

Energy Science Center

Annual report 2017



Energy
Science
Center

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

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Dear Colleagues and Partners,

We look back on another successful year of the Energy Science Center (ESC), supporting ETH Zurich's successes in Energy Research, Education and Outreach. And we are very happy to report that these achievements have been appreciated by the board of ETH Zurich which, in late 2017, confirmed that they will support us for another four years!

As you know, the ESC brings together many disciplines from ten departments. We warmly welcome two new members, Prof. Johan Lilliestam (D-USYS) and Prof. Roy Smith (D-ITET).

Last year our interdisciplinary research efforts again brought important achievements. We would like to mention in particular the successful completion of the research project "Integration of sustainable Multi-Energy-hub Systems at neighbourhood scale" (IMES), demonstrating how researchers from different disciplines can devise new methods to analyse future energy systems.

We organised two successful public events, "The Global Energy Challenge – A Corporate View", comparing companies' view to that of researchers, as well as the first "Energy Day @ ETH", which will be held again next December.

And now we are looking forward to 2018!

Dimos Poulikakos
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.

www.esc.ethz.ch →

The Research Center for Energy Networks (Forschungsstelle Energienetze – FEN) is affiliated with the Energy Science Center.

www.fen.ethz.ch →

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.

Organisational Structure

The General Assembly, containing the ESC members, is the ESC governing body. Currently 66 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.

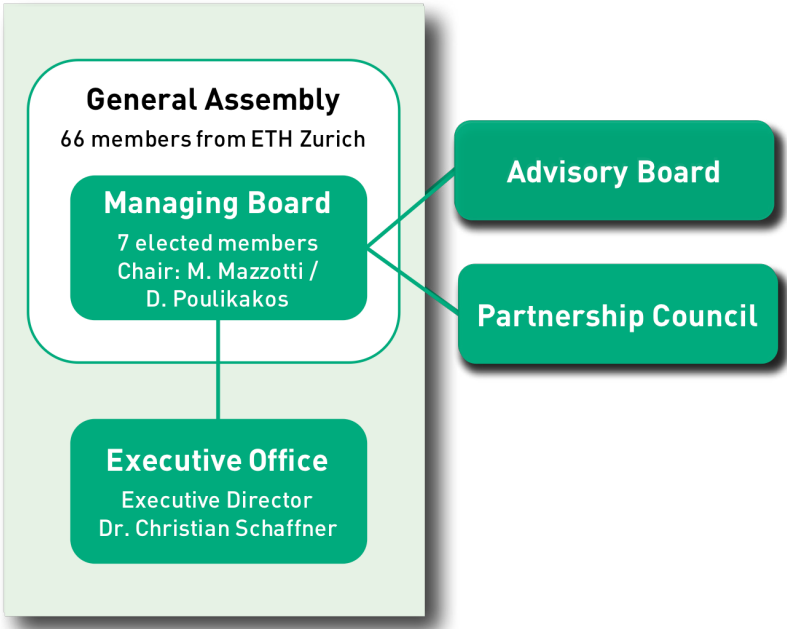
The **Executive Office** is run by the Executive Director, who reports to the chair of the managing board.

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

Partnership Council

The Partnership Council is formed of 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.



ESC structure 2017
Chair: Marco Mazzotti (01.10.2013- 30.09.2017)
Chair: Dimos Poulidakos (as of 01.10.2017)

News

The ESC will continue its work for the next four years

We are very happy to announce that the ESC was successfully re-accredited by the ETH Zurich in October 2017. We look forward to continuing our endeavours over the next four years.

We warmly welcome two new members in 2017



Prof. Dr. Johan Lilliestam, Renewable Energy Policy Group, D-USYS

Johan Lilliestam has been Assistant Professor of Renewable Energy Policy at ETH Zürich since August 2017.

His current research focuses on policies and strategies for a transition to renewables, including the effect of interactions between different policies, acceptance or opposition of different electricity visions, as well as energy security of renewable electricity systems.



