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Breaking Barriers: Unleashing Research's Potential for Shaping Decarbonized Futures

Sonja Wogrin
Institute of Electricity Economics and Energy Innovation
Graz University of Technology

02.05.2024

Institutsleiterin

Prof. DI Dr Sonja Wogrin MSc

Institut für Elektrizitätswirtschaft und Energieinnovation (IEE)

Technische Universität Graz

E-Mail: wogrin@tugraz.at

Web: IEE.TUGraz.at

Research Center energetic

Sprecherin

E-Mail: energetic@tugraz.at

Web: energetic.TUGraz.at

What's new?

Austrian Energy Transition

Research Center ENERGETIC

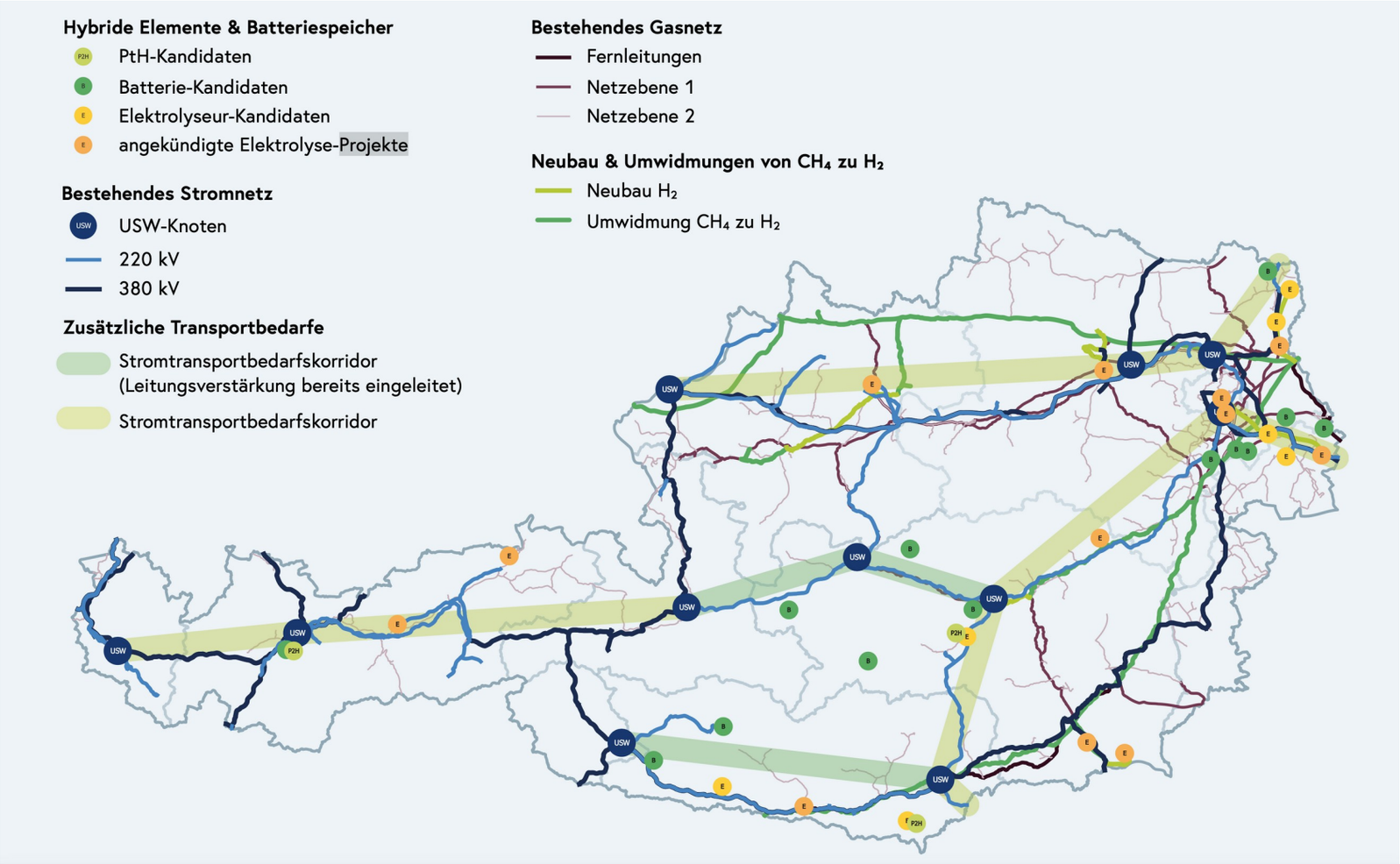
ERC Grant
Optimization and data aggregation for net-zero power systems

