

Energy Science Center

Annual Report 2019

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

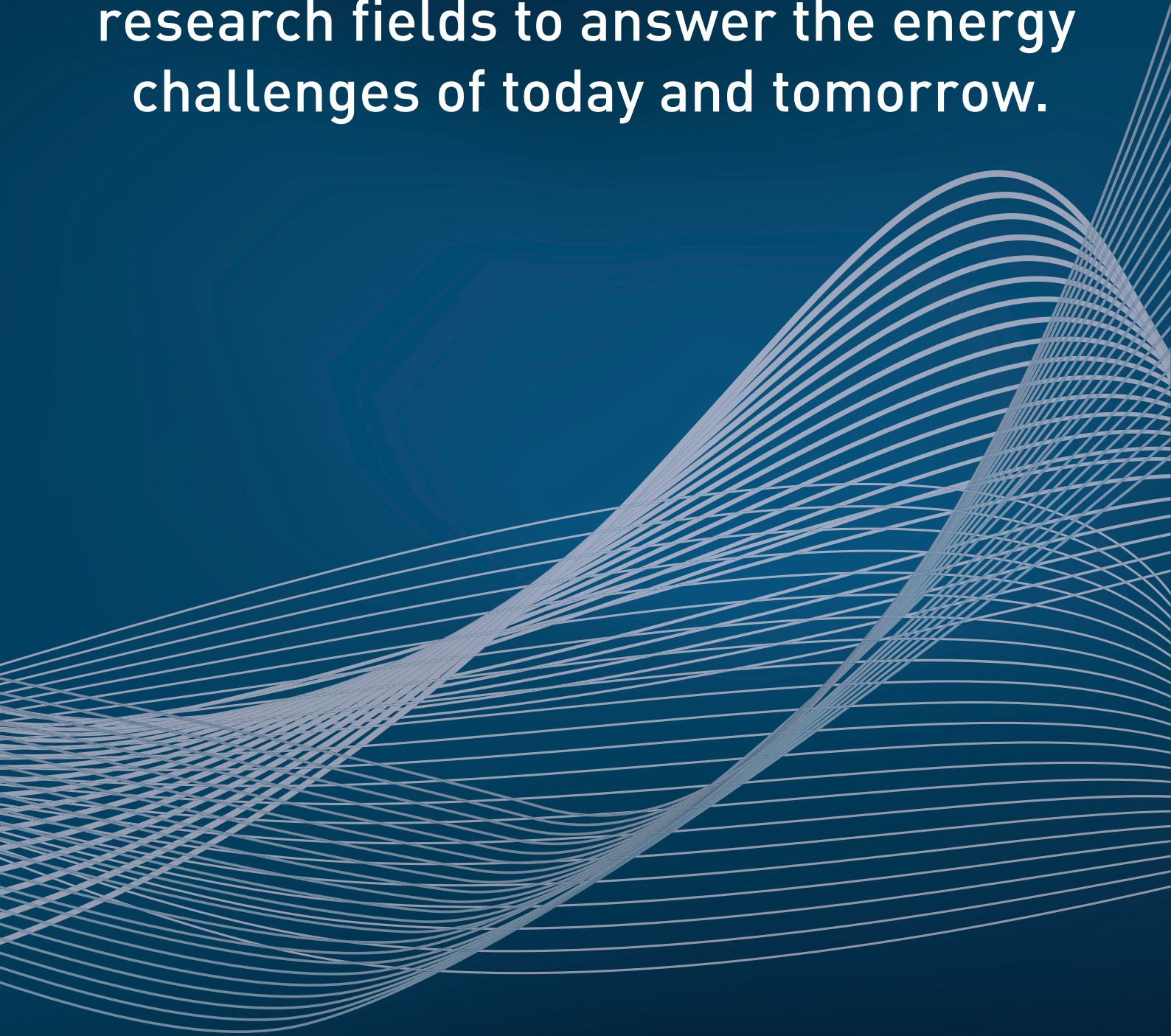


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DEAR COLLEAGUES, PARTNERS, AND FRIENDS OF THE ENERGY SCIENCE CENTER,

2019 was a very active year for our center: We were able to gain five new members from four different ETH departments, strengthening our interdisciplinary foundation both in research and education, we launched our “Renewable Management and Real-Time Control Platform” (ReMaP) together with our colleagues at Empa, PSI and the industry, we had a highly frequented booth at the Scientifica fair, where even “Globi” visited us and tested the electrified excavator and we finished the year with our legendary “Energy Day @ ETH”, just to name a few.

