ETH zürich

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

ENERGIEFORSCHUNGSGESPRÄCHE DISENTIS 2021

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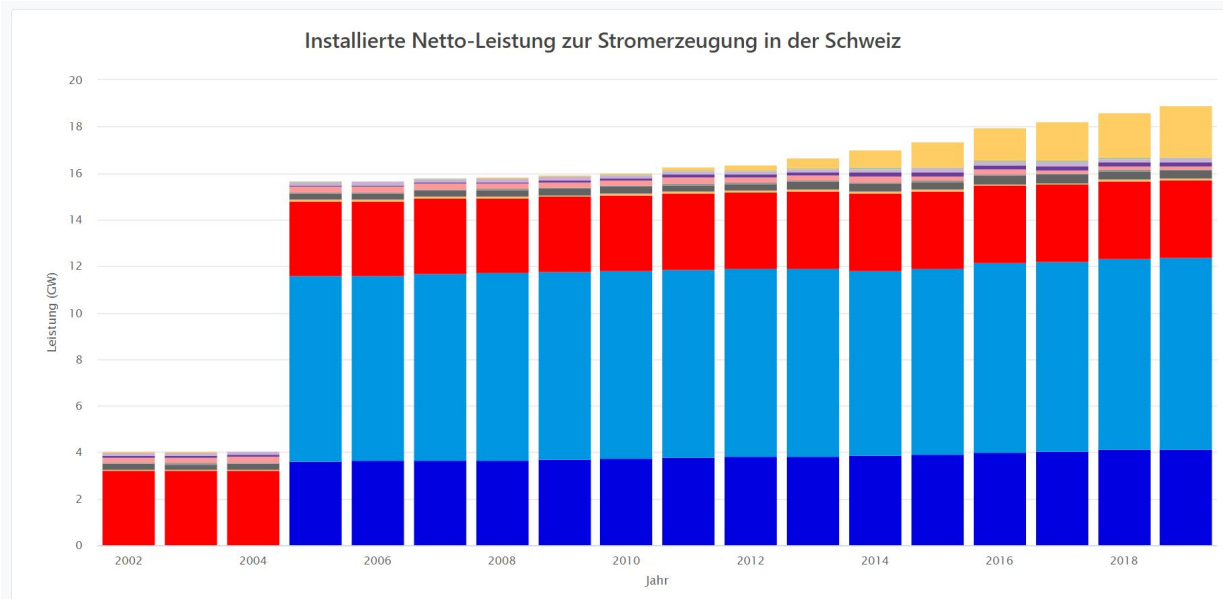
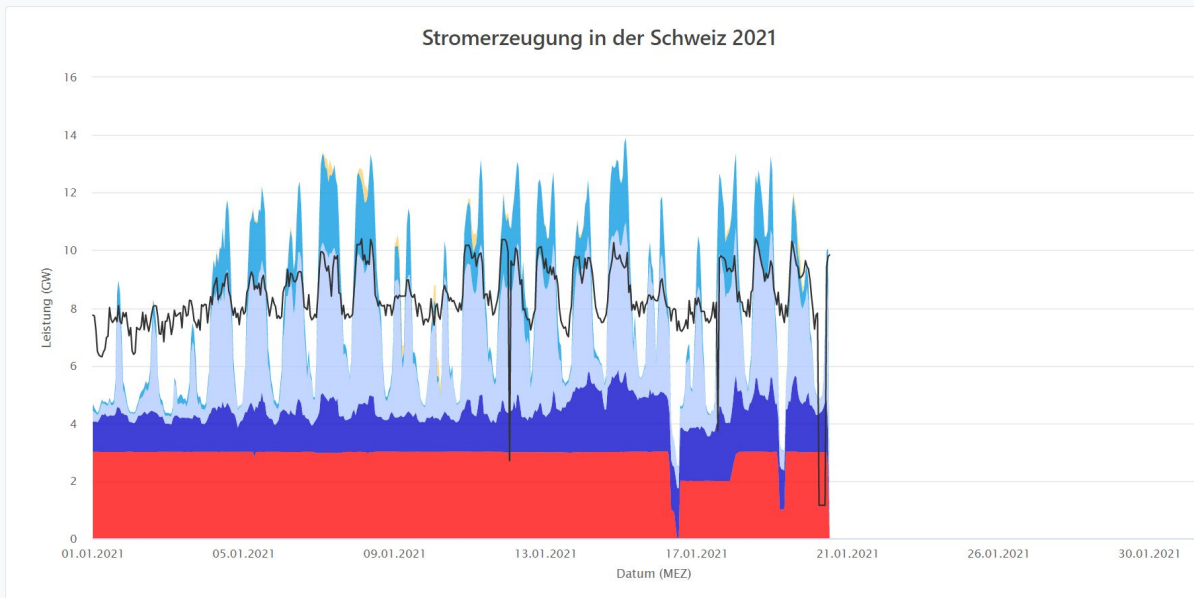
Energy Science Center