Austrian Energy Transition

Source: https://unsplash.com/photos/RVyc3Zzhpt8

Integrierter Österreichisches Netzentwicklungsplan

ÖNIP

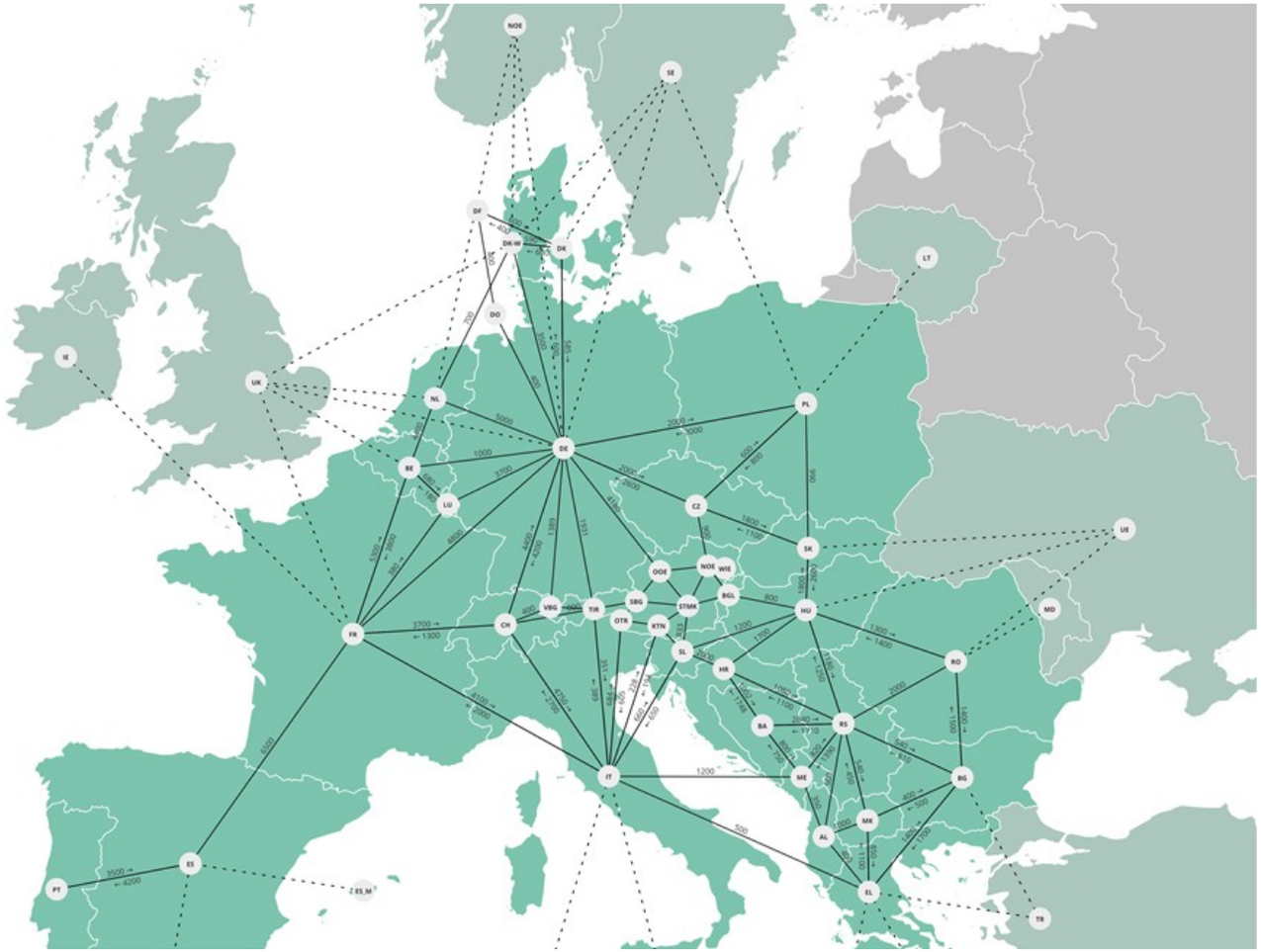


IEE war Teil des **InfraTrans2040 Projektes** & **ÖNIP**

Spoiler: wir brauchen **mehr Ausbau**!

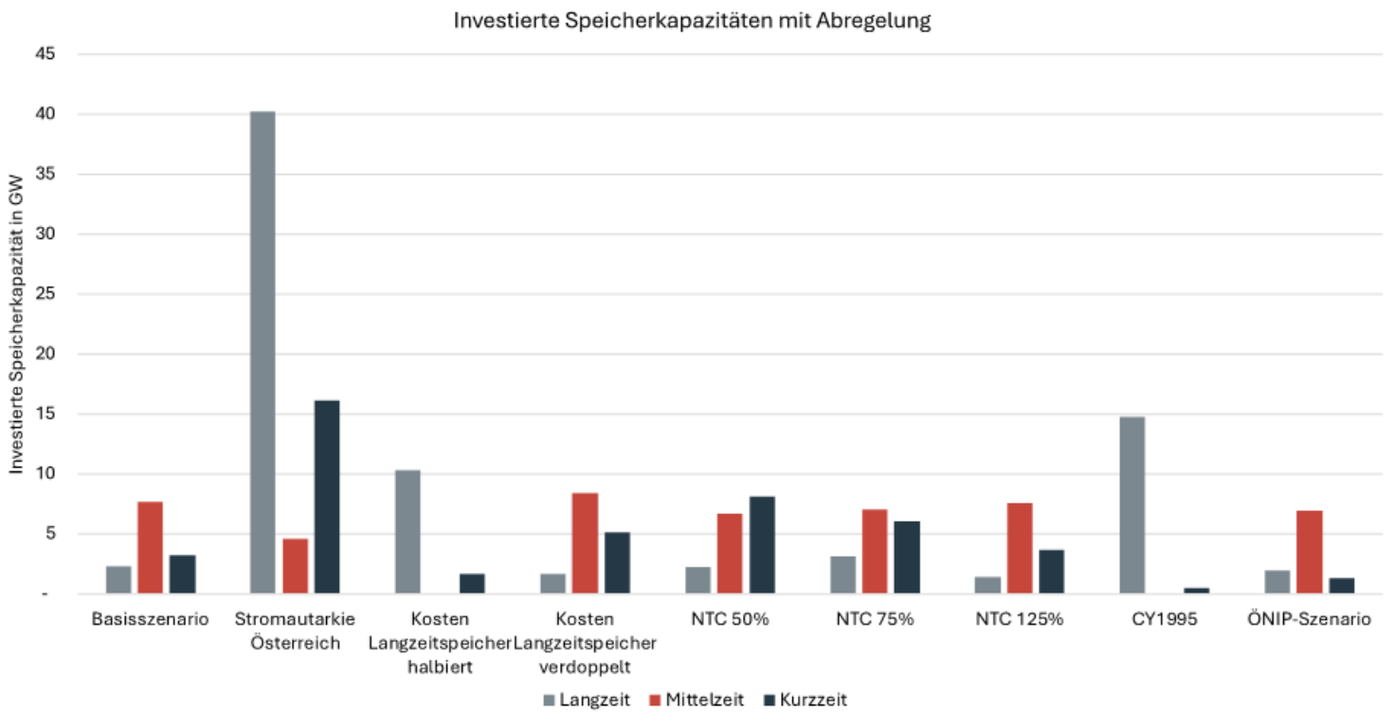
Challenge: **zugrundeliegenden Energiesystemmodelle** (z.B. Einbettung ins Europäische Übertragungsnetz) **sehr rechenintensiv**