Our research platform “Nexus-e” for integrated scenario analysis of future energy systems involving investigators from multiple departments at ETH accomplished for the first time to produce consistent results hard-linking bottom-up engineering based models as well as top-down macro-economic models. This lays the groundwork for the analysis of future energy system scenarios for Switzerland and beyond in an unprecedented level of detail and consistency.


The Master’s programme in Energy Science and Technology keeps attracting outstanding students from all over the world, proving that we can deliver excellency despite increasing competition from similar programs starting in other universities. Furthermore, we are preparing for the first run of our Certificate of Advanced Studies (CAS) Applied Technology in Energy for business professionals.

Now we look forward to 2020, together for a sustainable energy system!



Dimos Poulidakos

Chair



Christian Schaffner

Executive Director

The Energy Science Center (ESC)

To tackle the central challenges facing the energy system, i.e. climate change, access to energy services, local pollutants and risks and benefits to society, additional knowledge and new technologies are needed, relying on the expertise and cross-cutting research of engineering, economic and social scientists.

The Energy Science Center (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. In 2019, the ESC has continued to

integrate specialists and disciplines even further by facilitating inter-disciplinary and inter-departmental energy research, teaching and outreach activities. Therefore, the ESC has strengthened its role as national and increasingly international player in the energy sector.

www.esc.ethz.ch →

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

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.



ESC and FEN offices on their annual team event

Organisational Structure

The General Assembly, containing the ESC members, is the ESC governing body. Currently 61 professors from ten different departments are members of the ESC.

The **Managing Board** is the executive body of the ESC and is composed of seven 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.

News

The ESC welcomed five new members in 2019:



Prof. Dr. Olga Fink

Intelligent Maintenance Systems

Department of Civil, Environmental and Geomatic Engineering (D-BAUG)



Prof. Dr. Gonzalo Guillén Gosálbez

Sustainable Process Engineering

Department of Chemistry and Applied Biosciences (D-CHAB)



Prof. Dr. Maria Lukatskaya

Electrochemical Energy Systems

Department of Mechanical and Process Engineering (D-MAVT)



Prof. Dr. Sonia Seneviratne

Land-Climate Dynamics

Department of Environmental Systems Science (D-USYS)