Prof. Dr. Roy Smith, Automatic Control Laboratory, D-ITET

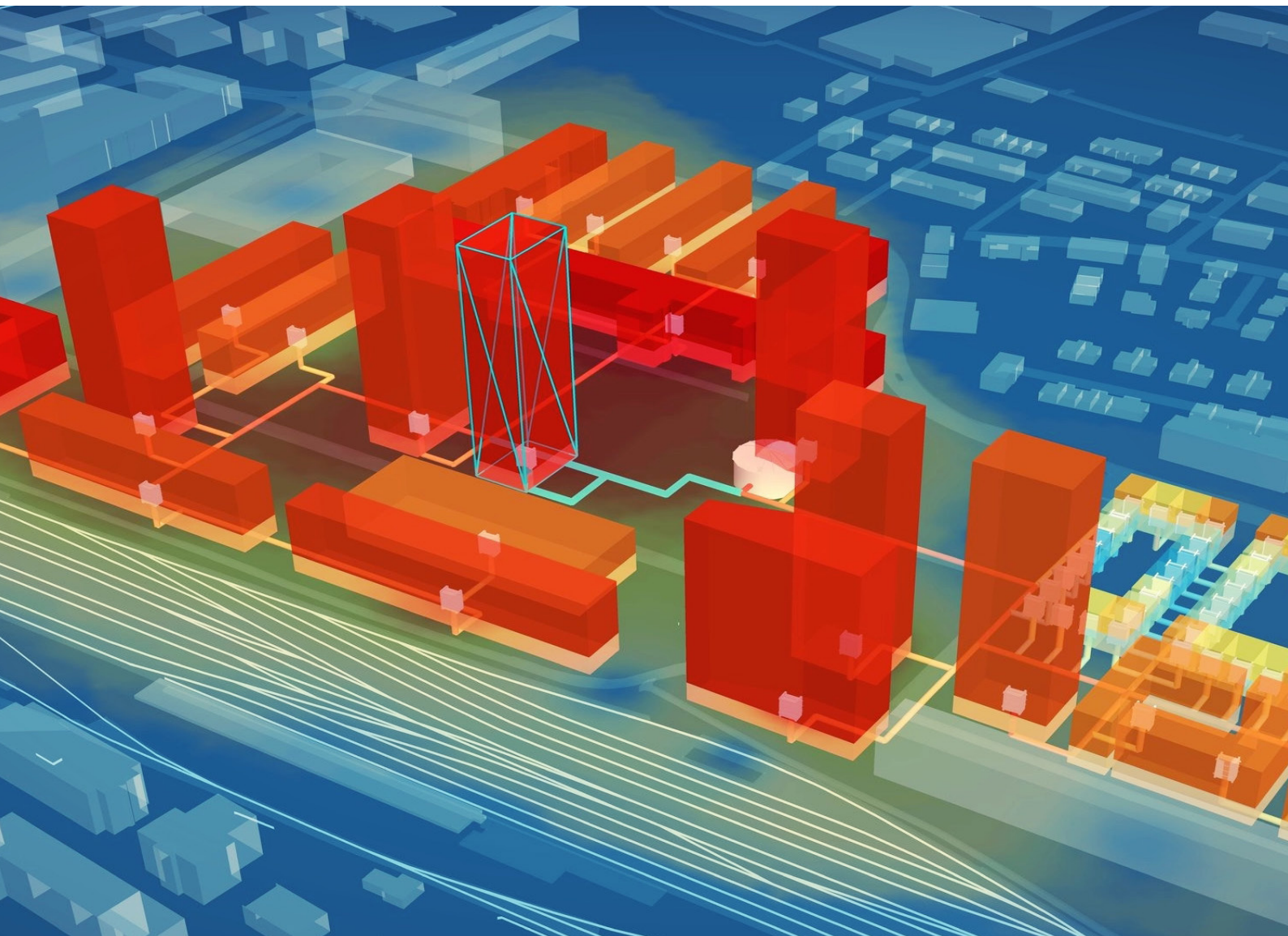
Roy Smith has been an Adjunct Professor at the Automatic Control Laboratory in the Department of Information Technology and Electrical Engineering since 2011.