Ermittlung des Speicherbedarfs im österreichischen Elektrizitätssystem 2040



- **Optimale Speicherinvestitionen** in Österreich für 2040:
  - **Kurz-/Mittel-/Langzeit** Speichertechnologien
  - **Ausbau in Erneuerbare** vorgegeben
  - **Stündliche** Auflösung
- **Szenarioanalysen:**
  - Stromautarkie
  - Kostensensitivität
  - NTC-Sensitivität
  - Wetterjahr-Sensitivität

Ermittlung des Speicherbedarfs im österreichischen Elektrizitätssystem 2040



- **Key Takeaways**:
  - **Ausbau** an **Speichern reduziert Importabhängigkeit**
  - **Stromautarkie** Österreichs ist **auf keinen Fall anzustreben** (Auswirkungen auf Gesamtsystemkosten)
  - Berücksichtigung **verschiedener Klimajahre** kann den **Bedarf** an Speicherkapazität **erheblich verändern**
  - Zusammenhang zwischen dem Ausbau von Speicherkapazitäten und dem **Ausmaß der erlaubten Abregelung**

- **Future Work:**
  - Erneuerbare und Netzinfrastruktor **co-optimieren**
  - **Integration** der Sektoren **Gas/Wärme etc.**
  - **Analyse Wirtschaftlichkeit** von Speichern

Research Center
energetic

Research Center for ENERGy Economics & Energy AnalyTICs

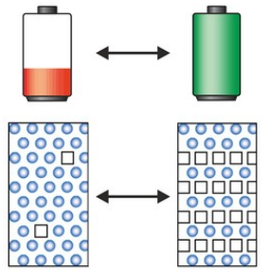
Research Center ENERGETIC

puts into reality

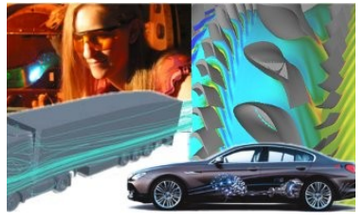
Interdisciplinary cutting-edge research that supports transitioning energy systems on the path toward full **decarbonization.**

Scientific competence to tackle this **energy crisis** with efficient and **sustainable solutions**.

Techn. Chemie & Verfahrenstechnik



Mathe, Physik & Geodäsie



Maschinenbau & Wirtschaftswiss.

Architektur

Bauingenieurwesen

Elektrotechnik

Informatik & Biomed.

Core Research Areas (CRA)

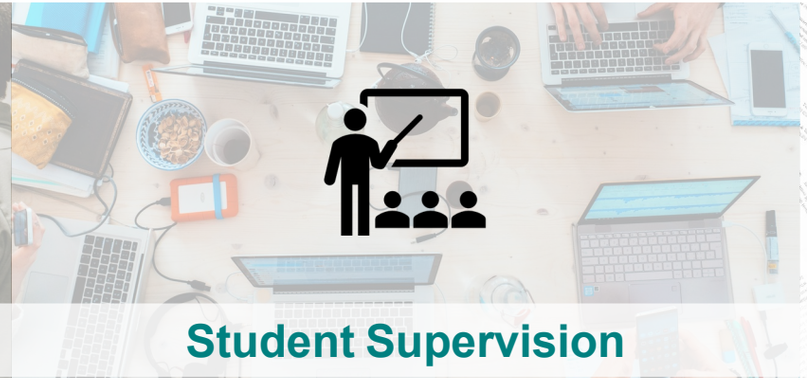
CRA1: Energy System Modeling & Analysis

CRA2: Digital Energy Systems

CRA3: Innovative Technology Solutions

ENERGETIC Inter-disciplinary Activities

Research Projects

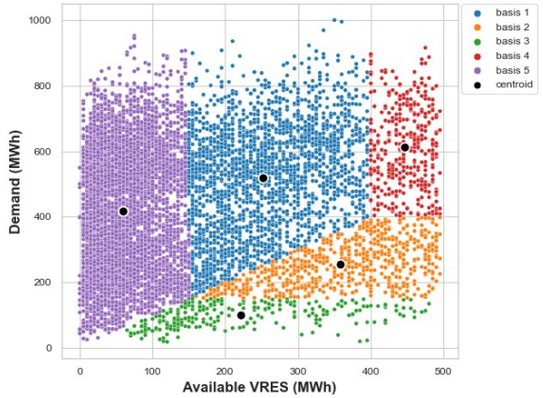


Student Supervision

Journal Papers

RINGs

iKlimEt



Source: https://www.tugraz.at/forschung/forschen-an-der-tu-graz/research-centers/research-center-for-energy-economics-and-energy-analytics-energetic
Foto von Kaleidico auf Unsplash sowie von Marvin Meyer auf Unsplash