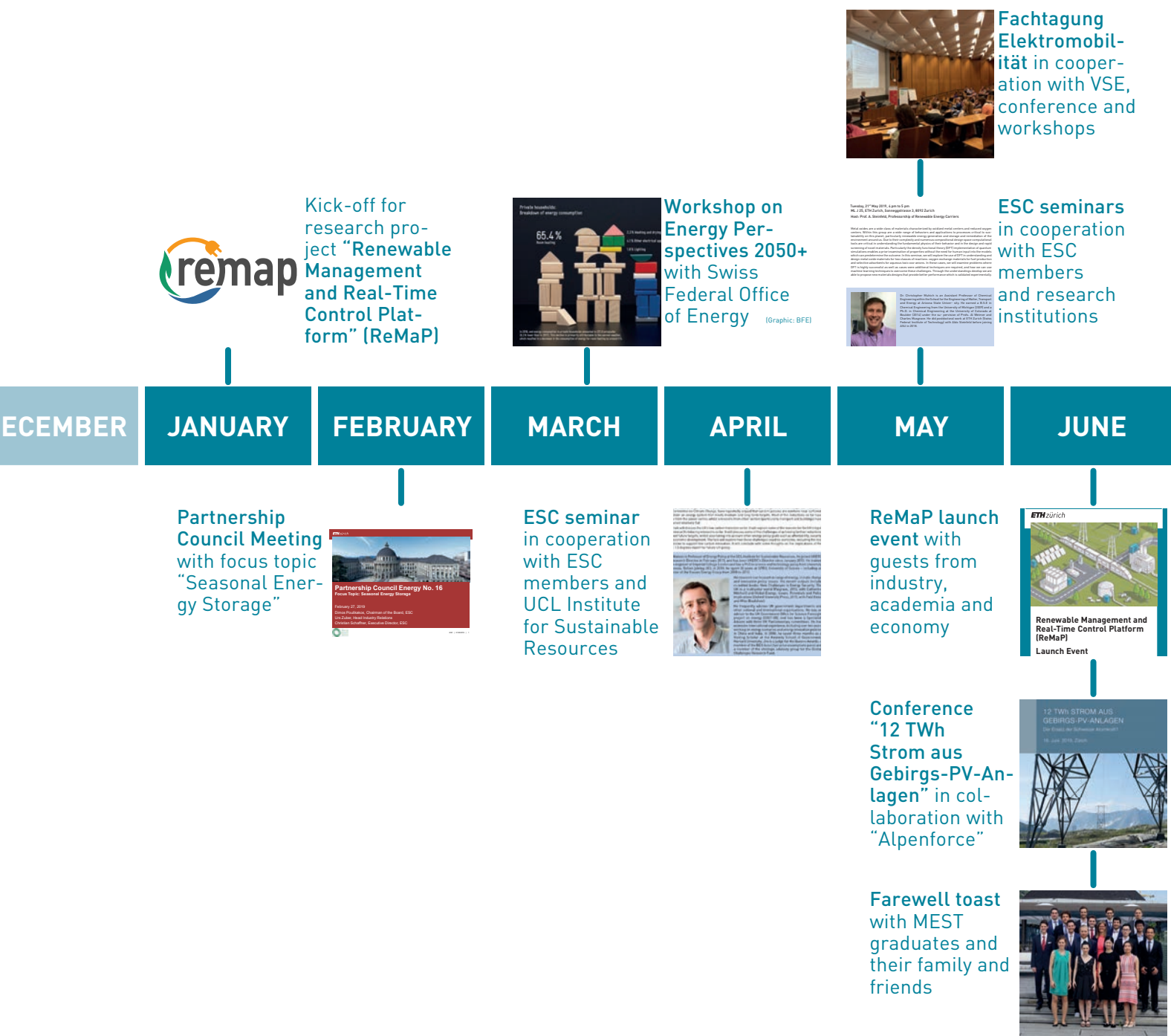



Prof. Dr. Jeroen Anton van Bokhoven

Heterogeneous Catalysis


Department of Chemistry and Applied Biosciences (D-CHAB)

ESC highlights in 2019






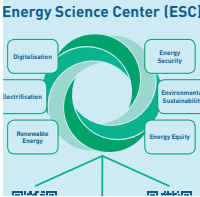
ESC seminar with a delegation from North China Electric Power University




Conference on second-life applications of car batteries, in collaboration with partner institutions



Smart Grid and Energy Storage Road Show, in collaboration with the Canadian Embassy in Switzerland




ETH industry day, ESC showcasing its inter-disciplinary research projects ReMaP and Nexus-e



Conference and workshops: Saisonale Wärmespeicherung in der Schweiz

JULY


Science fair “Scientifica”, ESC booth with “e-excavator”, research items, science cafés, shows and visits



AUGUST


SEPTEMBER

ESC hosts roundtable by Forum Energiespeicher Schweiz, organised by AEE SUISSE




OCTOBER

Klimarunde, co-organised by the ESC and C2SM, public conference and discussions with experts




NOVEMBER

FCL Roundtable in Singapur, ESC presents research project ReMaP and partakes in open discussion




DECEMBER

Energy Day @ ETH 2019, focus dialogues, symposium, youth energy conference



JANUARY

Energy Start-up Day, co-organised by the ESC and ZHAW, investor meetings, talks and pitches



Research



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Research Approach

The ESC research activities focus on large, cross-cutting themes run as inter-departmental and inter-disciplinary projects. In 2019, two flagship programs that started as strategic initiatives, have been further developed to build the basis for services to the ETH research community and beyond: “Renewable Management and Real-Time Control Platform (ReMaP)” and “Integrated Energy Systems Modelling Platform (Nexus-e)”.

