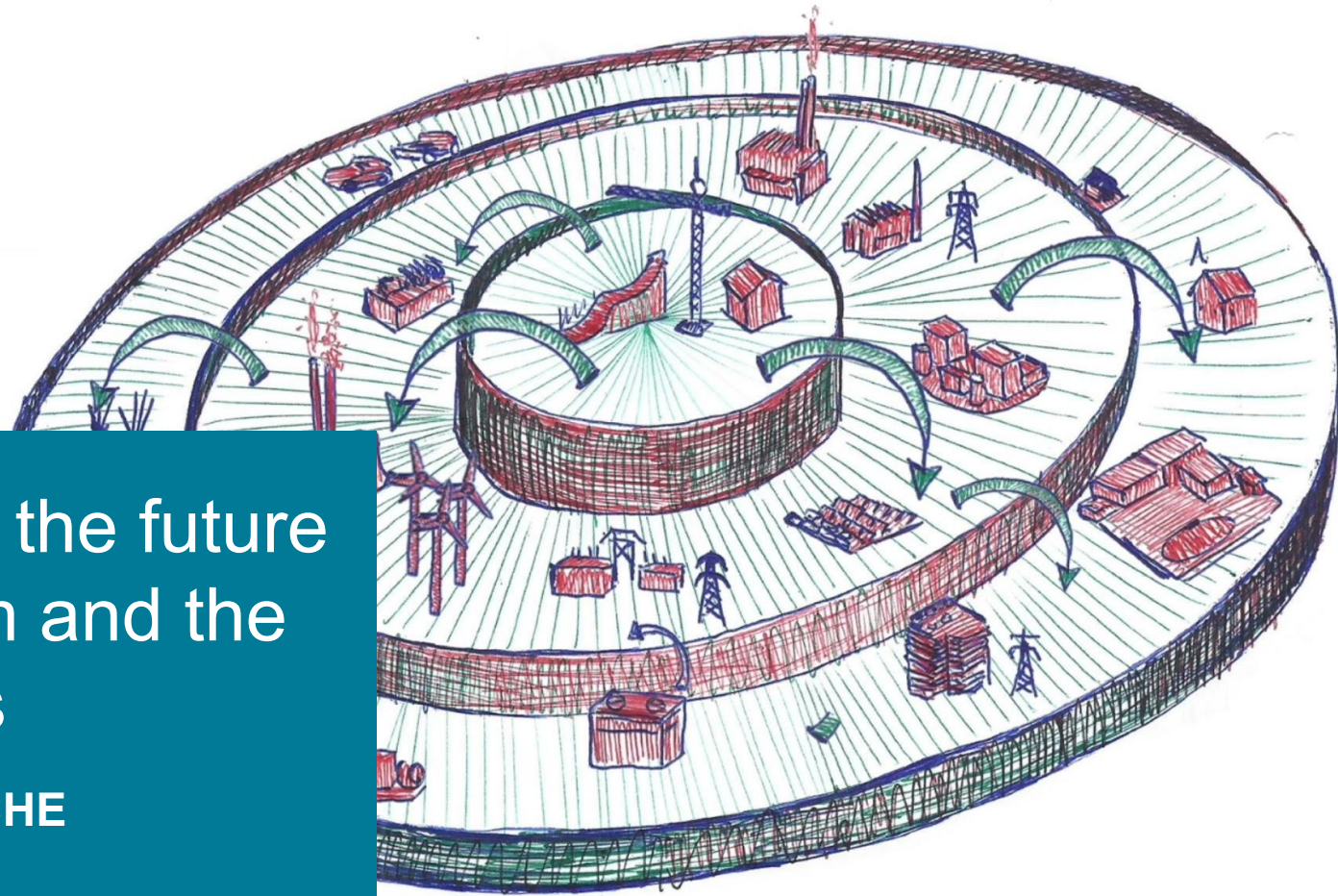


Nexus-e: Scenarios for the future Swiss electricity system and the role of flexibility options