RINGs

Struktur- und Prozessoptimierung resilienter Quartiers-Anergienetze

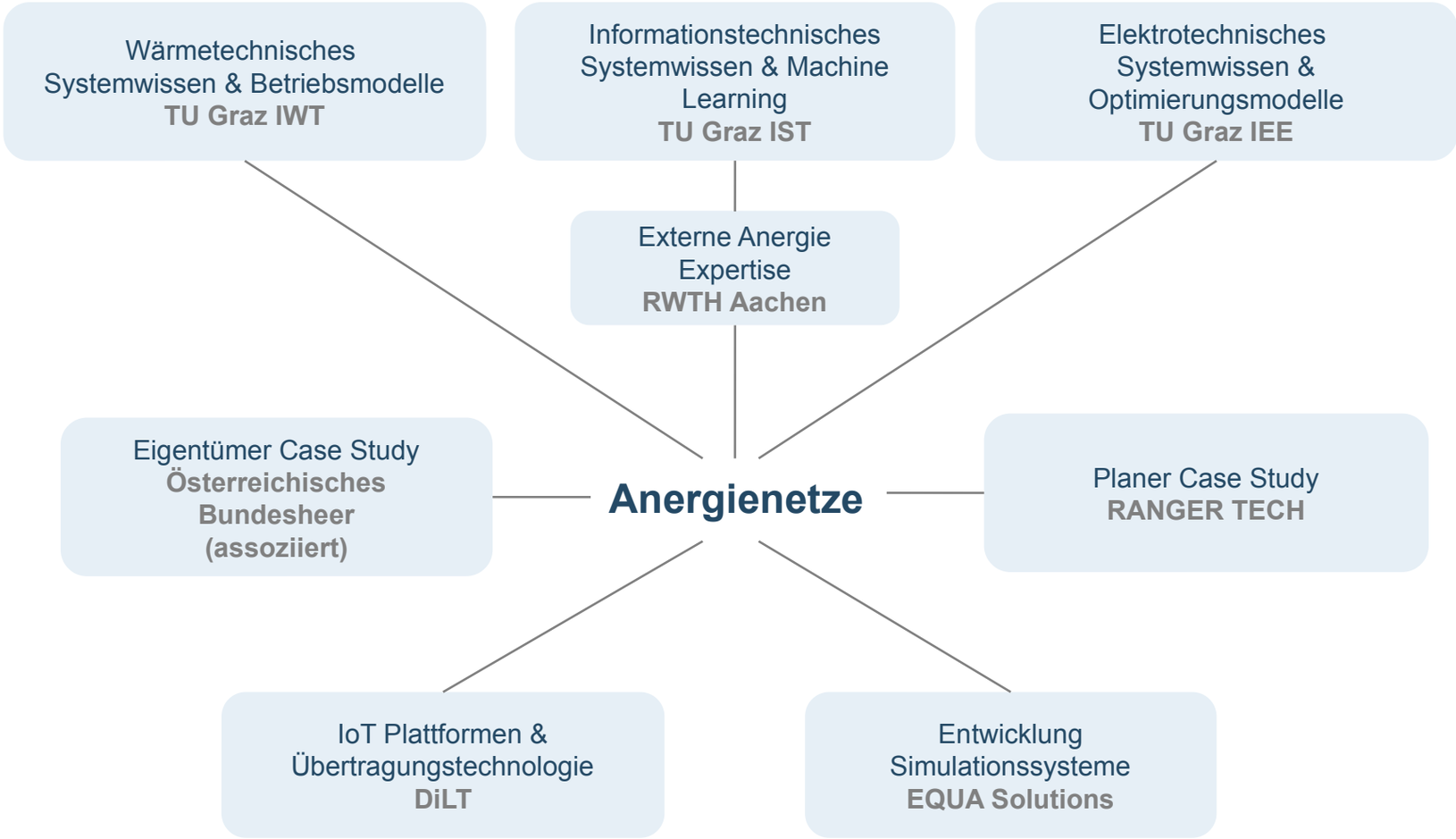
Rahmenbedingungen

Laufzeit:
Juni 2024 – Mai 2027

Förderung:
FFG

Programm:
ENERGIEFORSCHUNG 2022

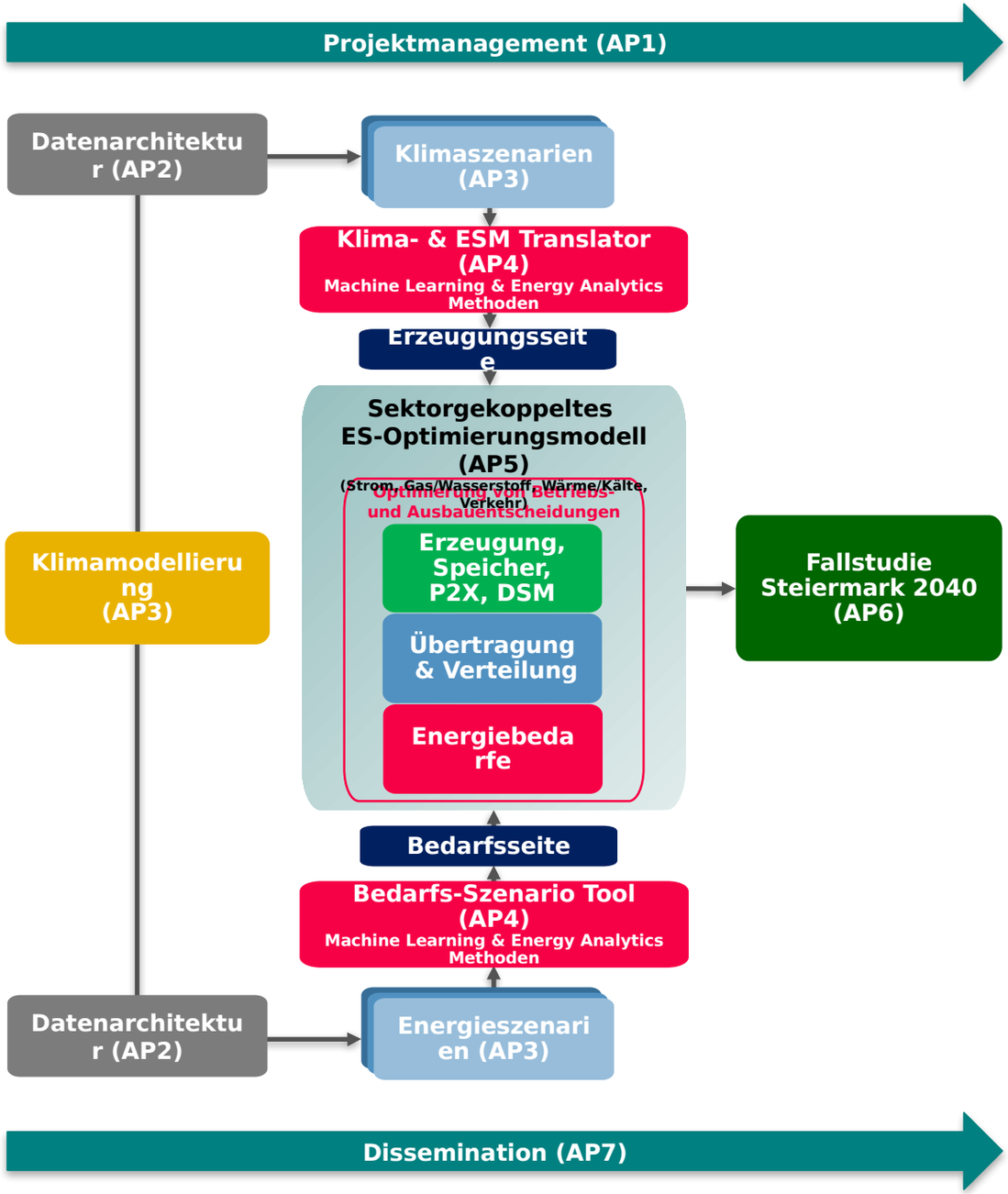
Forschungskategorie:
Industrielle Forschung