Professor Smith's field of expertise is feedback control systems and automation, in which he is known as an experimentalist and design engineer as well as a theorist.

ESC core activities

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

Research



Jimeno A. Fonseca. Energy efficiency strategies in urban communities: Modeling, analysis and assessment. Doctoral Thesis, Zürich, ETH Zürich, 2016.

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.

Research Projects

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 Energy Strategy 2050.

Over the next year the modelling tool developed in AFEM will be applied to analyse scenario options

including variations of: capacity markets, renewable support policies, and balancing market enhancements. By combining multidisciplinary models, such as dynamic investment decisions, hourly dispatch with detailed hydro cascades, GIS-based renewable potential assessments, and full AC grid reliability analysis, AFEM will investigate future options for improvements to the Swiss electricity market.

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

This project developed a holistic and integrated methodology for the optimal design, operation, control and evaluation of decentralized multi-energy-hub systems (MES), accounting for techno-economic and societal factors.

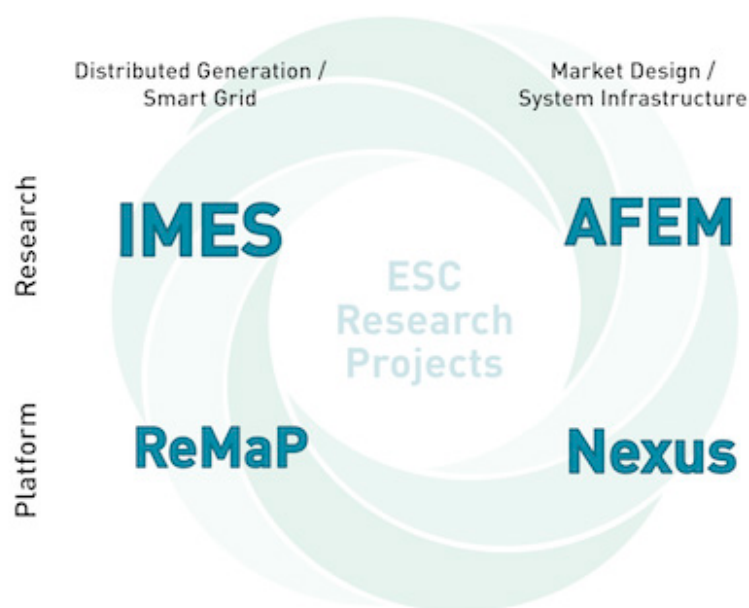
The methodology was applied to optimally design and control the MES in two Swiss case studies: the rural village of Zerneß (GR) and the urban neighbourhood of Altstetten (ZH). In each, optimal technologies and control strategies to satisfy the electricity and heat demands were determined, minimising total annual costs and CO₂ emissions. Different possible techno-economic MES scenarios were evaluated to determine the feasibility of achieving the goals of the Energy Strategy 2050.

Findings show that different neighbourhoods require different MES. The main drivers to defining the optimal design and control strategies are energy

demand and renewables availability, which in turn requires installation of long-term storage devices. Ideally, to meet the goals of the Energy Strategy 2050, both building retrofit and renewable integration need to be pursued.

Technology approximations implemented in the analysis of MES initially led to unrealistic and possible unfeasible solutions, overcome by incorporating more accurate micro-cogeneration and power-to-gas technology models.

The results show the importance of considering robust and distributed control approaches, as well as network constraints, to meet customer satisfaction while considering customer privacy. Whilst the social assessment showed a positive attitude towards MES, it identified barriers such as ownership and financing mechanisms.



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

Integrated Energy Systems Modelling Platform (Nexus)

This research project is part of an initiative of the Energy Science Center to develop an integrated modelling platform for assessing energy systems that cuts across the boundaries of established fields of knowledge by combining existing and new tools from different disciplines.