Furthermore, 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).

Generally, 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;

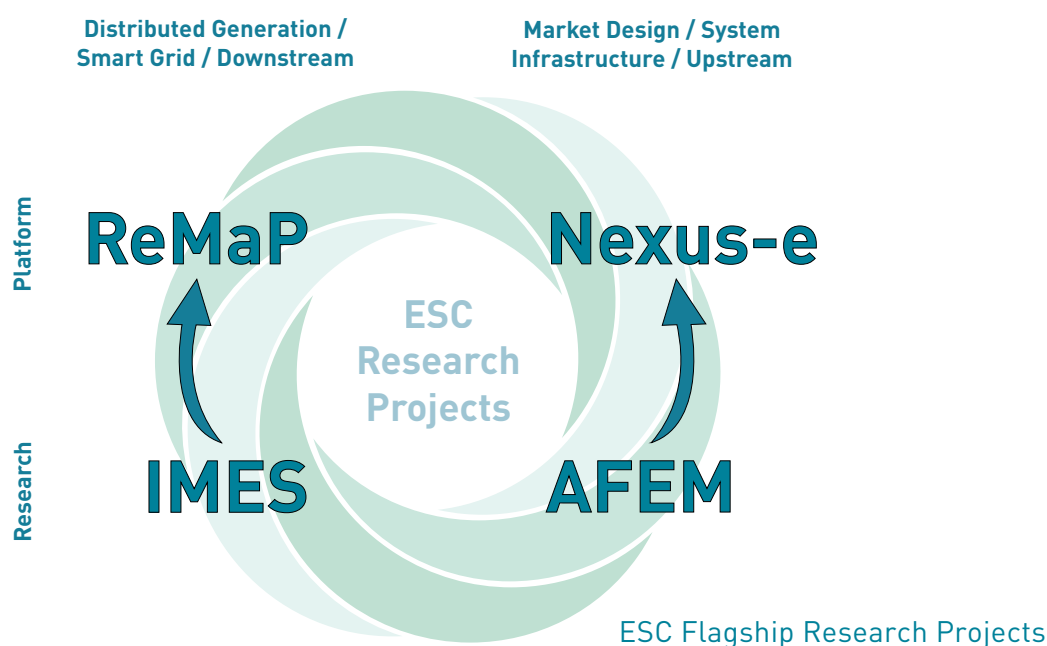
Hosting researchers for specific projects in order to facilitate inter-departmental research projects;

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

Integrated Energy Systems Modelling Platform (Nexus-e)

The objective of the project Nexus-e – Integrated Energy Systems Modelling Platform is to develop and maintain a modelling platform that cuts across the boundaries of established fields of knowledge by combining existing and new tools from different disciplines. This 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 electric power system.

Policy changes in the energy sector impose wide-ranging implications throughout the whole energy system and influence all sectors of the economy. Therefore, the analysis of how the electric power system will and should evolve and the study of what the consequences of such far-reaching policy decisions in the power sector are of high importance. However, currently there is no 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, political sciences, economics and risk engineering and management is in the unique position to develop such a comprehensive platform. While the Nexus platform will enable studying a wide range of questions, the first phase has been focusing on the role of flexibility providers in Switzerland for the future electricity system. The Swiss Energy Strategy 2050 aims at a shift towards new renewable energy technologies and energy saving using several efficiency measures. Hence, with renewable energy sources (RES), such as wind and solar, becoming an important share of the Swiss

generation mix in the foreseeable future, system operators will face major challenges in their effort to keep the system safe and reliable. As a result, the “residual load” which must be served from the remaining generation fleet will become more and more volatile and the power system has to be flexible enough to cope with the variability and uncertainty of RES, and it also must have sufficient back-up capacities for times when RES production is low. Both traditional centralized flexibility providers (i.e., hydropower, gas-fired stations) and decentralized flexibility resources (i.e., storage, demand-side management) have emerged as the essential technologies to balance supply and demand under a high RES scenario. However, there is a certain hesitation to invest in large centralized or smaller decentralized units due to uncertain electricity prices, insufficient market incentives, and absence of a valued flexibility product in today’s electricity markets. At the same time, it is not yet clear how decentralized resources will fit in with the traditional centralized production units. All these issues have raised the complex question of what should be the optimal mix of flexibility providers for Switzerland in a scenario with high RES deployment.