iKlimEt

Optimierung und Machine Learning für integrierte Klima- und Energiesystemmodelle

Klimawandel



Energiesystemplanung

Sources: Thomas Richter, https://unsplash.com/de/@thomasrichter
Johannes Plenio, unsplash.com/de/@jplenio

iKlimEt

Optimierung und Machine Learning für integrierte Klima- und Energiesystemmodelle

FFG
Forschung wirkt.

Rahmenbedingungen

Laufzeit:
Jänner 2024 – Dezember 2026

Förderung:
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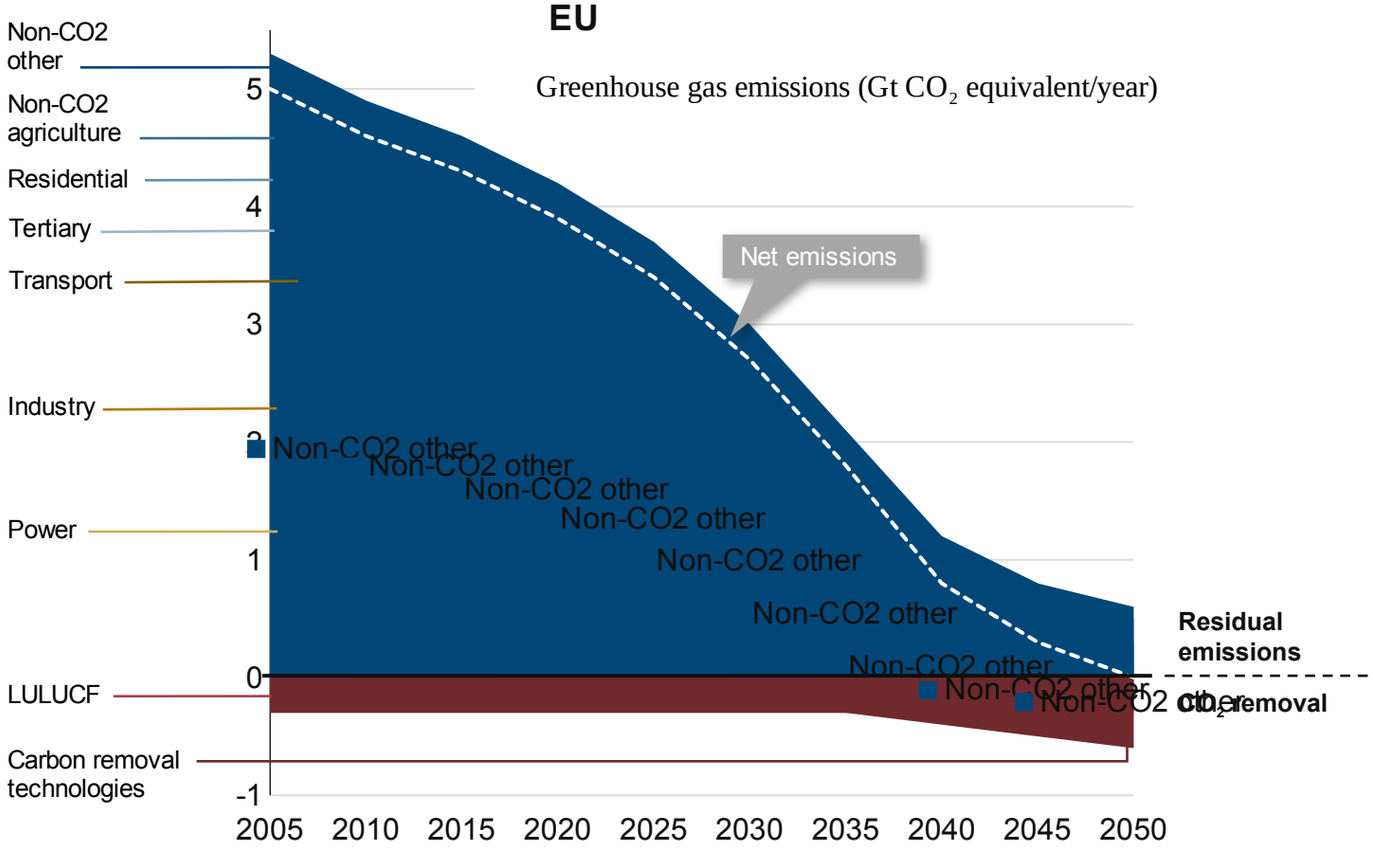
Forschungskategorie:
Industrielle Forschung

