood environments will be used to formulate techno-economic decision guidelines for current and future implementation of decentralized power. Bringing together all the required expertise, from the thermodynamic to the economic and social point of view, IMES will permit to clearly assess the potential role of decentralized multi-energy systems.

AFEM

Assessing Future Electricity Markets

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 Energy Strategy 2050.
AFEM researches the design of the electricity market in Switzerland- Europe today and then identify shortcomings both of the existing setup and the additions of capacity markets or capacity payments. AFEM is developing new models to analyse the specific behaviour of future electricity supply systems and their energy network structure in which renewable energy sources are likely to be deployed on a large scale.

ReMaP

Renewables Management and Real-time Control Platform

ReMaP is a modular and flexible demonstration platform using synergies of multi-energy systems ("Energy Hub") at neighbourhood scale, in order to: assess the challenges due to high shares of local renewable energy sources, evaluate the interplay between local and global systems/grids (e.g. control systems) and provide a demonstration platform for stakeholders (academia, industry, government). The technology platform will be characterized by large-scale and specific infrastructure that will be fully integrated to yield an experimental environment allowing the execution of pilot investigations and research, development and demonstration (RD&D) initiatives, thus ensuring its visibility and long-term impact. 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. Planning and project management started in 2015

www.esc.ethz.ch/research-projects.html →

Nexus

Integrated Energy Systems Modelling Platform

Nexus is an analytical tool that adopts a holistic approach to modelling the energy system using an integrated platform to analyse energy systems at regional, national and EU scale. Nexus combines strengths of top-down and bottom-up modelling approaches to account for complexity and interplay of energy demand-supply, macro energy-economic factors and energy policy drivers. Through developing interfaces or defining coupling points between models, Nexus provides the capability to create synergies between different modelling paradigms. To accomplish a holistic perspective of the energy-economic system, the Nexus platform is developed around core modules that represent the key layers and sectors of the energy system. This modular based approach aims at linking a broad coalition of existing models and integrate cross disciplinary approaches and perspectives to represent the whole energy system.

Education

MEST

Master in Energy Science and Technology

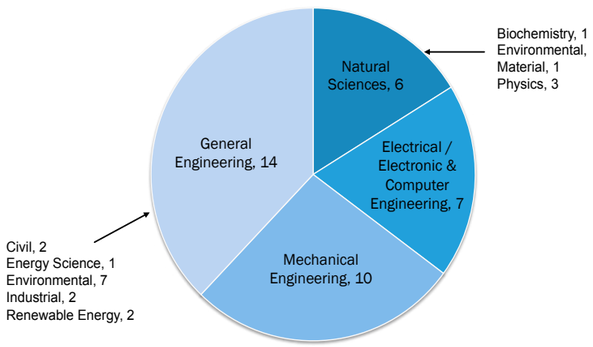
The ESC supports a world-class interdisciplinary master programme for energy engineers. The Master in Energy Science and Technology (MEST) is a specialised programme of a unique type, enabling studies across a wide range of energy–related courses offered by ETH Zurich.
Running since 2007, it is a joint programme between two Departments: the Department of Information Technology and Electrical Engineering (D-ITET), as the host department, and the Department of Mechanical and Process Engineering (D-MAVT). Another nine departments actively contribute to the MEST through the tutors and their offer of over fifty energy-related core courses.
In the nine years that it has been running, the MEST has grown to become the third most sought-after Master at ETH Zurich and also the largest inter-disciplinary master's programme. The number of energy-related courses that the students can choose from has risen from 40 at its inception to 54 to date (4 compulsory and 49 elective).

The ESC coordinates the interdisciplinary Master's degree programme Master in Energy Science and Technology (MEST) at ETH Zurich.
For autumn 2015 the MEST admission committee received more than 140 applications from all over the world.