Energy transition in Switzerland

What is Nexus-e?

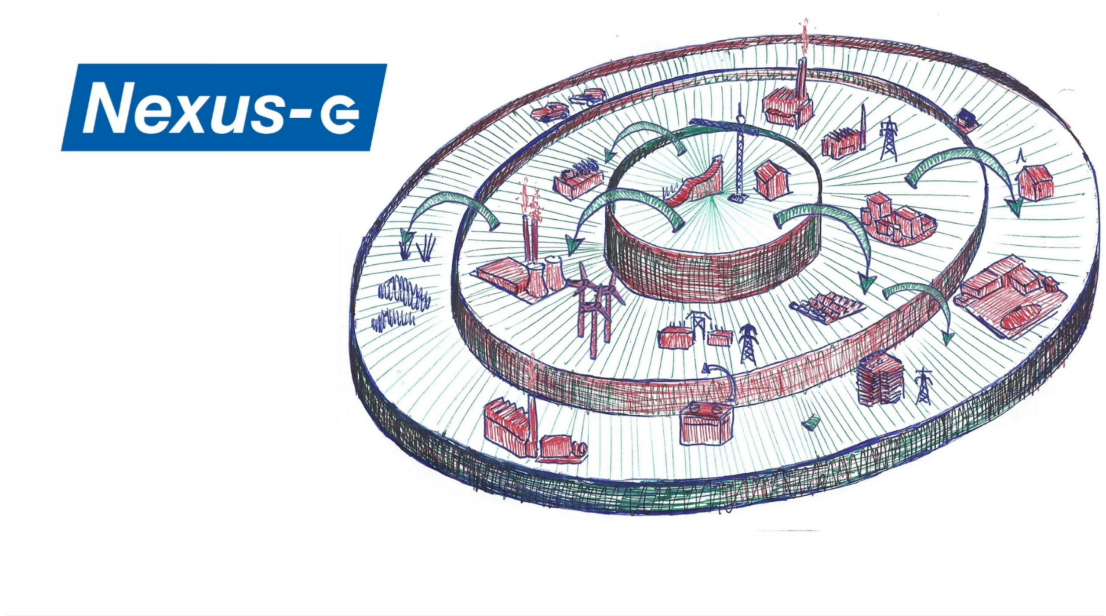




Vision of a Modeling Infrastructure for energy systems:

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 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:

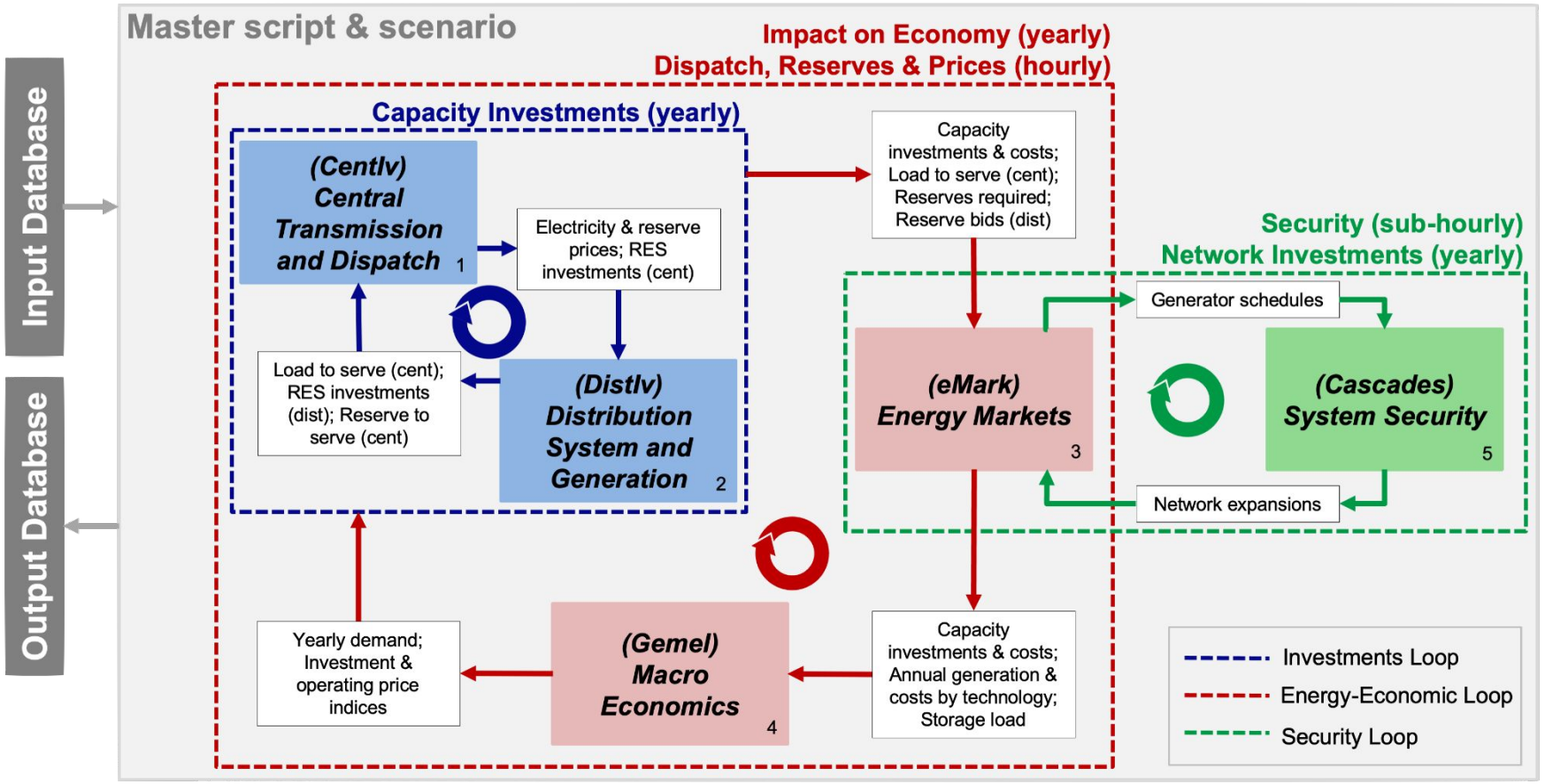
- Integrate cross-disciplinary models through a flexible and modular structure
- Interact with existing projects to capture/keep know-how

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?

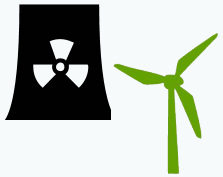


- Key model paradigms:
  - (non-)Linear & mixed integer optimization
  - High temporal and spatial resolution
  - Interfaces & hard linking modules from different sectors
- Loops & Interfaces
  - Capacity investments between central and distributed systems
  - Influences between energy and the economy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

Energy Transition in other European Countries

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.

