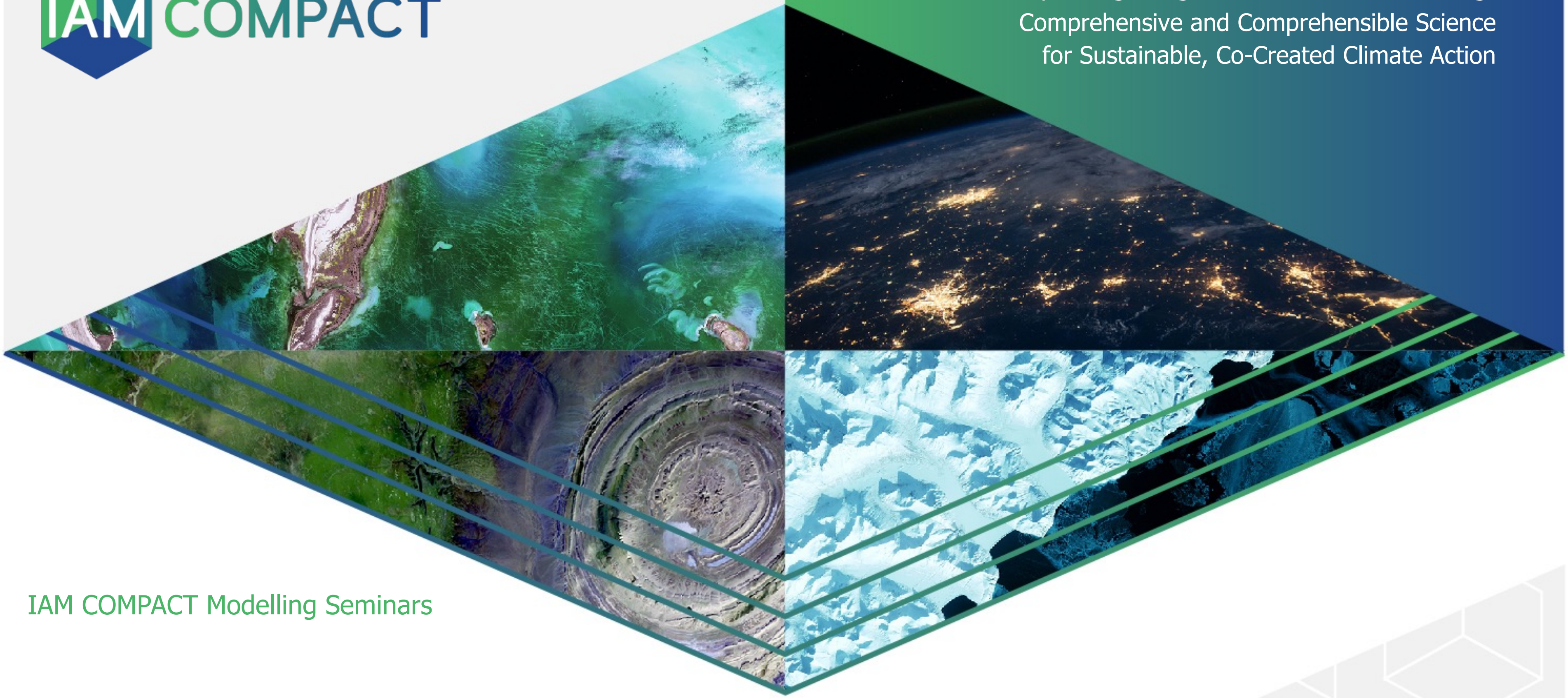
IAM COMPACT

Expanding Integrated Assessment Modelling:
Comprehensive and Comprehensible Science
for Sustainable, Co-Created Climate Action



IAM COMPACT Modelling Seminars

Model Presentation: EXPANSE

University of Geneva, Renewable Energy Systems group

The IAM COMPACT project has received funding from the European Union's Horizon Europe Research and Innovation Programme under grant agreement No 101056306.

www.iam-compact.eu

- Electricity system model for Europe (whole energy system coverage in progress)
- Two versions:
    - high spatial and temporal resolution for a year (spatial EXPANSE)
    - modeling transition pathways under deep uncertainty at a country level (D-EXPANSE)
- Optimization model with Modeling to Generate Alternatives (MGA) to analyze near-optimal scenarios informed by transitions in history; Monte-Carlo analysis for uncertainty
- Developed 'in house'