ENERGIEFORSCHUNGSGESPRÄCHE
DISENTIS 2021

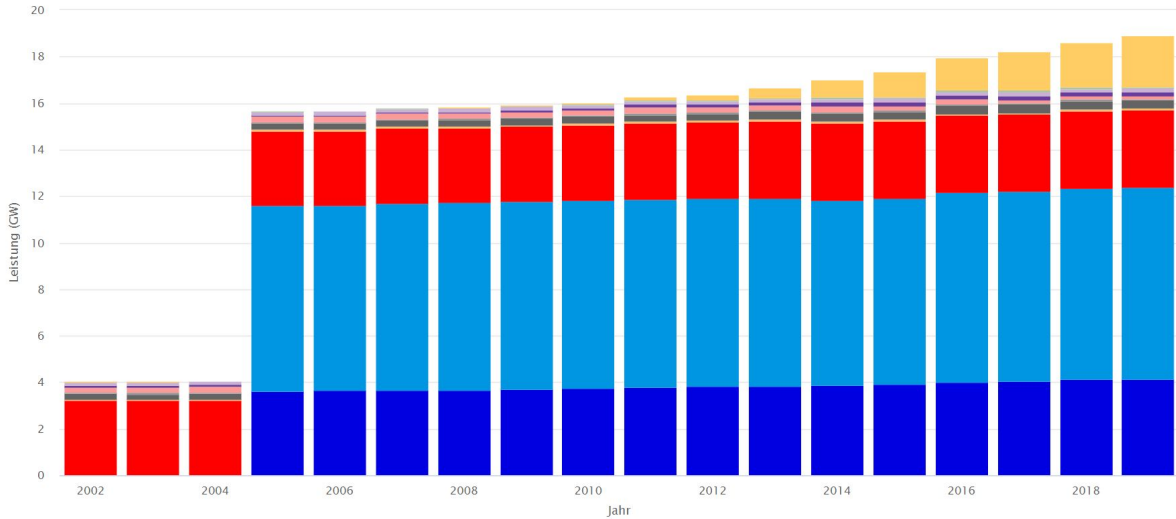
Marius Schwarz, Energy Science Center, ETH Zürich



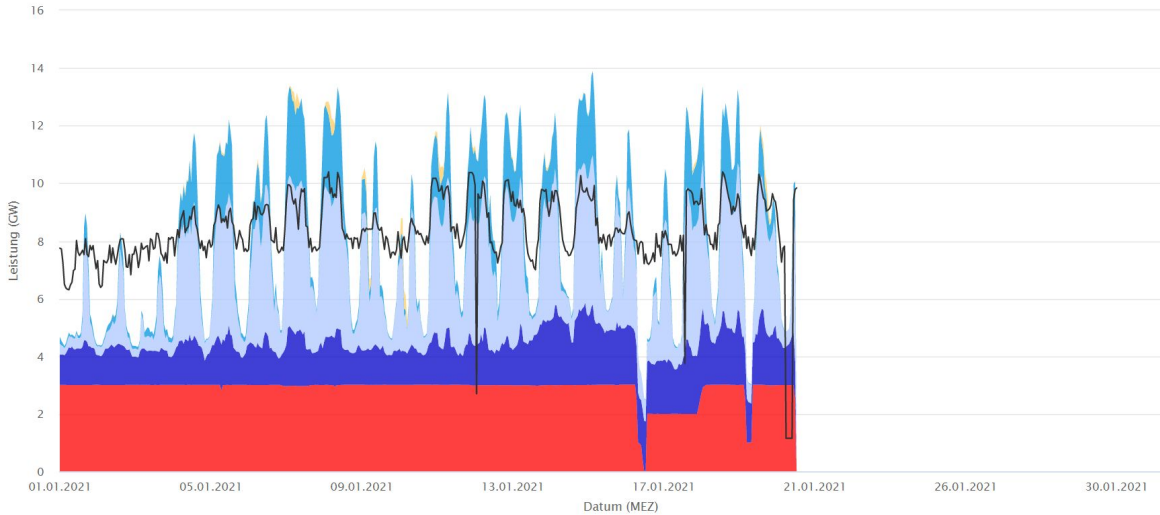
Energy transition in Switzerland

What is Nexus-e?