Being able to answer questions relevant to the energy future of Switzerland and of Europe in a comprehensive, reproducible and transparent fashion is immensely important for well-founded discussions on how the future energy structure should look like in terms of infrastructure but also in terms of policies. It can be expected that this platform can serve as a test environment for a wide range of scenarios and as an evaluation tool for what impacts certain decisions will have.

Renewables Management and Real-time Control Platform (ReMaP)

The main objective of the ReMaP project is to provide a platform that allows the interaction of diverse energy conversion and storage technologies to be tested and demonstrated in a realistic environment. This platform builds on and extends the NEST/move/ehub demonstrators at Empa and the Energy System Integration (ESI) platform at PSI. Additional objectives of the ReMaP project are the use of the platform in (a) educating students in decentralized renewable energy systems and (b) informing decisionmakers and the public about the importance and the development of such systems.

Using a cloud-based infrastructure, the platform will allow researchers to carry out experiments with hardware at NEST/move/ehub and ESI and as well as simulations of the hardware. In addition, the platform will permit the exchange of information

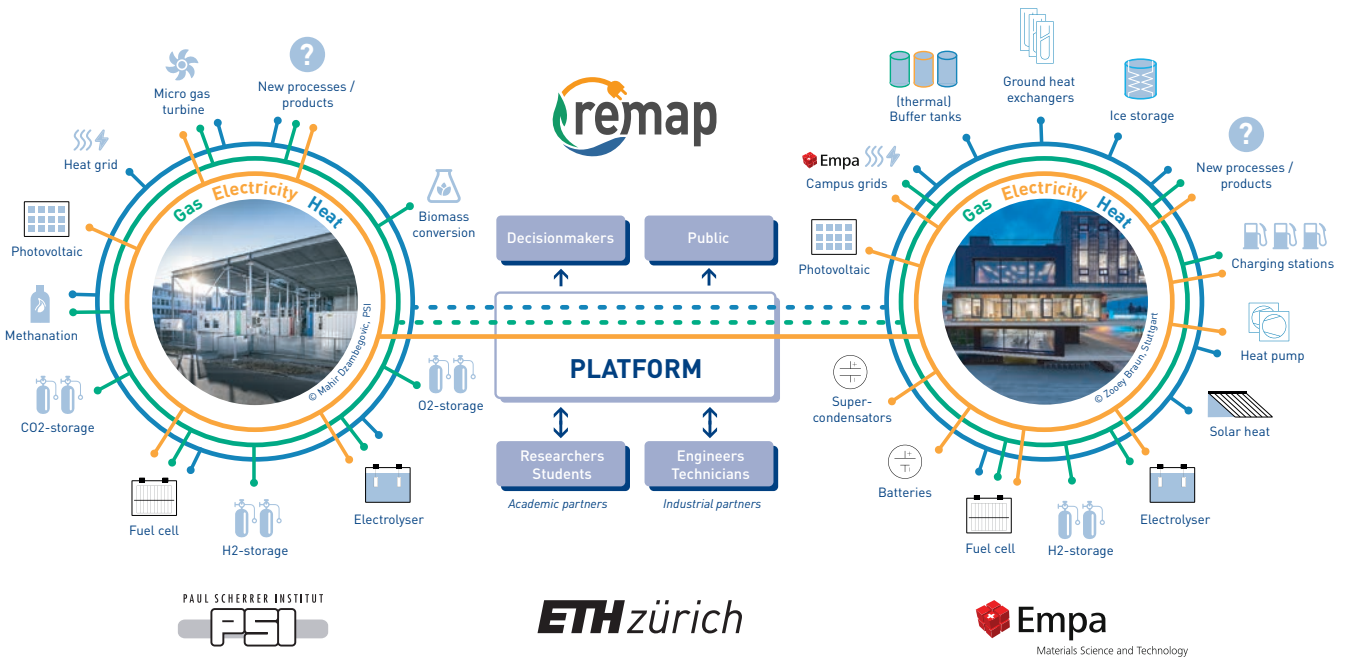
between the experiments and simulations and therefore enable hardware-in-the-loop simulations. Data from the experiments and simulations will be stored in a dedicated archive, permitting its later use in simulations as well as model formulation and validation. The platform is designed to allow the integration of further demonstrators. A long-term goal of the ReMaP project – especially in a possible second project phase (July 2021+) – is therefore to convince demonstrators developed in other projects (e.g., Quartierstrom) and making both the hardware at the various locations as well as the simulation and archiving capabilities accessible to a broad research community.