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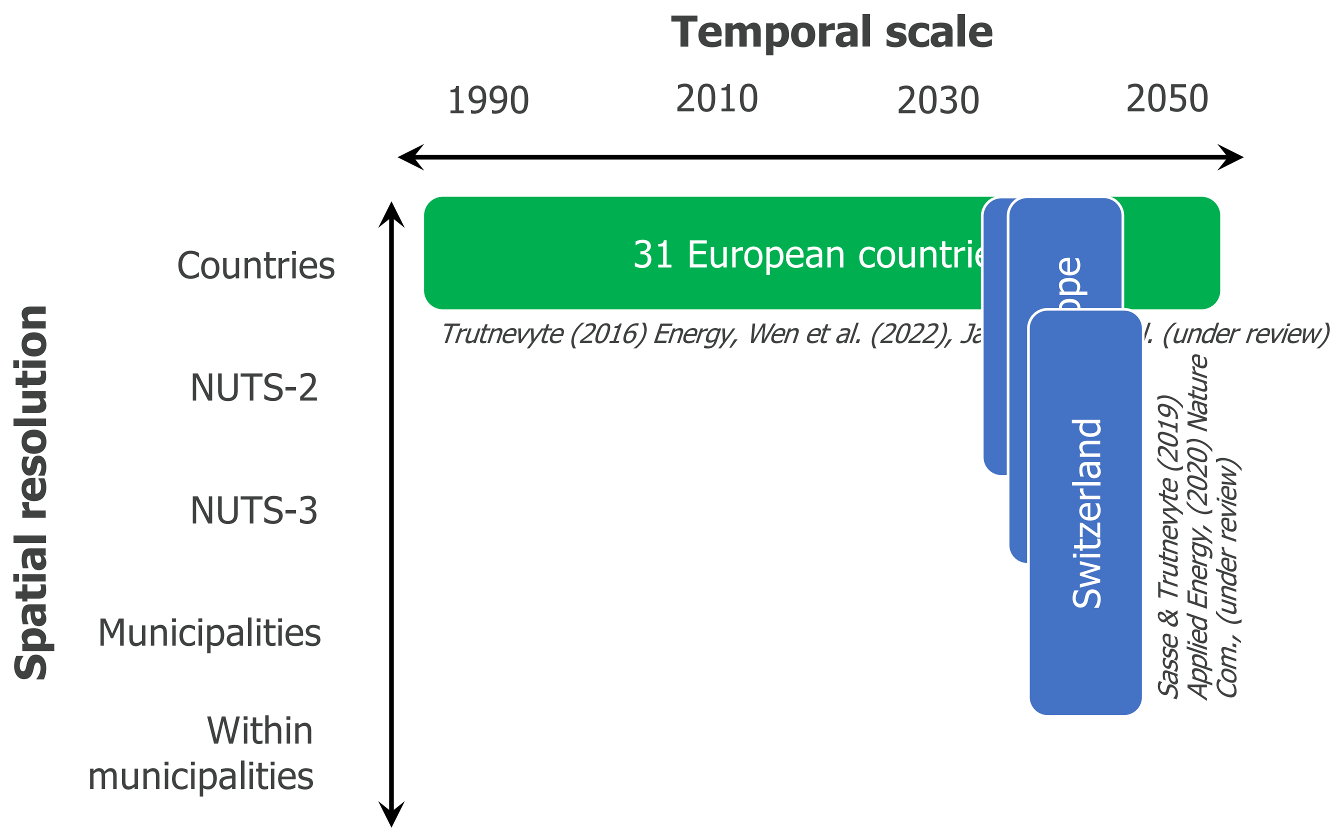
Applied at global, regional, national and sub-national scale.