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

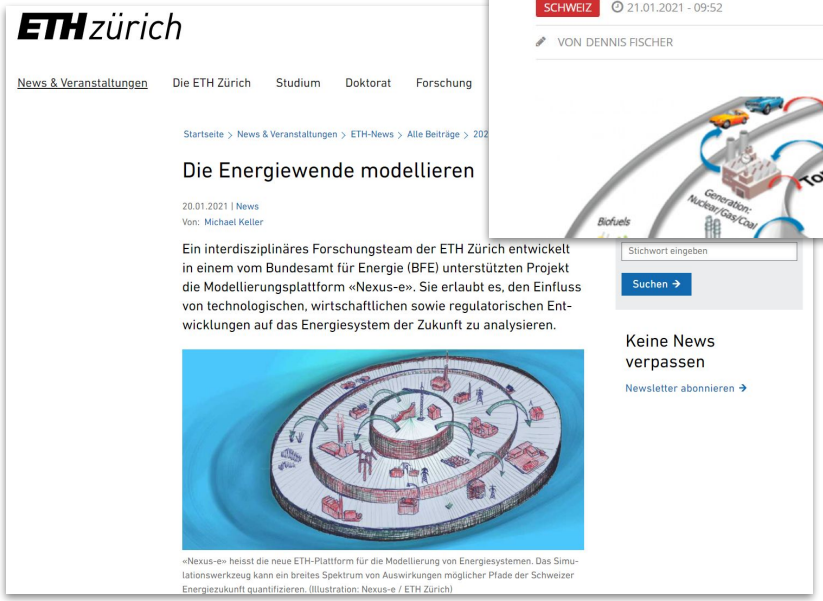
Table 6: Overview nuclear power phase out under 50 and 60 years of lifetime

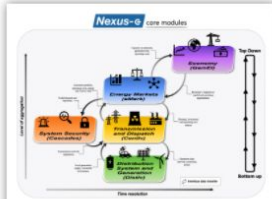
Nuclear power plant/reactor	Capacity	Operation since	Phase-out in year (runtime 50 years)	Phase-out in year (runtime 60 years)
Beznau 1	365	1969	2019	2029
Beznau 2	365	1972	2022	2032
Mühleberg (KKM)	355	1972	-	-
Gösgen (KKG)	1060	1979	2029	2039
Leibstadt (KKL)	1220	1984	2034	2044

[1]: N Lebedeva. Li-ion batteries for mobility and stationary storage applications. Publications Office of the European Union, 2018.
[2]:André Vossebein, Stefan Muster Muster, Ueli Betschart, and Beat Kölliker. Studie «Potential Demand Side Management in der Schweiz», 2019.
[3]: Verband Schweizerischer Elektrizitätsunternehmen. Themenpapier 44: Flexibilität, Fokus Demand Side und Energieerzeugungsanlagen auf Netzebene 7, 2019.

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

Envisioned development of the Nexus-e platform





Scenario Results

Download

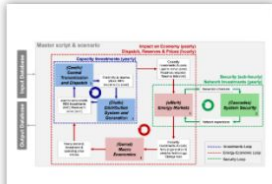
Interact with the results

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

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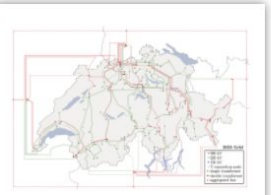

Input Data and System Setup

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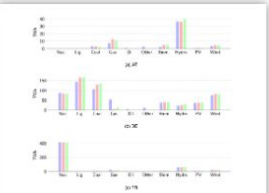

Validation and Calibration of Modules

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GemEl Module Documentation

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CentIv Module Documentation

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DistIv Module Documentation

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eMark Module Documentation

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Cascades Module Documentation

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

(BFE. energiea, https://energeiaplus.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

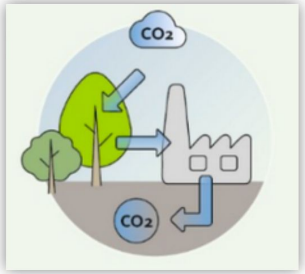
CH2040: Systems analysis to support rapid complete Swiss decarbonization

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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Thank you for your attention.

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

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