Project partners:

Empa, PSI, Adaptricity, Smart Grid Solutions, Supercomputing Systems, National Instruments



ReMaP launch event in June 2019 at ETH Zurich



Education



Farewell toast with MEST graduates 2019 (Photo: Elena Raycheva / ETH Zurich)

Master Energy Science and Technology (MEST)

The ESC coordinates the interdisciplinary Master's programme Master Energy Science and Technology (MEST) at ETH Zurich, a world-class Master's programme for energy engineers, aimed at students with an engineering or a technological science background. MEST continues to offer a specialised programme of a unique type, enabling study across a wide range of energy-related courses offered by ETH Zurich and providing students with the academic skills required by the energy marketplace.

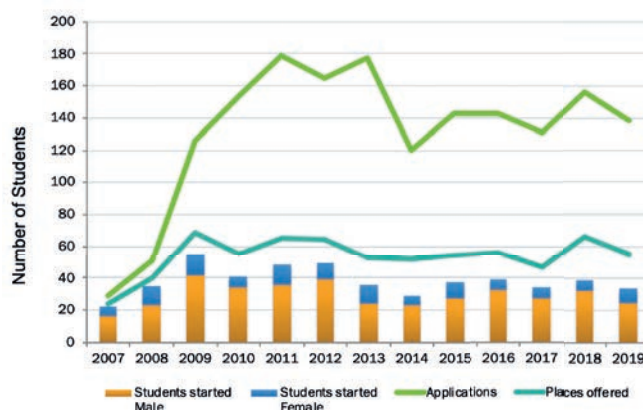
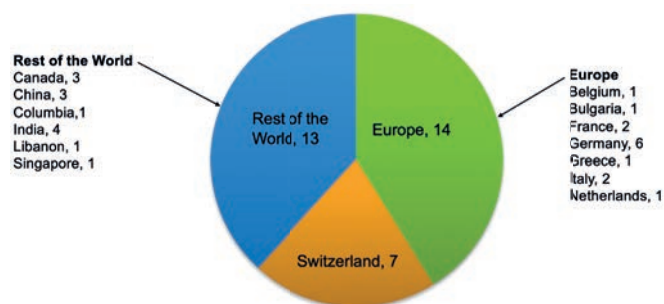
The joint programme between D-ITET and D-MAVT has been running since 2007 and has grown to become one of the most sought-after interdisciplinary Master's programmes at ETH Zurich. The fundamental aspects of Energy Science and Technology are covered by a range of compulsory courses in the three academic areas of electrical power engineering, energy flows and processes, and energy economics and policy; elective courses can be selected from any energy-related course within the ETH Course catalogue. Another nine departments actively contribute to the MEST through tutors and

their offer of nearly 50 energy-related core courses.

Commencing in 2018, the MEST programme was lengthened from 90 credits to 120 credits, bringing it into line with the majority of other ETH Zurich Master's programmes. This enabled the expansion of courses available and, most innovatively, a new course designed uniquely for the MEST programme.