Basis: bottom-up technology-rich optimization model

Coverage:

- electricity (Switzerland, Europe)
- whole system (under development)
- electricity and heat (local)

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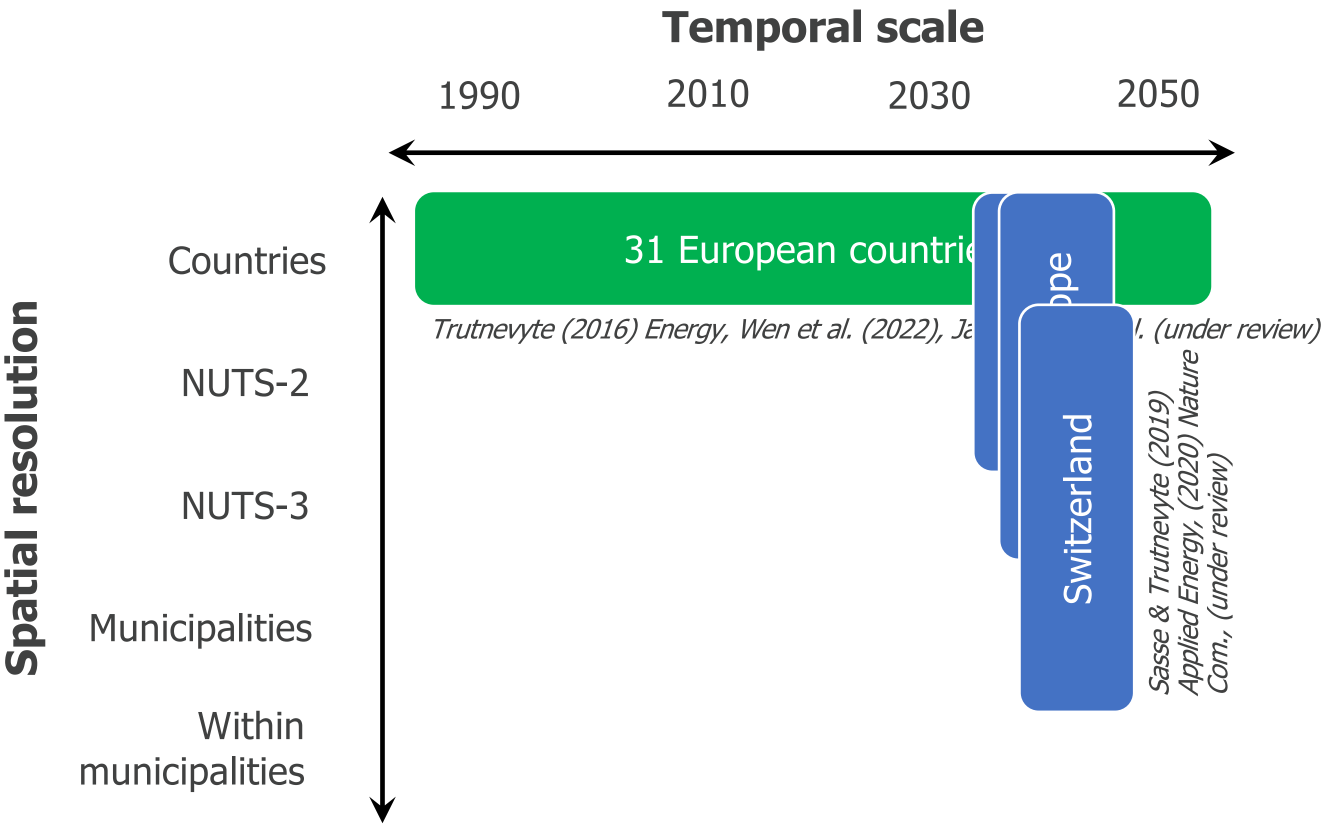

Innovative features:

- Closing the gap between the model and real-world transition
- Extensive uncertainty analysis