Installierte Netto-Leistung zur Stromerzeugung in der Schweiz



Stromerzeugung in der Schweiz 2021



- Laufwasser
- Kernenergie
- Kehrlichtverbrennung mit Wärme
- Wind
- Speicherwasser
- Konventionell-thermisch
- Industrie
- Solar
- Pumpspeicher
- Deponiegas
- Fernheizkraftwerke
- Umwälzwerk
- Kehrlichtverbrennung ohne Wärme
- Klein-WKK

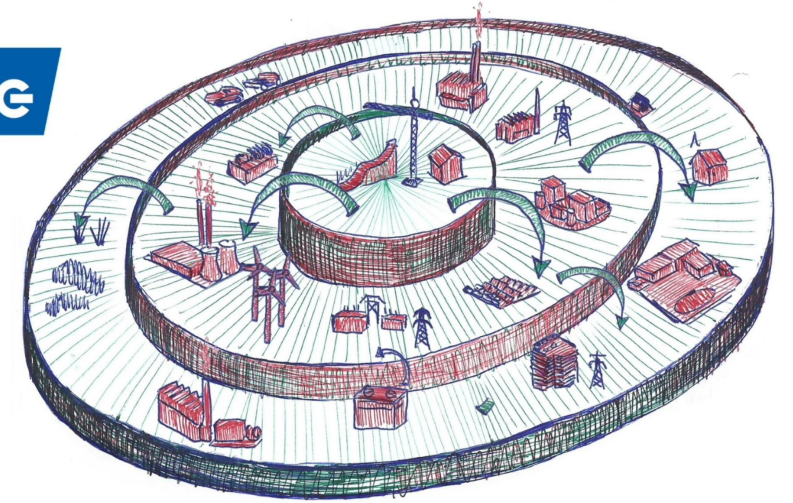
Energy-Charts.info - letztes Update: 03.12.2020, 22:57 MEZ

Vision of a Modeling Infrastructure for energy systems:

What is Nexus-e?

- A modelling platform that aims to represent the whole electricity system at regional and national scale.
- Based on modularity, transparency, and the definition of interfaces between models.
- Combines strengths of top-down and bottom-up modelling approaches to account for complexity in the electricity system

Nexus-e



Nexus-e is based on three principles:

Transparency:

- Be a transparent and well-trusted, ready-to-access platform that is openly available to ETH researchers, industry and partners
- Provide reproducible results and analyses: not a 'black box' and keep/capture the *know how* of existing/ongoing research projects (effectively transfer the "know-how" across disciplines)
- Harmonize research viewpoints, data and modelling assumptions

Modularity:

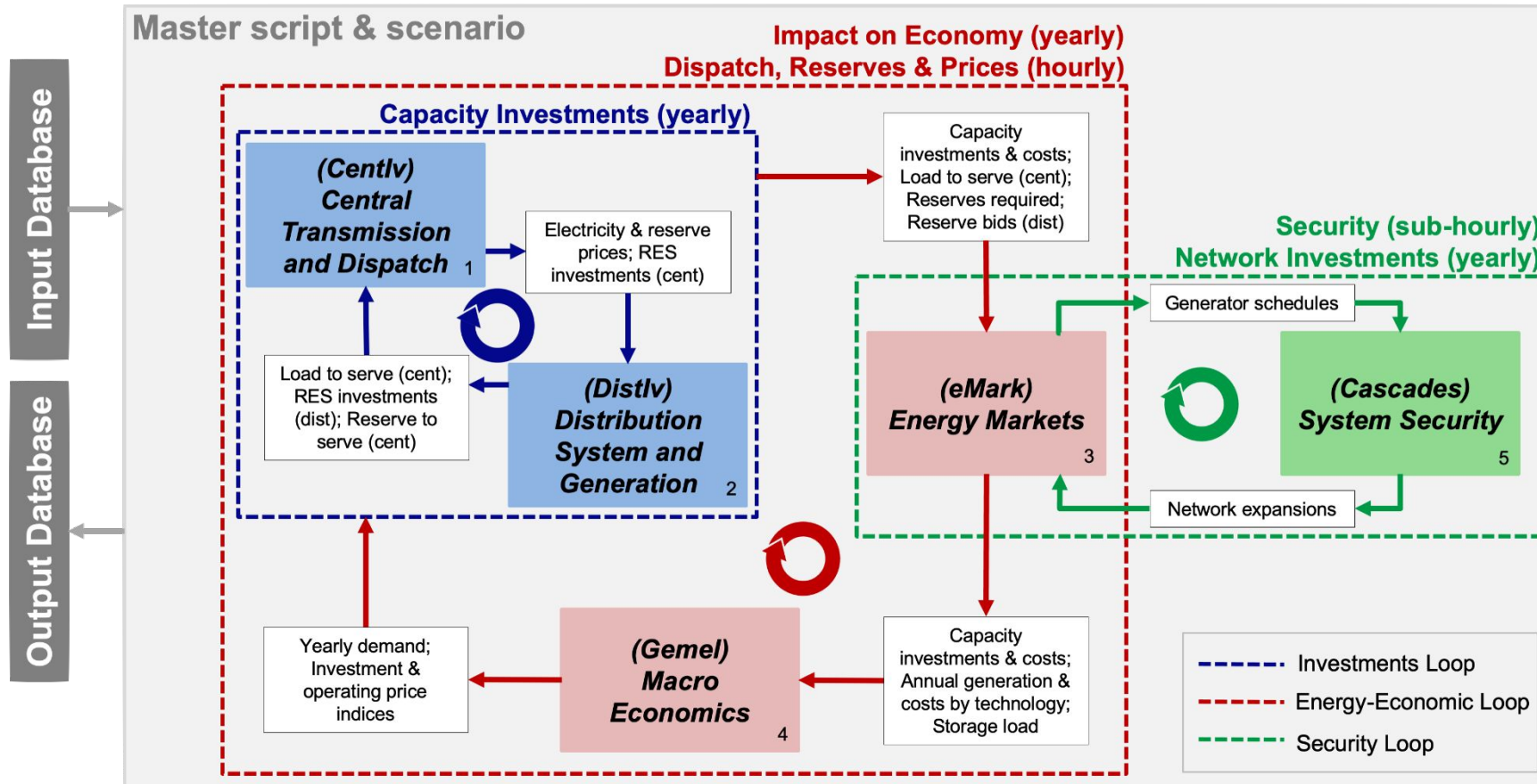
- Integrate cross-disciplinary models through a flexible and modular structure
- Interact with existing projects to capture/keep know-how

Defined interfaces:

- Identify, define and implement interfaces to capture model interdependencies
- Interconnect layers and sectors of the energy system

The actual implementation connects and loops the modules to address

What is Nexus-e?

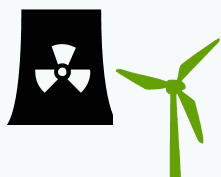


- Key model paradigms:
 - (non-)Linear & mixed integer optimization
 - High temporal and spatial resolution
 - Interfaces & hard linking modules from different sectors
- Loops & Interfaces
 - Capacity investments between central and distributed systems
 - Influences between energy and the economy
 - System security and network expansion

P&D Project: The role of flexibility providers in shaping the future energy system

What is Nexus-e?

Energy Strategy 2050



- Nuclear phase-out
- Renewables
- Demand reduction
- Deep decarbonization



- Security of supply
- Investment and incentives



Renewables cause higher variability and uncertainty and needs to be matched with **increased flexibility**.

- Short-term flexibility: balances sub-hourly and hourly deviations in the actual electricity demand and generation; supports system stability and frequency control,
- Long-term flexibility: accounts for the daily, weekly, and seasonal needs for generation or oversupply because of outages, weather conditions, or seasonal changes.