Such a platform 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. While such decisions in the energy sector are of high national importance, currently there is no comprehensive and transparent platform that enables such broad studies and that provides a holistic view. With expertise in the energy domains of electrical engineering, building technologies, political sciences, economics and risk management, ETH Zürich is in the unique position to develop such a comprehensive platform.

The on-going effort to develop this integrated platform of models has progressed rapidly and will soon

combine the following modules in an iterative simulation process: a top-down economic computable general equilibrium module, a bottom-up centralized generation expansion and dispatch module, a decentralized (distribution grid scale) generation expansion module, a markets-based generator scheduling module, and a cascading-failure grid reliability module.

While the platform will enable studying a wide range of questions, the first case study will focus on the role of flexibility providers in the future electricity system, i.e. what level of flexibility will be needed and who can provide it in a scenario where nuclear energy is phased out and the penetration of variable renewable energy resources has increased significantly. These and other questions are directly linked to the needs and consequences of realizing the Energy Strategy 2050. Hence, this modelling framework (Nexus platform) will help to answer current and upcoming energy policy questions.

Renewables Management and Real-time Control Platform (ReMaP)

The aim of this project is to design, build and deploy an advanced technology platform of both national and international relevance that will contribute to the understanding of future energy supply systems by:

1. providing academic and industrial researchers with a test bed infrastructure to assess the performance, risks and general issues associated with a volatile supply from renewable energies embedded within smart grids exploiting 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).

Education



Master in Energy Science and Technology (MEST)

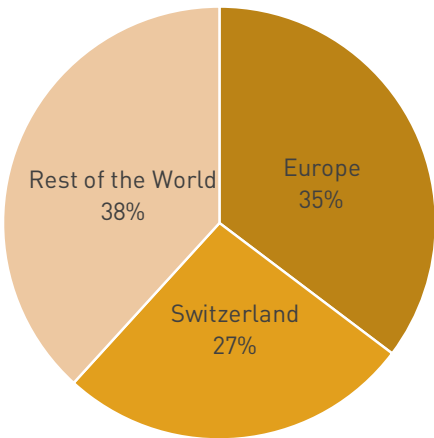
The ESC coordinates the interdisciplinary Master’s degree programme Master in Energy Science and Technology (MEST) at ETH Zurich, a world-class master programme for energy engineers, aimed at students with an engineering or a technological science background. This specialised programme is of a unique 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. The compulsory courses are in the key areas of electrical power engineering, energy process and mechanical engineering, and energy economics and policy. For the electives, students can choose any energy-specific course from the whole of the ETH course catalogue (in accordance with their tutor).

Founded in 2007, the MEST programme is jointly run by two Departments: the Department of Information Technology and Electrical Engineering (D-ITET), as the host department, along with the Department of Mechanical and Process Engineering (D-MAVT). Tutors from another seven departments actively contribute to the MEST, along with their energy-related core courses.

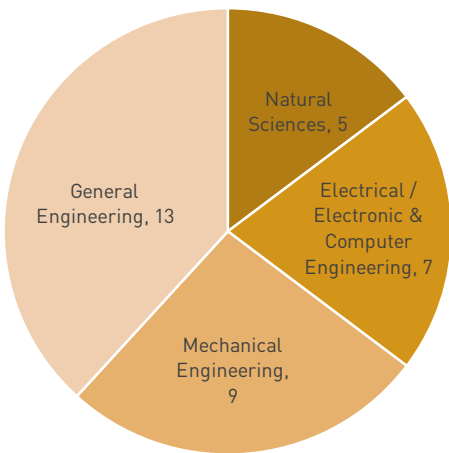
For entry in autumn 2017, the MEST admission committee received more than 130 applications from all over the world, of which 47 high-calibre students were offered a place.

www.master-energy.ethz.ch

2017 MEST students: Home country



2017 MEST students: Previous study



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

Frontiers in Energy Research

Frontiers in Energy Research is a series of lectures which disseminates knowledge of ETH Zurich energy-related research activities throughout the research community. Each lecture is given by a different PhD student who is at an advanced stage of their research, and attended by any PhD student interested in this area. The weekly presentations are open to the public, free and do not require registration.