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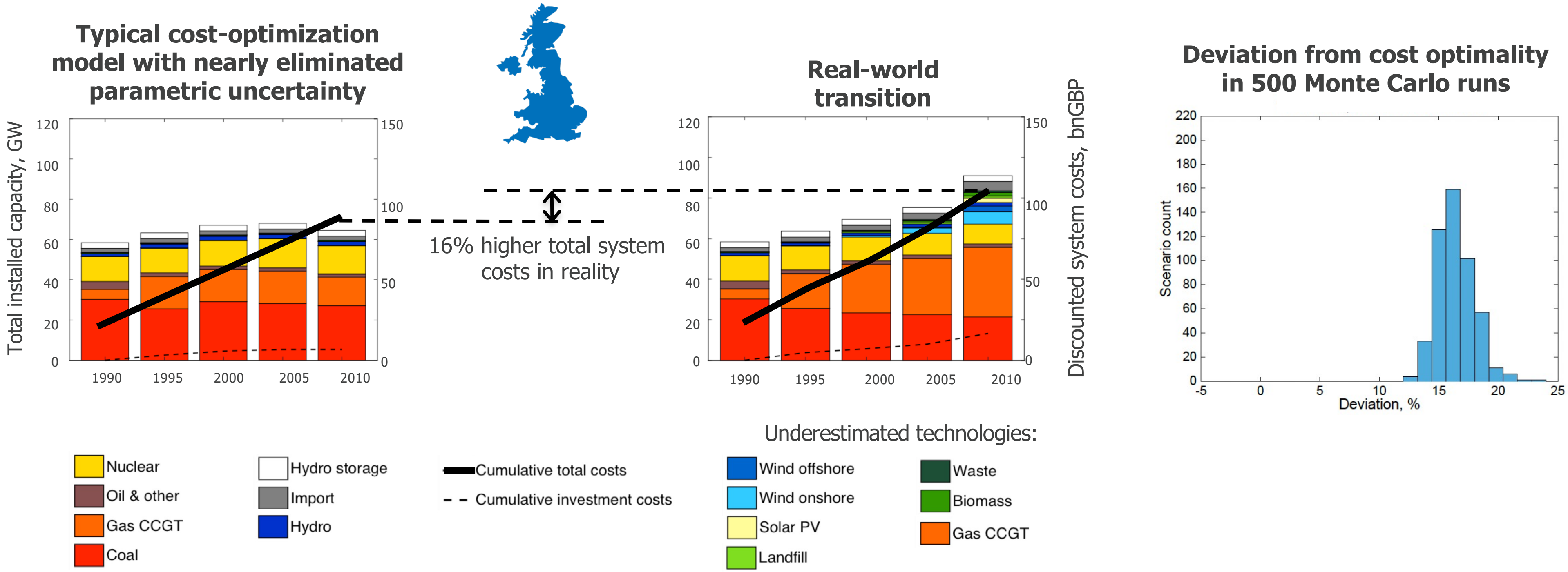
Cost optimization is fiction!



Source: Trutnevyte (2016) *Energy*

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Model workflow

Input data

↓

Model logic:
cost-optimization

↓

Model logic:
Modeling to Generate Alternatives (MGA)

↓

Results

Model data

Input data

Costs (CAPEX, OPEX)	Electricity demand	Resource availability
Generation parameters	Storage parameters	Transmission parameters

Results

Regional generation portfolio	Regional system capacity	Regional system costs
Regional impacts	Regional equity score	Regional vulnerability score

- 298 NUTS-2 regions (up to NUTS-3) in 33 European countries (up to 36)
- Six-hourly operation (up to hourly)
- Hundreds of MGA scenarios for uncertainty

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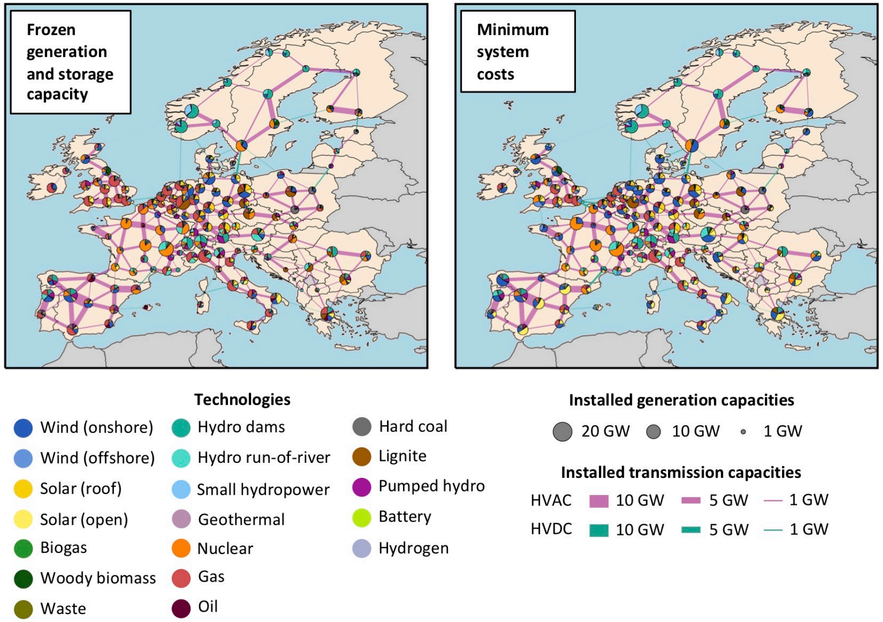
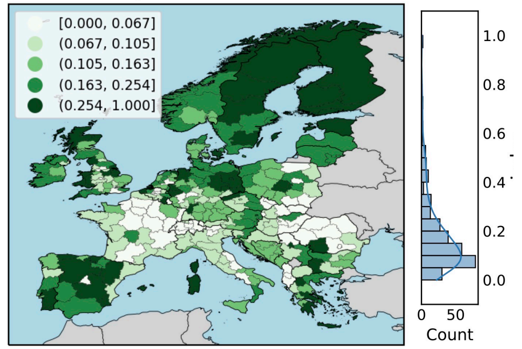
Case study: benefits and vulnerabilities in Europe at NUTS-3 level