ERC Grant

ata aggregation for net-zero power systems (NetZero-Opt)

The Path Towards Net-zero Power Systems

Illustrative emissions pathways to achieve a net-zero target in the EU



Source: European Commission, In-depth analysis in support of the commission Communication com(2018) 773

The Path Towards Net-zero Power Systems

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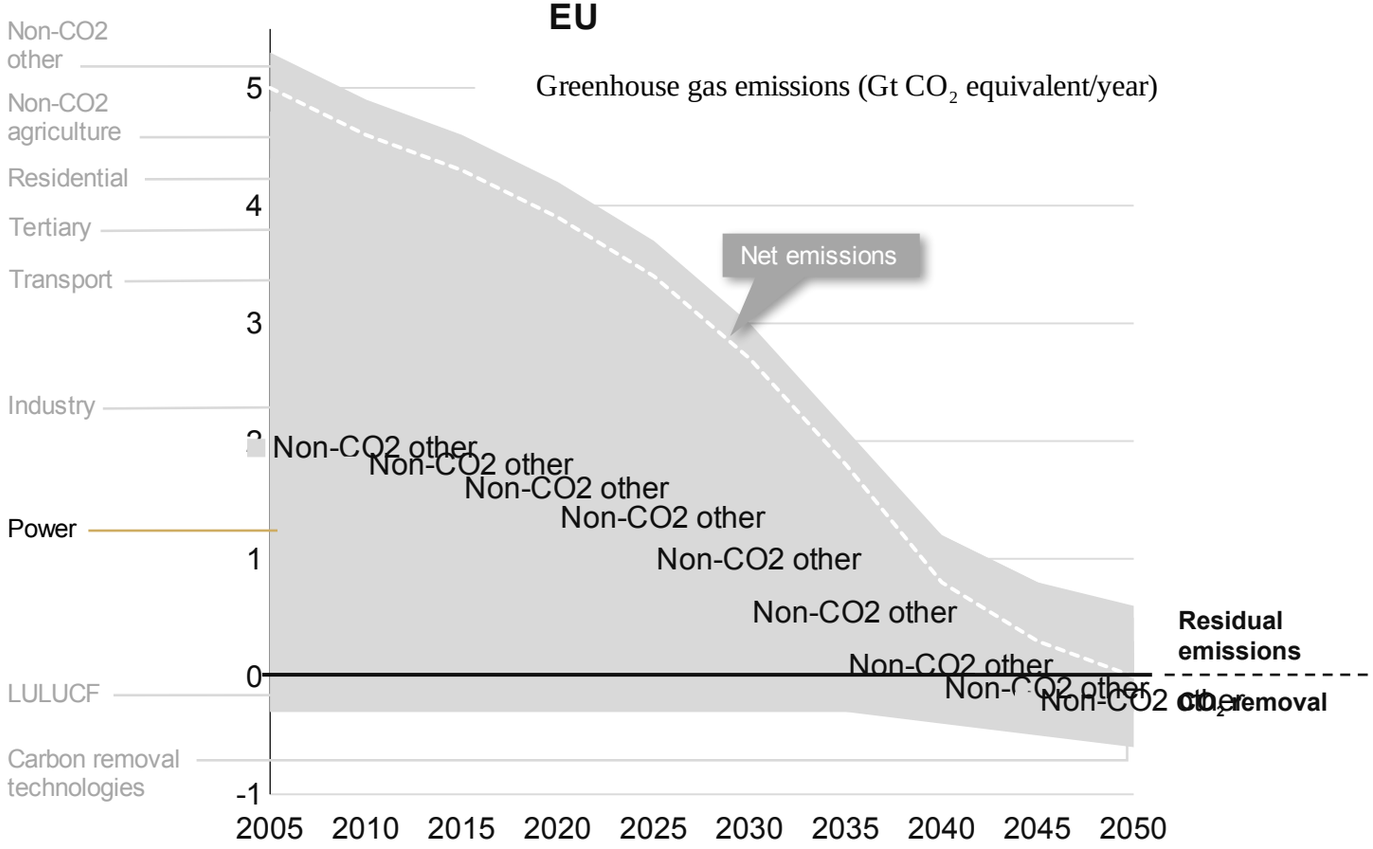


Power System Optimization Models

Objective:

Minimize total system cost

Constraints:

Intermittent renewables

Power flow

Source: European Commission, In-depth analysis in support of the commission Communication com(2018) 773

Power System Optimization Models are Complex

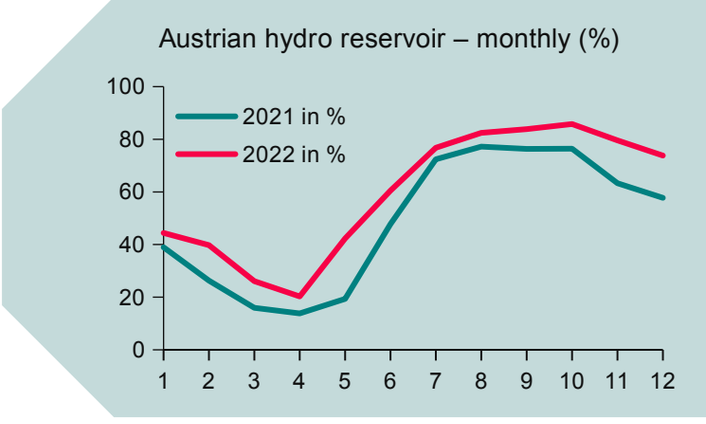
Technical
Power flow, unit commitment, etc.

Uncertainty
Renewable energy sources etc.

Spatial
Power grids etc.

NetZero-OPT

Temporal
Long planning horizons with hourly resolution.
Challenge: interdependent time periods.