This course focuses on giving MEST students the experience of working on real-world problems currently faced by companies within the energy sector, linking industry and academia, and covering some of the technical, economic and regulatory aspects of the challenges of building a sustainable energy system for the future. The students work together in teams, and present their final work to the whole class and industry partners.

www.master-energy.ethz.ch



2019 MEST students: home country

Number of MEST students

Master Integrated Building Systems (MBS)

The ESC supports the interdisciplinary Master's degree programme in Integrated Building Systems (MBS) at ETH Zurich. The chair of the board and the executive director of the ESC are members of the admission committee and were on the advisory committee during the initial planning phase of the Master programme.

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

CAS Applied Technology in Energy (CAS ATE)

ETH Zurich's continuing education programme CAS Applied Technology in Energy (CAS ATE) is part of the Master of Advanced Studies in Applied Technology (MAS AT), together with other CAS courses. The CAS ATE is designed to provide managers with a deeper education in the rapidly evolving world of energy and electrification. It's a so-called "Reverse MBA". It will help participants to better understand the ongoing "Energy Revolution" and enable them to shape the energy future of their company and industry.

The MAS AT is a continuing education programme offered by D-ITET in cooperation with multiple departments and research centres at ETH Zurich. Within the MAS AT, ESC executive director Dr. Christian Schaffner is programme co-director of the CAS ATE. Furthermore, the ESC and its staff contribute directly to two modules within the CAS ATE, one of which is an online module to transfer the basics of energy engineering and systems.

mas-at.ethz.ch/cas-programs/cas3a.html

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

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. At the MEST 10-year event (see below) held in May 2018, two MEST alumni, now both working for ewz, gave short talks outlining their careers to date. The Frontiers presentations are held annually throughout the spring semester, 14 each year, and have been running since 2012. In spring 2018, both the presenters and the attendees (just over 50 of them) came from 11 different ETH departments, plus PSI & EMPA.

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

Outreach



ESC Events

Energy Day @ ETH 2019

December 10, 2019

During the full-day conference, ETH and high school students as well as participants from academia, industry and the public discussed approaches and strategies towards achieving a climate neutral energy system by 2050. In the morning, in a new format called “Jugend-Energiekonferenz”, high school students, ETH students, ETH experts and industry partners jointly worked on real-life energy challenges. Simultaneously, the other participants discussed current research on climate-neutral mobility and electricity systems with ETH experts. In the afternoon, all participants learned about the scientific ETH perspective towards achieving climate neutral energy systems. The conference was concluded with a compelling panel discussion that involved the novel aspect of student challengers.

esc.ethz.ch/events.html



“Jugend-Energiekonferenz” in the morning

Photo: ETH Zürich / Alessandro Della Bella



Symposium in the afternoon with Prof. Arno Schlüter

Photo: ETH Zürich / Alessandro Della Bella

Scientifica 2019

August 30 to September 1, 2019

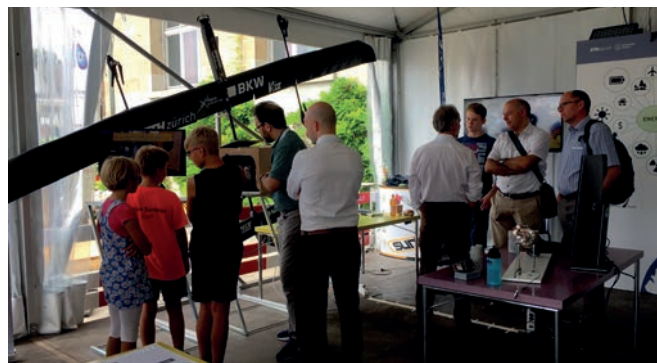
During the three-day event Scientifica, the ESC hosted an interdisciplinary booth, lab visits, special shows and a panel discussion. At the booth, visitors had the opportunity to learn about selected ETH research projects from the field of energy, discuss about current and future energy trends with ETH experts and personally try a fully electrical excavator of a former ETH focus project. During lab visits and special shows on Saturday and Sunday, visitors could see first-hand how research is being conducted at labs of ESC members. Finally, Christian Schaffner and Bastien Girod, member of the National Council, held a panel discussion on the topic of “Die Energieversorgung der Schweiz nachhaltig gestalten – aber wie?”.

esc.ethz.ch/events/scientifica-2019.html



Globo operating the E-excavator from Suncar HK

Photo: Annina Gantenbein



Visitors at ESC's booth learn about ETH focus projects

Photo: Annina Gantenbein

ESC Collaborations

Fachtagung Elektromobilität

May 23, 2019

The conference on E-Mobility was organized in collaboration with the Verband Schweizerischer Elektrizitätsunternehmen (VSE). Experts from academia and industry and the participants discussed opportunities and challenges regarding the integration of e-mobility in existing and future electricity grids.