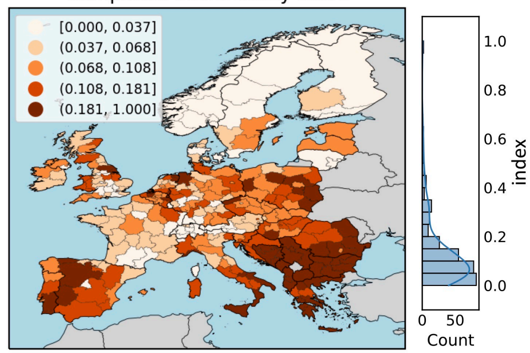
2035



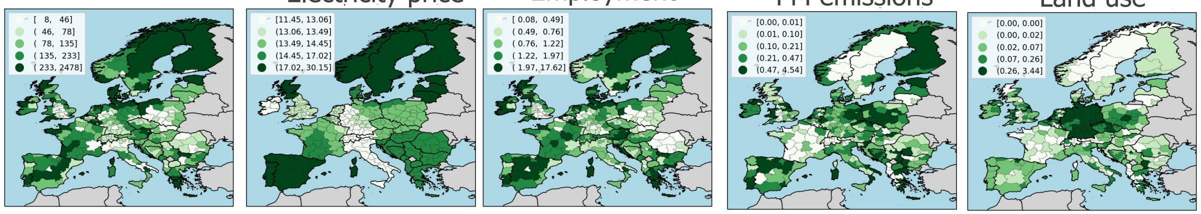
Composite benefit score



Composite vulnerability score



Investment Electricity price Employment PM emissions Land use



Source: Sasse & Trutnevyte (2022) Under review

Note: Installed capacities are shown at grid-node level instead of NUTS-2 level for visualization purposes.

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Case study: analysis for Central Europe at NUTS-2 level (1)