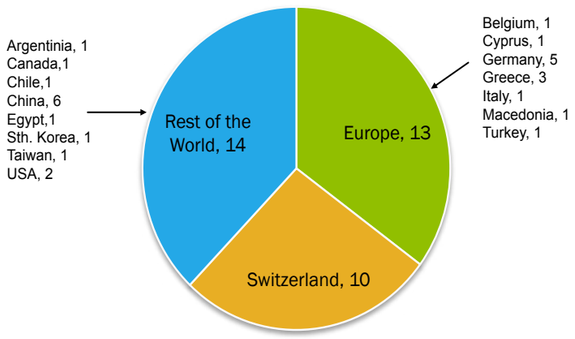
Since Autumn 2015, Prof Christian Franck is the MEST Programme Director.

www.master-energy.ethz.ch →

MEST Students - Home country



MEST Students – Previous Study



MBS

Master in Integrated Building Systems

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 →

Alumni Support and Career Development

Aiming to the development of a stronger Alumni Network, the ESC had organised MEST info and social events for students with the aim to strengthen the MEST students network.

Frontiers

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 →




Outreach

Events

Das Stromnetz der Zukunft

Auditorium Maximum, ETH Zurich, June 18th

Topic of this event was the transmission network, which plays a central role in the power supply. In order to be prepared to the future challenges, it must be adapted to the current and future developments. Concretely it means to develop an economically efficient, socially accepted and environmentally sustainable network which can ensure the supply security. The event gave a contribution to the public discussion concerning the Swiss Strategy Network from a scientific point of view. Central elements of the discussion were the technical and economic challenges for the network development, considering also the political developments in Switzerland and Europe.

Grid Expo

Haupthalle, ETH Zurich, June 16th – 19th

This exhibition provided an insight into the scientific work done at ETH Zurich in the field of power grids as well as an overview of the latest technological development of the network infrastructures.

The events were organised in collaboration with Renewable Grid Initiative (RGI) and Swissgrid.

www.esc.ethz.ch/events/zukunftstromnetz.html →



Klimarunde 2015

The event was jointly organized by the Center for Climate Systems Modelling and the Energy Science Center with the usual format:

- *Tischgespräche* - where the general public had the opportunity to discuss the conference topic directly with the ETH experts.
- Presentations and panel discussion - with important speakers from industry, politics and academia.

More than 500 people took part at the 2015 edition of Klimarunde to discuss about the "Vision Null: Wege zur einer CO2-neutralen Gesellschaft". In light of the upcoming COP21, the question of how to move towards a low-carbon world was addressed.

www.c2sm.ethz.ch/klimarunde2014 →

Collaborations

Earth's Treasures – A *focusTerra* special exhibition

This exhibition was about the formation, mining and use of mineral resources, and how to deal with products we no longer need. What can we do to ensure that resources are extracted in an economical, environmentally friendly and socially responsible way and that they are used and reused for as long and as efficiently as possible?
The ESC contributed to the section dedicated to "Energy and Energy Sources".

www.focusterra.ethz.ch/en/news-and-events/current.html →

Swiss Energy and Climate Summit (SwissECS) – Solution Expo

The ESC has been involved in the "New Solution Expo" of the SwissECS 2015 edition as representative of ETH Zurich. The New Solution Expo is an integral part of SwissECS and it is an exhibition zone for start-up and spin-off companies and for companies.

www.swissecs.ch →

Workshops

Frontiers in Energy Systems Modelling

The goal of this workshop was to stimulate cross-disciplinary discussions and potential collaborations, to share current research initiatives on addressing energy challenges, and to bring energy systems modellers together to share and discuss latest research results. Overall the discussed topics included: modelling energy markets, impact of renewable energy sources on energy networks and risk aspects, interdisciplinary discussion between macro-economic-policy and energy-technology disciplines. The models presented focused on Switzerland and neighbouring countries. More than 40 experts joined the workshop on Energy Systems Modelling.