Following each presentation, there is a discussion of the work presented and the audience are requested to provide feedback on the presentation style and content, making this a useful platform for

practising presentation skills. At the end of the semester, a 'Best Frontiers Presenter' award is given based on the audience feedback.

The Frontiers presentations are held annually throughout the spring semester, 14 each year, and have been running since 2012. In spring 2017, both the presenters and the attendees (just under 50 of them) came from 11 different ETH departments, plus PSI & EMPA.

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



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



ESC Events

The Global Energy Challenge A Corporate View



Prof. Stefan Wiemer, ETH Zurich challenging Dr. Juerg Trueb, Swiss Re

April 3, 2017

How are global corporations, institutional players and first-tier research institutions reacting to the new, global challenges in the energy sector? At this event, global stakeholders presented their visions and strategies, which then were challenged by ETH faculty members and researchers. This was followed by an open panel discussion, where the audience also had the possibility to challenge the panelists.

<http://www.esc.ethz.ch/events/previous.html>

Energy Day @ ETH

Engagiert für die Energiezukunft

December 12, 2017

During the Energy Day @ ETH, scientists and students discussed challenges and opportunities with guests to make the energy system of the future sustainable – in Switzerland, in Europe and worldwide.

In the morning, during the “Focus-Dialogues” students discussed different visions of a future energy system together with the participants. The topics of these debates were: consumer behaviour, electricity production, mobility, and start-up/innovation.

In the afternoon, during a public symposium, ETH Zurich scientists and invited guest speakers spoke on the same topics.

In a subsequent panel discussion representatives from science, industry and commerce evaluated how the presented visions can become reality taking into account technological developments, financing possibilities and regulatory challenges.

www.esc.ethz.ch/events/energy-day-2017.html



Focus-Dialogue “Mobility” with Claus Ghesla, doctoral student Prof. Schubert



Prof. B. Haering – University Lausanne and member ETH-Council



Panel discussion: “A sustainable energy future: reality or fiction?”

ESC Collaborations

Low-Carbon Energy and Development Strategies



July 9 to 28, 2017

The E4D School on Energy took place as part of the programme "Engineering for Development - Science & Technology for the South", funded by the Sawiris Foundation for Social Development. It was organised by ETH Global, the Energy Policy Group and the ESC, and hosted by the University of Cape Town, South Africa.

<http://www.esc.ethz.ch/events/previous.html>

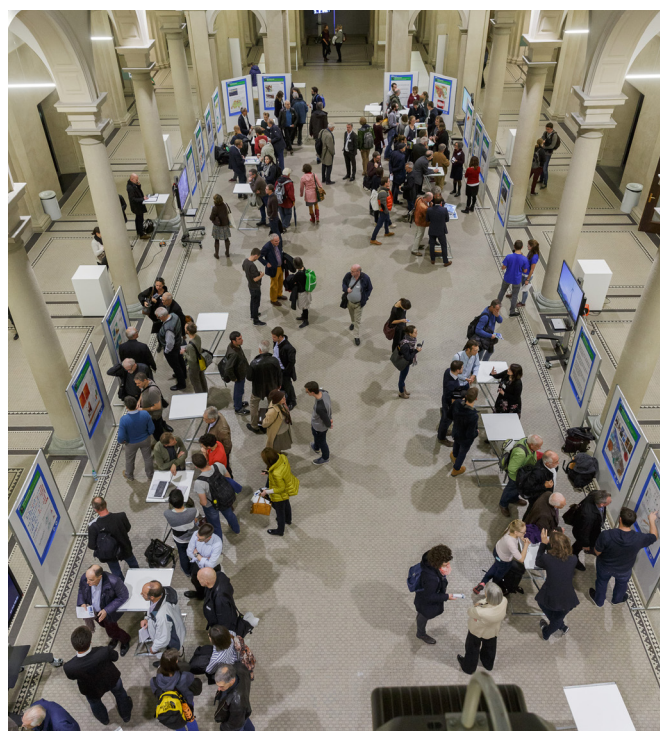


Table talks with experts and the participants

ETH-Klimarunde 2017

Stadt- und Klimawandel: Wie stellen wir uns den Herausforderungen?