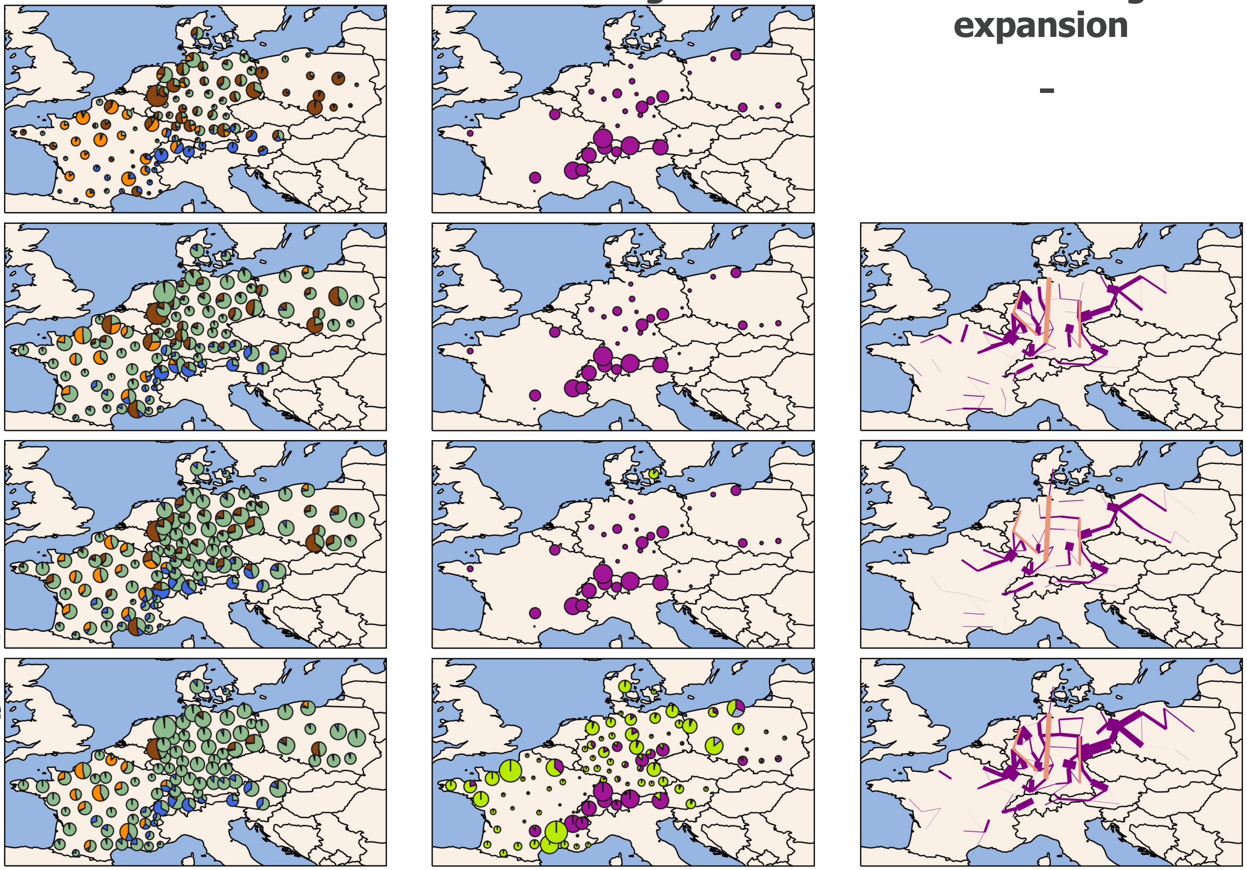
Generation | Storage | Transmission grid expansion

Frozen generation (2018 generation in 2035)

Cost-optimal scenario (countries meet their 2035 targets)

Max. regional equality scenario (countries meet their 2035 targets)

Max. renewable generation (countries meet their 2035 targets)