Energy Transition in other European Countries



1. *What are potential pathways for the future Swiss electricity system?*
2. *What is the need for flexibility in the projected Swiss electricity system?*
3. *Who provides the required flexibility?*
4. *What are the macroeconomic and environmental impacts of the future Swiss electricity system?*

We analyze three scenarios (Baseline, Nuclear 60, High Flexibility) of the future Swiss power system.

Simulated scenarios

Baseline

- Includes the projected development of input parameters (e.g., 50 year lifetime of nuclear power plants)
- Represents the status quo (i.e., in place and planned) of the policy framework (e.g., financial subsidies for PV systems)

Nuclear 60

- Reflects the discussion about the nuclear power phase-out
- Assumes a lifetime of 60 years for nuclear power plants
- Swiss law forbids the construction of new and fundamental modifications to existing nuclear plants
- However, existing plants can operate as long as they fulfill the conditions for safe operation

High Flexibility

- Reflects the discussion on the impact, value and uncertainty of an increased supply of distributed flexibility in the power system and
- Assumes 50% lower battery costs and 100% higher demand-side management potential for 2030-2050
- Battery costs: 200 - 1400 €/kWh [1], uptake of electric vehicles crucial
- Demand side management potential: 0.6 - 1.15 GW today, potential increase to 2.5 GW by 2030 [2][3]; general electrification crucial

Table 6: Overview nuclear power phase out under 50 and 60 years of lifetime

Nuclear power plant/reactor	Capacity	Operation since	Phase-out in year (runtime 50 years)	Phase-out in year (runtime 60 years)
Beznau 1	365	1969	2019	2029
Beznau 2	365	1972	2022	2032
Mühleberg (KKM)	355	1972	-	-
Gösgen (KKG)	1060	1979	2029	2039
Leibstadt (KKL)	1220	1984	2034	2044

Web Viewer: <https://nexus-e.org/results-flexibility-providers/>

Envisioned development of the Nexus-e platform

The diagram illustrates the Energy Ecosystem, showing the interaction between various energy sectors and the macro economy. At the center is a circular flow labeled "Macro Economy & Policy" and "Energy sectors". The flow is divided into "Top-Down" (Energy markets, Economy: labor, capital, goods, Investments) and "Bottom-Up" (Utilities + distribution, Policy, Smart Grids). The flow is also divided into "Generation: Nuclear/Gas/Coal", "Biofuels", "Agricultural sector", "Wind power", "Solar farms", "Hydro power", and "sub-stations + Netw". The diagram shows the interaction between these sectors and the macro economy.



DIE ENERGIEZUKUNFT MODELLIERE
ENERGIEPERSPEKTIV

Industrie- und
Dienstleistungssektor
Private Haushalte
Öffentliche Haushalte
Gewerbe- und Industrie

Deutsch

Die ETH Zürich hat ihre neue Modellierungsplattform Nexus-e vorgestellt. Sie soll künftig ermöglicht werden, die Energieperspektiven der Zukunft zu analysieren.

Entwickelt wird Nexus-e von einem interdisziplinären Forschungsteam der ETH Zürich. Das Bundesamt für Energie (BFE) erklärt im Interview, was sich das BFE von dieser neuen Plattform verspricht.

Energieplus: Warum hat das BFE Nexus-e unterstützt?

ener|gate
messenger⁺

ener|gate
messenger.ch

SCHWEIZ

DEUTSCHLAND

EUROPA

INTERNATIONAL

ENERGIEFORSCHUNG

ETH MODELLIERT DIE ENERGIEWENDE

SCHWEIZ

21.01.2021 - 09:52

AUF MERKLISTE SETZEN

DRUCKEN

VON DENNIS FISCHER

ETH zürich

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Die Energiewende modellieren

20.01.2021 | News
Von: Michael Keller

Ein interdisziplinäres Forschungsteam der ETH Zürich entwickelt in einem vom Bundesamt für Energie (BFE) unterstützten Projekt die Modellierungsplattform «Nexus-e». Sie erlaubt es, den Einfluss von technologischen, wirtschaftlichen sowie regulatorischen Entwicklungen auf das Energiesystem der Zukunft zu analysieren.