Distributed Generation and Smart Grids

By bringing together several experts both from academia and industry, the workshop on Distributed Generation and Smart Grids triggered interesting discussions about the important reorganisation of the energy sector which most of the developed countries worldwide are undergoing. This reorganisation is often prompted by new regulatory frameworks and strategies, but also due to market developments and will lead to multiple challenges. In this context, decentralized energy systems together with smart grids represent promising solutions which could facilitate the transformation of the energy sector.

www.esc.ethz.ch/events/previous.html →



Annex

Members (As of 31.12.2015)

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. Stefanie Hellweg
Prof. Dr. Martin Raubal
Prof. Dr. Bozidar Stojadinovic

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. Chrtistoph A. Heinrich
Prof. Dr. Johan Robertsson

D-GESS
Prof. Dr. Renate Schubert
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. Johann Walter Kolar
Prof. Dr. John Lygeros
Prof. Dr. Ayodhya Nath Tiwari
Prof. Dr. Vanessa Wood

D-MAVT
Prof. Dr. Reza S. Abhari
Prof. Dr. Konstantinos Boulouchos
Prof. Dr. Chiara Daraio
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

D-MATL
Prof. Dr. Jennifer Rupp

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

Total: 67 members

Managing Board (As of 31.12.2015)

Prof. Dr. Marco Mazzotti
Prof. Dr. Reza S. Abhari
Prof. Dr. Göran Andersson
Prof. Dr. Jan Carmeliet
Prof. Dr. Massimo Filippini

Executive Office (As of 31.12.2015)

Dr. Christian Schaffner – Executive Director
Deborah Hufton - Education
Lisa Bettoni - PR and Communications
Dr. Pedro Crespo del Granado – Post-doctoral Fellow
Dr. Fredrik Rütten – ReMaP Project Manager

Members Partnership Council

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

Honours and prizes awarded to members of ESC

Prof. Dr. Göran Andersson, D-ITET, Member of the Swiss Academy of Engineering Sciences (SATW), Switzerland

Prof. Dr. Eleni Chatzi, D-BAUG, ERC Starting Grant, European Research Council, Belgium

Prof. Dr. Christophe Copéret, D-CHAB, Paul H. Emmett Award in Fundamental Catalysis, The North American Catalysis Society (NACS), United States of America

Prof. Dr. Gabriela Hug, D-ITET, Eta Kappa Nu Excellence in Teaching Award, Carnegie Mellon University, United States of America

Prof. Dr. Petros Koumoutsakos, D-MAVT, Fellow of the Society for Industrial and Applied Mathematics (SIAM), United States of America

Prof. Dr. Johann W. Kolar, D-ITET, IEEE William E. Newell Power Electronics Award, Institute of Electrical and Electronics Engineers, United States of America

Prof. Dr. Nicolas Noiray, D-MAVT, SNSF Assistant Professor Energy Grant, Swiss National Science Foundation, Switzerland

Prof. Dr. David J. Norris, D-MAVT Max Rössler Prize, ETH Zurich, Switzerland

Prof. Dr. Dimos Poulikakos, D-MAVT, ERC Advanced Grant, European Research Council, Belgium

Prof. Dr. Johan Robertsson, D-ERDW, New Frontiers of Hydrocarbons, Ente Nazionale Idrocarburi (ENI), Italy

Prof. Dr. Aldo Steinfeld, D-MAVT, Kekulé Lecture, University of Antwerp, Belgium

Prof. Dr. Vanessa Wood, D-ITET, ERC Starting Grant, European Research Council, Belgium

List of Seed Project 2015

Name of the Project	Group	Professor
Development of highly active and selective methanol synthesis catalysts to provide a versatile storage concept for surplus renewable energy	Surface and Interfacial Chemistry	Prof. Christophe Copéret
Novel control approaches for low-inertia power grids	Complex Systems Control	Prof. Florian Dörfler
Behavioural and technical optimisation for building energy efficiency and flexibility	Automatic Control Laboratory	Prof. John Lygeros
A novel theoretical and numerical framework to predict and control aero-acustic instabilities in energy systems	Combustion and Acoustics for Power Systems	Prof. Nicolas Noiray
High-efficiency thin-film CIGS photovoltaic/thermal hybrid system for building integration	Architecture and Building Systems	Prof. Arno Schlüter
Enabling Deployment while Leaving Room for Experimentation: Toward a Framework for Renewable Energy Financing in Emerging Economies	Energy Politics	Prof. Tobias Schmidt