Generation

- Fossil fuels
- Nuclear
- Solar PV and wind
- Other renewable technologies

Storage

- Pumped hydropower
- Battery
- Hydrogen

Transmission grid expansion

HVDC HVAC

10 GW

5 GW

1 GW

Source: Sasse & Trutnevyte (2020) *Nature Communications*

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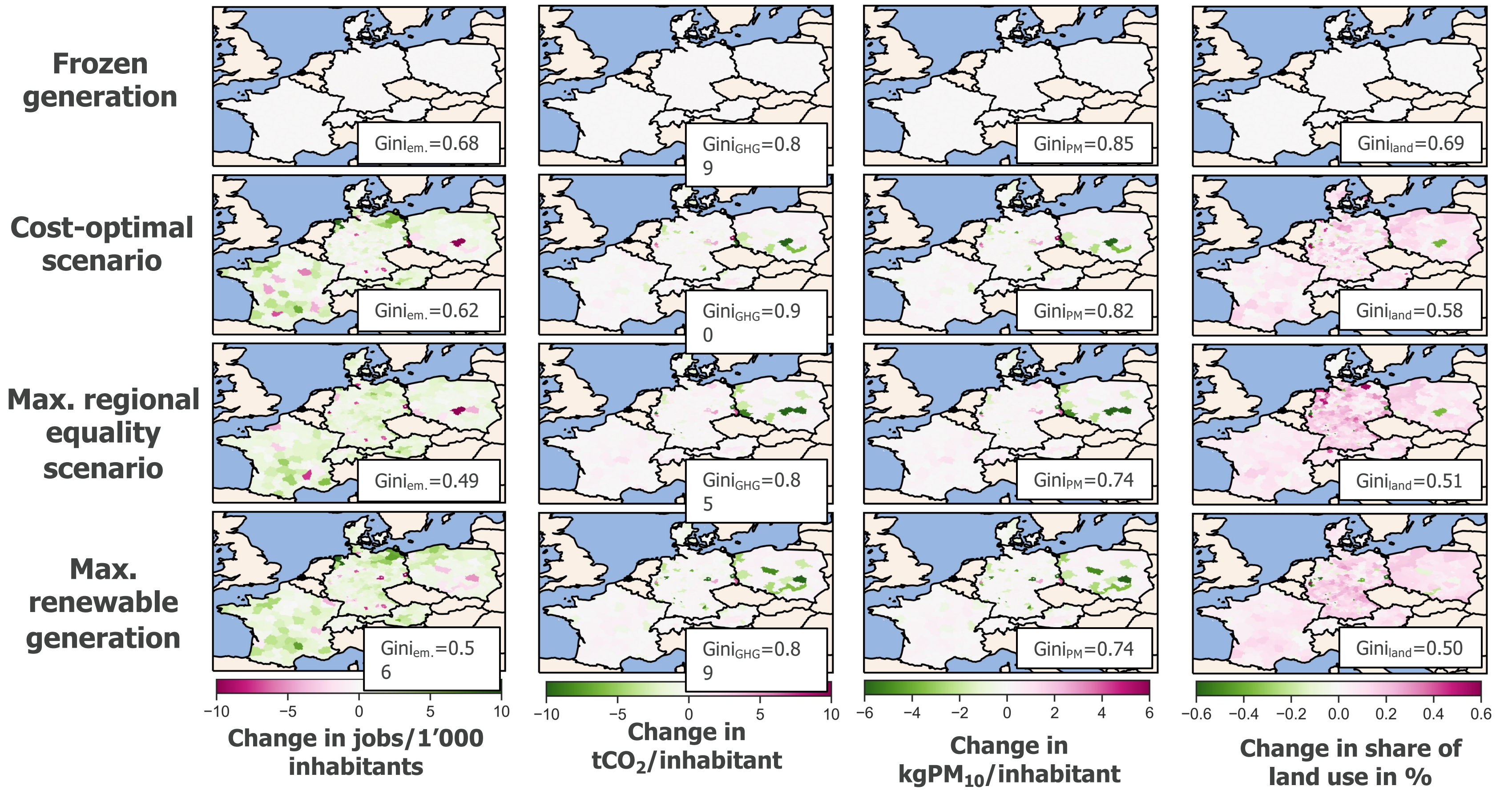
Case study: analysis for Central Europe at NUTS-2 level (2)



(as compared to 'frozen generation')

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Source: Sasse & Trutnevyte (2020) *Nature Communications*

D-EXPANSE model

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Historic data of the national electricity system transitions in 31 European countries in 1990–2019 (Jaxa-Rozen et al., 2022).