«Nexus-e» heisst die neue ETH-Plattform für die Modellierung von Energiesystemen. Das Simulationswerkzeug kann ein breites Spektrum von Auswirkungen möglicher Pfade der Schweizer Energiezukunft quantifizieren. (Illustration: Nexus-e / ETH Zürich)

Scenario Results

[Download](#)

[Interact with the results](#)

Summary

In 2020, we have successfully completed Phase 1 of the Nexus-e project, including the pilot project ["The role of flexibility providers in shaping the future energy system"](#).


Read our **Scenario Results** report to find out

- What are potential pathways for the future Swiss electricity system?
- What is the need for flexibility in the projected Swiss electricity system?
- Who provides the required flexibility?
- What are the macroeconomic and environmental impacts of the future Swiss electricity system?

Simulation Framework and Interfaces


[Download](#)

A graphic for the GemEI Module Documentation. It features a circular flow diagram with various icons representing different modules and their interactions. A vertical bar on the right side of the diagram is labeled 'Data Flow'. Below the diagram, the text 'GemEI Module Documentation' is displayed in a large, bold, black font. At the bottom right, there is a blue button with the word 'Download' in white text.




Centiv Module Documentation

[Download](#)



Distiv Module Documentation

[Download](#)



eMark Module Documentation

[Download](#)

“Im derzeit sehr dynamischen energiepolitischen Umfeld braucht es zuverlässige Analysetools, um einen Blindflug zu verhindern.”

(BfE, energiea,
<https://energieplus.com/2021/01/21/die-energiezukunft-modellieren-wie-sich-nexus-e-und-die-energieperspektiven-2050-ergaenzen/>)

Envisioned development of the Nexus-e platform

Envisioned Extensions



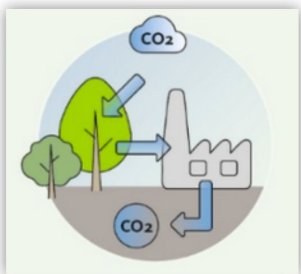
CH2040: Systems analysis to support rapid complete Swiss decarbonization

🕒 Project period: 2020-2021

👤 Partner(s): Prof. Dr. Anthony Patt (ETHZ CP)

We analyze the feasibility of the Swiss decarbonization by combining the detailed representation of the Swiss electricity market of Nexus-e with the pan-European, energy sector-wide perspective of Calliope, an energy system model developed by the Climate Policy group at ETH Zurich. The collaboration with Calliope will provide Nexus-e with new scenarios of electricity demand and energy system cost. Calliope in turn profits from Nexus-e's feedback about what its assumptions about generation capacities mean for electricity markets and for the Swiss transmission grid.

[Read more ...](#)



The role of bio-energy with carbon capture and storage to deliver net-zero emissions in Switzerland

🕒 Project period: 2021-2022

👤 Partner(s): Prof. Dr. Marco Mazzotti, Dr. Lorenzo Rosa

Negative emission technologies will likely play a critical role in reaching the goal of net-zero carbon emissions. In this project, we will analyze the technical and environmental feasibility of carbon removal with Bio-Energy with Carbon Capture and Storage (BECCS), based on the availability of biomass, bioenergy potential, and of the infrastructure for CO2 capture and sequestration.

[Read more ...](#)

New scenarios

- Net-zero energy system in Switzerland and neighboring countries

New/Extension of modules

- Model full energy system
 - electrification of the mobility and building sector
 - sector coupling with industry
- Increase the level of detail of the European power system
- Expand system security modelling (e.g., risk-index based dispatching)
- Coordinated expansion planning for generation and transmission
- Additional macro economic assessments

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Please find the project reports and visualization tool
on: www.nexus-e.ethz.ch

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Energy
Science
Center



Power
Systems
Laboratory



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FORSCHUNGSSTELLE ENERGIE NETZES



Centre for Energy Policy
and Economics



Reliability and
Risk Engineering