November 8, 2017

How important are cities as drivers of climate change? What are the consequences of climate change in our cities? How can cities prepare for climate change? How can we adapt our urban lifestyles to mitigate climate change? These pressing topics were discussed among decision-makers from politics, industry, associations and public administration, researchers and students, as well as the public. This year's ETH-Klimarunde was jointly organized by C2SM (Center for Climate Systems Modelling) and the ESC.

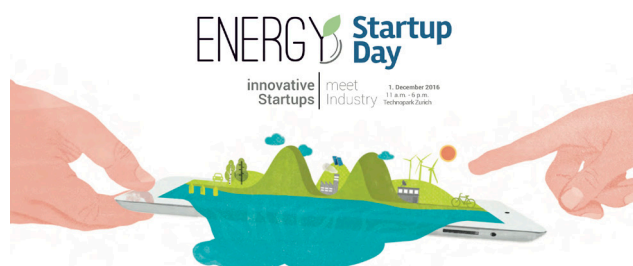
www.c2sm.ethz.ch/events/eth-klimarunde-2017.html

Energy Startup Day

November 30, 2017

The main goal of the Energy and Cleantech Startup day was to initiate collaboration for knowledge exchange between startups, incumbent companies, public institutions and new actors in the energy sector. This event was organized by the ZHAW School of Management and Law together with Impact Hub Zurich, SCCER CREST (Competence Center for Research in Energy, Society and Transition), CTI (Commission for Technology and Innovation, and the ESC.

www.energy-startup-day.ch



Annex

66 Active Members (as of 31.12.2017)

D-ARCH

Prof. Dr. Kees Christiaanse
Prof. Dr. Andrea Deplazes
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. Javier Pérez-Ramírez
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. Tobias Schmidt

Prof. Dr. Renate Schubert
Prof. Dr. Andreas Wenger

D-INFK

Prof. Dr. Friedemann Mattern

D-ITET

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. Roy Smith
Prof. Dr. Ayodhya Nath Tiwari
Prof. Dr. Vanessa Wood

D-MAVT

Prof. Dr. Reza S. Abhari
Prof. Dr. Konstantinos Boulouchos
Prof. Dr. Jan Carmeliet
Prof. Dr. Paolo Ermanni
Prof. Dr. Lino Guzzella
Prof. Dr. Patrick Jenny
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. Dimos Poulidakos
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
Prof. Dr. Johan Lilliestam
Prof. Dr. Anthony Patt
Prof. Dr. Michael Stauffacher
Dr. Evelina Trutnevyte
Prof. Dr. Bernard Wehrli

Total: 66 members

Former ESC members

Prof. Dr. Göran Andersson (Em.)
Prof. Dr. Wolfgang Kröger (Em.)
Prof. Dr. Hansjürg Leibundgut (Em.)
Prof. Dr. Reinhard Nesper (Em.)
Prof. Dr. Jennifer Rupp

Managing Board (as of 31.12.2017)

Prof. Dr. Dimos Poulidakos (Chair)

Prof. Dr. Robert Boes

Prof. Dr. Volker Hoffmann

Prof. Dr. Gabriela Hug

Prof. Dr. Marco Mazzotti

Prof. Dr. Anthony Patt

Prof. Dr. Arno Schlüter

Executive Office (as of 31.12.2017)

Dr. Christian Schaffner – Executive Director

Deborah Hufton – Education

Tanja Meier – PR and Communication

Members Partnership Council

ABB Schweiz

Alpiq

GE Power

Axpo

BKW

CKW

EKZ

ewz

Repower

Shell

swisselectric

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