Contents lists available at ScienceDirect

Data in Brief

journal homepage: www.elsevier.com/locate/dib

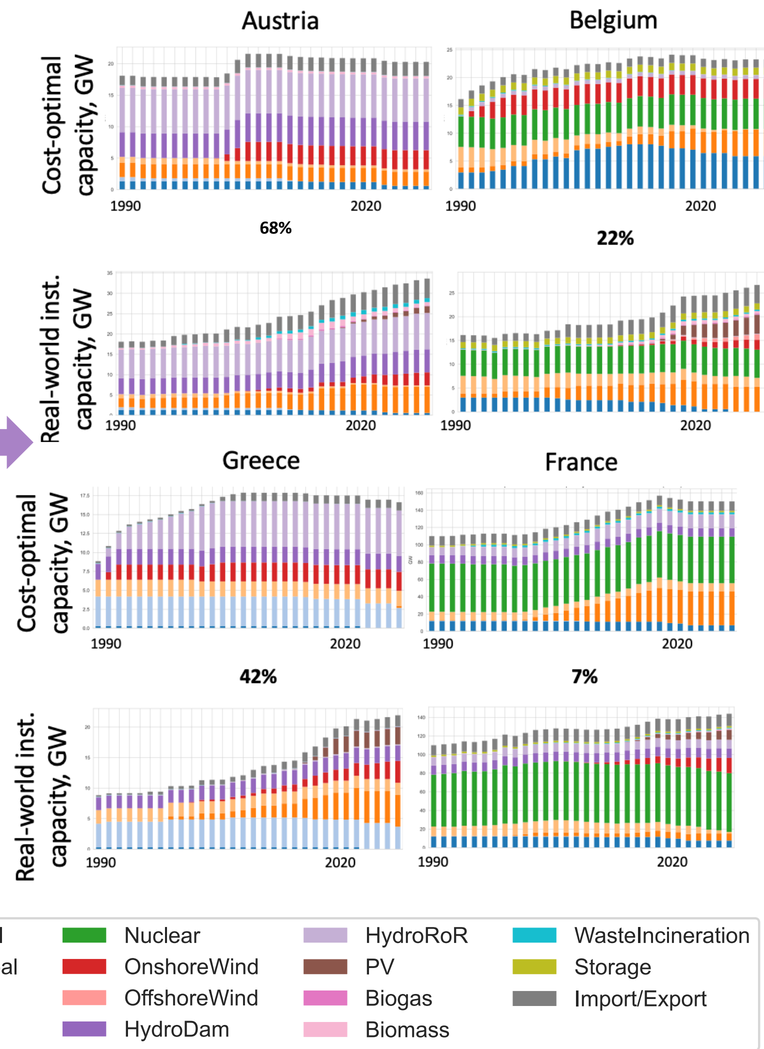
Data Article

Historic data of the national electricity system transitions in Europe in 1990–2019 for retrospective evaluation of models

Marc Jaxa-Rozen[1,*], Xin Wen, Evelina Trutnevyte

Renewable Energy Systems, Institute for Environmental Sciences (ISE), Section of Earth and Environmental Sciences, University of Geneva, Switzerland

31 national D-EXPANSE models



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Source: Wen et al. (2022) *Applied Energy*, Jaxa-Rozen et al. (2022) *Data in Brief*

The following policies can be implemented:

- Emissions or energy supply targets at a country or continental level
- More specific technology and resource targets, e.g. technology or fuel availability, minimum or maximum desired levels of operation, growth rates
- More specific targets on pollution impacts, employment etc. are possible
- Subsidies, feed-in tariffs, carbon tax are possible
- More work on policies in the future

Key policy-relevant questions:

- Technology mixes and locations to achieve targets
- Regional impacts, benefits, vulnerabilities, and equity of electricity system transition (Sasse and Trutnevyte, 2019, 2020, under review)

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SDG	Details
§1. No Poverty (e.g., intra-country distributional impact by income level)	Regional electricity sector costs, locational prices and investment; employment in the electricity sector
§3. Health (e.g., air-pollution related mortality)	Particulate matter emissions (PM10) from electricity generation
§7. Affordable and clean energy (e.g., traditional biomass use, %renewable energy)	Share of renewable electricity generation, electricity system costs and investment, key environmental and economic impacts of the electricity generation, regional equity
§8. Decent work & economic growth (e.g., impact on GDPpc, jobs)	Impact on employment by the electricity sector; regional electricity sector costs and investment
§10: Reduced inequalities (e.g., intra-country distributional impact, gini coefficient)	Gini coefficient of regional impacts on costs, employment, greenhouse gas and particulate matter emissions, and land use
§13: Climate action	Greenhouse gas emissions
§15: Life on land (e.g., land use for forests, rate of land use change)	Land use impacts of the electricity sector

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Jaxa-Rozen, M., Wen X., & Trutnevyte, E. Historic data of the national electricity system transitions in Europe in 1990–2019 for retrospective evaluation of models. Data in Brief 43, 108459 (2022).

Sasse, J.-P. & Trutnevyte, E. Distributional trade-offs between regionally equitable and cost-efficient allocation of renewable electricity generation. Applied Energy 254, 113724 (2019).

Sasse, J.-P. & Trutnevyte, E. Regional impacts of electricity system transition in Central Europe until 2035. Nature Communications 11, 4972 (2020).

Sasse, J.-P. & Trutnevyte, E. Low-carbon electricity sector in Europe risks sustaining regional inequalities in benefits and vulnerabilities. Submitted to Nature Communications.

Trutnevyte, E. Does cost optimization approximate the real-world energy transition? Energy 106, 182-193 (2016).

Wen, X., Jaxa-Rozen, M., & Trutnevyte, E. Accuracy indicators for evaluating retrospective performance of energy system models. Applied Energy 325, 119906 (2022).

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Thank you!

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