Computational Challenge

EU Power System Model

 # Variables: 630 M

NetZero-Opt
 # Variables: 0.5 M

3 orders of magnitude

World's Fastest Supercomputer*
600 M$

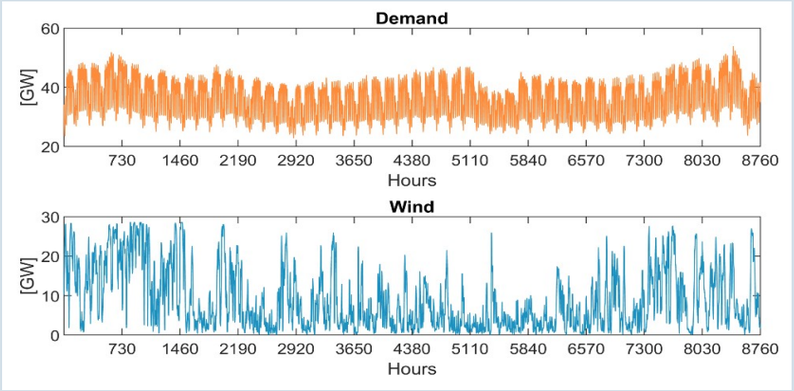
Typical Workstation**
5000 €

	Hourly Resolution	NetZero-Opt
World's Fastest Supercomputer*	18 Days	<1 ms
Typical Workstation**	Intractable	12 Days

Source*: Frontier (supercomputer) - Hewlett Packard Enterprise Frontier, or OLCF-5, 1102 exaFLOPS. Estimated cost: 600 M$.
Source**: Normal PC assumed to carry out 120 gigaFLOPS. Estimated cost: 5000€.

Time Series Aggregation* (TSA)

Original Data Time Series

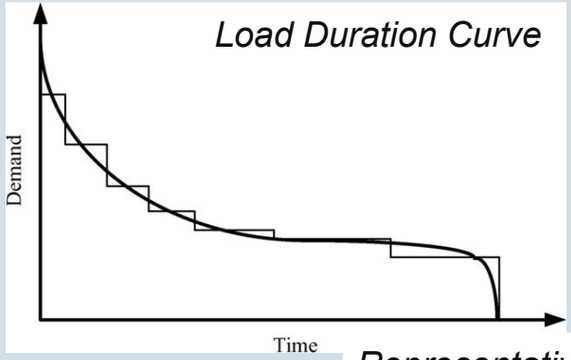


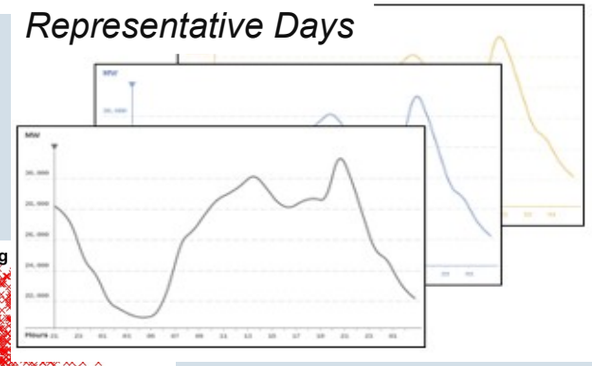
Traditional Framework

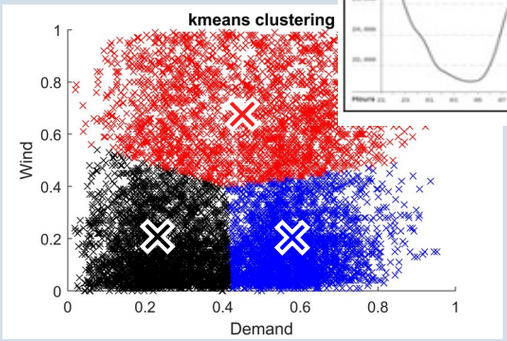
Focus on best approximation of input data.

TSA

Times Series Aggregation







Representative Hours

Source*:
Teichgraeber, H. and A.R. Brandt. "Time-series aggregation for the optimization of energy systems: Goals, challenges, approaches, and opportunities." Renewable and Sustainable Energy Reviews (2022)
Li, C. et al. "On representative day selection for capacity expansion planning of power systems under extreme operating conditions." International Journal of Electrical Power & Energy Systems (2022)
Hoffmann, M. et al. "A review on time series aggregation methods for energy system models." Energies (2020)
Hilbers, A.P. et al. "Importance subsampling: improving power system planning under climate-based uncertainty." Applied Energy (2019).

Net-Zero Power Systems

Traditional aggregation framework **no longer valid for net-zero power systems**!

Time series aggregation should **focus** on approximating full **model outputs**.

NetZero-Opt

Theoretical and universally applicable time series aggregation framework.

Build **reliable net-zero** power systems.

Save costs in a global **1.8 trillion* €** industry.

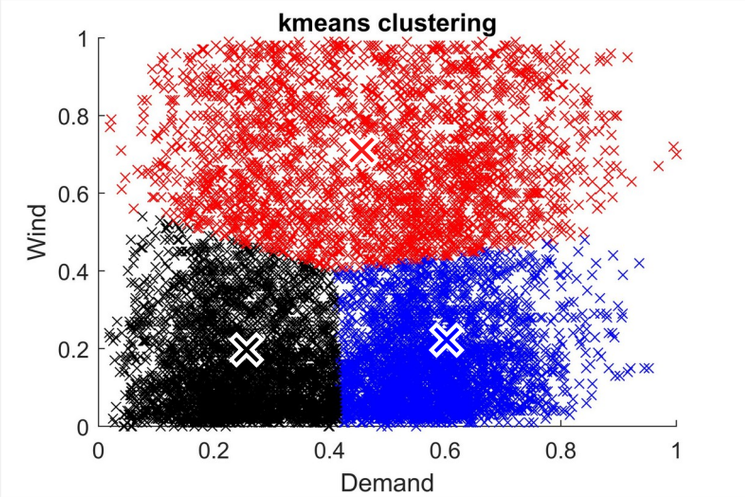
Source* (estimated for 2022): https://www.precedenceresearch.com/power-generation-market