Photo: Christian Schaffner



Second Life Conference

September 12, 2019

As the global demand for batteries to be used in e-mobility is raising fast, in less than ten years, all these batteries will be ready for second-life use. The aim of the conference was to bring together stakeholders from economy and science and to present and share current second-life trends and applications in order to overcome still-existing obstacles. In collaboration with Ökozentrum.



Photo: Ökozentrum

ESC Seminars

The UK's transition to a low carbon economy: progress and challenges ahead

April 10, 2019

Prof. Jim Watson, University College London

Research Opportunities and Challenges for a Sustainable Energy Future

May 21, 2019

Dr. Arun Majumdar, Stanford University

Klimarunde 2019

October 23, 2019

The ESC supported the C2SM (Center for Climate Systems Modeling) in the organization and successful realization of Klimarunde 2019, where top climate researchers discussed what consequences climate change has in alpine regions or which risks emerge in these regions due to climate change. The event also highlighted what could be done to mitigate climate change.



Photo: ETH Zürich / Tom Kawara

Smart Grids & Energy Storage Roadshow

November 15, 2019

In partnership with the Embassy of Canada, the ESC organised this one-day event on smart grids and energy storage to enable exchange between Canadian and Swiss participants from industry and academia on current research and best practice. The event comprised research and industry presentations, a panel and B2B meetings.

Understanding and Designing Metal Oxide Behavior from the Ground up

May 21, 2019

Dr. Christopher Muhich, Arizona State University

North China Electric Power University

July 9, 2019

Prof. Yongping, Prof. Yongqian, Prof. Chao, Prof. Jianbin (all NCEPU)

Annex

61 active Members (as of December 31, 2019)

D-ARCH

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. Olga Fink
Prof. Dr. Guillaume Habert
Prof. Dr. Stefanie Hellweg
Prof. Dr. Martin Raubal

D-CHAB

Prof. Dr. Gonzalo Guillén Gosálbez
Prof. Dr. Maksym Kovalenko
Prof. Dr. Javier Pérez-Ramírez
Prof. Dr. Thomas Schmidt
Prof. Dr. Jeroen A. van Bokhoven

D-ERDW

Prof. Dr. Domenico Giardini
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. Konstantinos Boulouchos
Prof. Dr. Jan Carmeliet
Prof. Dr. Paolo Ermanni
Prof. Dr. Lino Guzzella
Prof. Dr. Patrick Jenny
Prof. Dr. Maria Lukatskaya
Prof. Dr. Edoardo Mazza
Prof. Dr. Marco Mazzotti
Prof. Dr. Christoph Müller
Prof. Dr. Nicolas Noiray
Prof. Dr. David Norris
Prof. Dr. Christopher Onder
Prof. Dr. Dimos Poulidakos
Prof. Dr. Horst-Michael Prasser
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. Anthony Patt
Prof. Dr. Sonia I. Seneviratne
Prof. Dr. Michael Stauffacher
Prof. Dr. Bernard Wehrli

Managing Board (as of December 31, 2019)

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 December 31, 2019)

Dr. Christian Schaffner – Executive Director

Annina Gantenbein - PR, Communication and Events

Dr. Andreas Haselbacher - Senior Scientist, Project Manager ReMaP

Deborah Hufton – Education

Elena Raycheva – Research and Teaching Assistant

Partnership Council (as of December 31, 2019)

ABB Schweiz

Alpiq

Axpo

BKW

CKW

EKZ

ewz

GE Power

Repower

Shell



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