Proof of Concept

Economic Dispatch Problem

Traditional Framework

- Approximate 8760 hours of original time series using only **3 representative hours** with kmeans clustering:

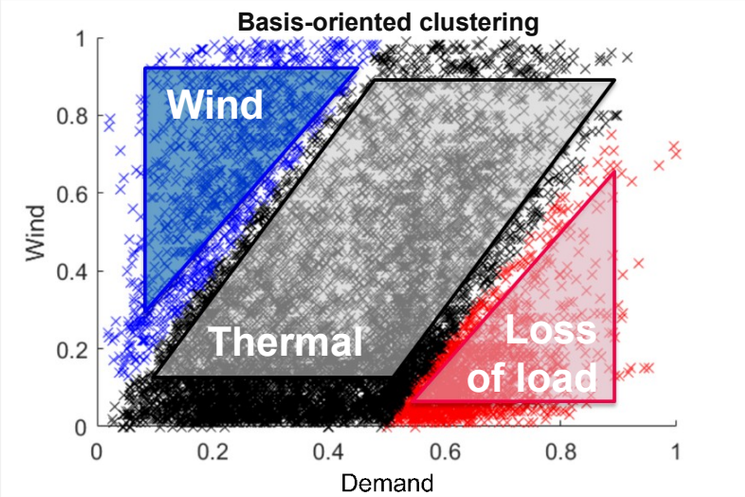


Results of economic dispatch problem:

- Relative **total system cost error 91%.**
- Relative **error** in estimated **loss of load 100%.**

NetZero-Opt

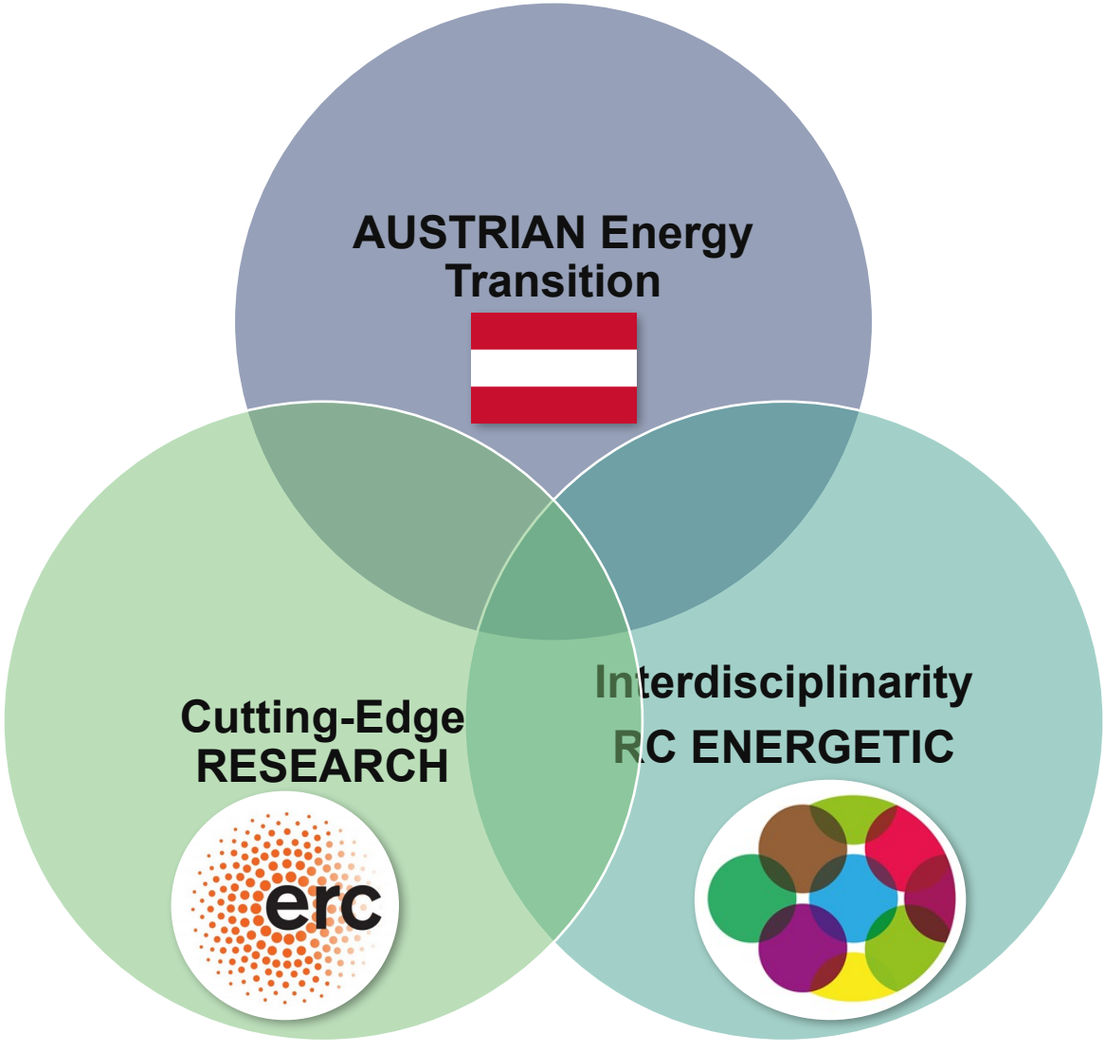
- Also uses 3 representative hours, but chosen with **theoretical underpinnings***:



- Results yields **proven** relative **error of 0%!**
- Aggregation potential of **3 orders of magnitude** (measured in number of model variables).

Source*: **Wogrin, S.** "Time series aggregation for optimization: One-size-fits-all?" IEEE Transactions on Smart Grid (2023).

Summing up!



Source: Foto von Jeremy Yap auf Unsplash