TOWARDS AN OPEN AUSTRIAN SECTOR-COUPLED ENERGY SYSTEM MODEL WITHIN A EUROPEAN CONTEXT

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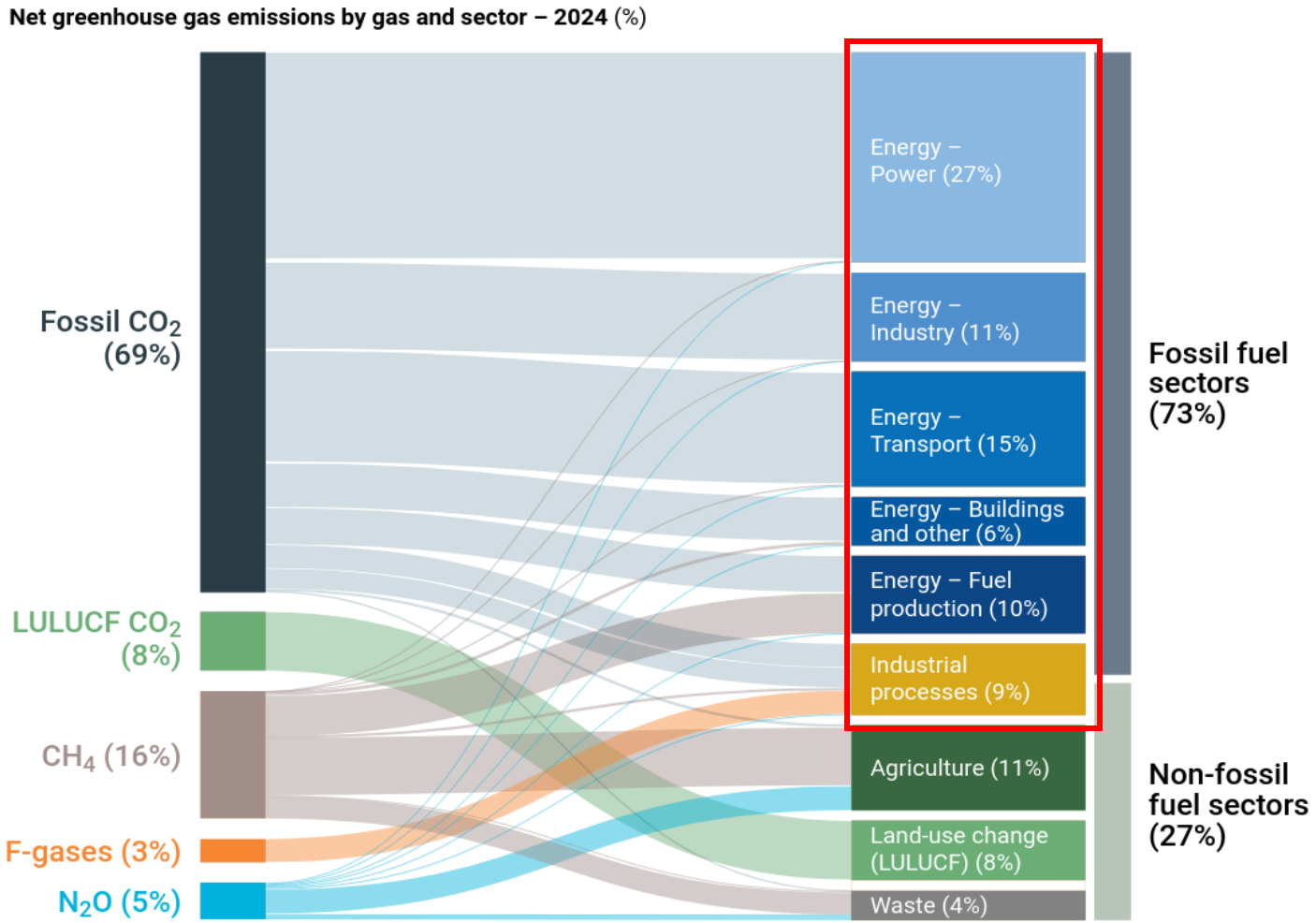
One day's emissions

(c) Carbon Visuals.

Background

- Paris Agreement: Combined national efforts
  - AT: Net Zero 2040
  - EU: Net Zero 2050

- Energy is key driver for emissions!



United Nations Environment Programme, *Emissions Gap Report 2025*

Energy System Modelling

- Energy has high relevance (economy, society, (climate)-policy)
- Large uncertainties, many trade-offs beyond costs

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Planning tool for energy systems and transformation

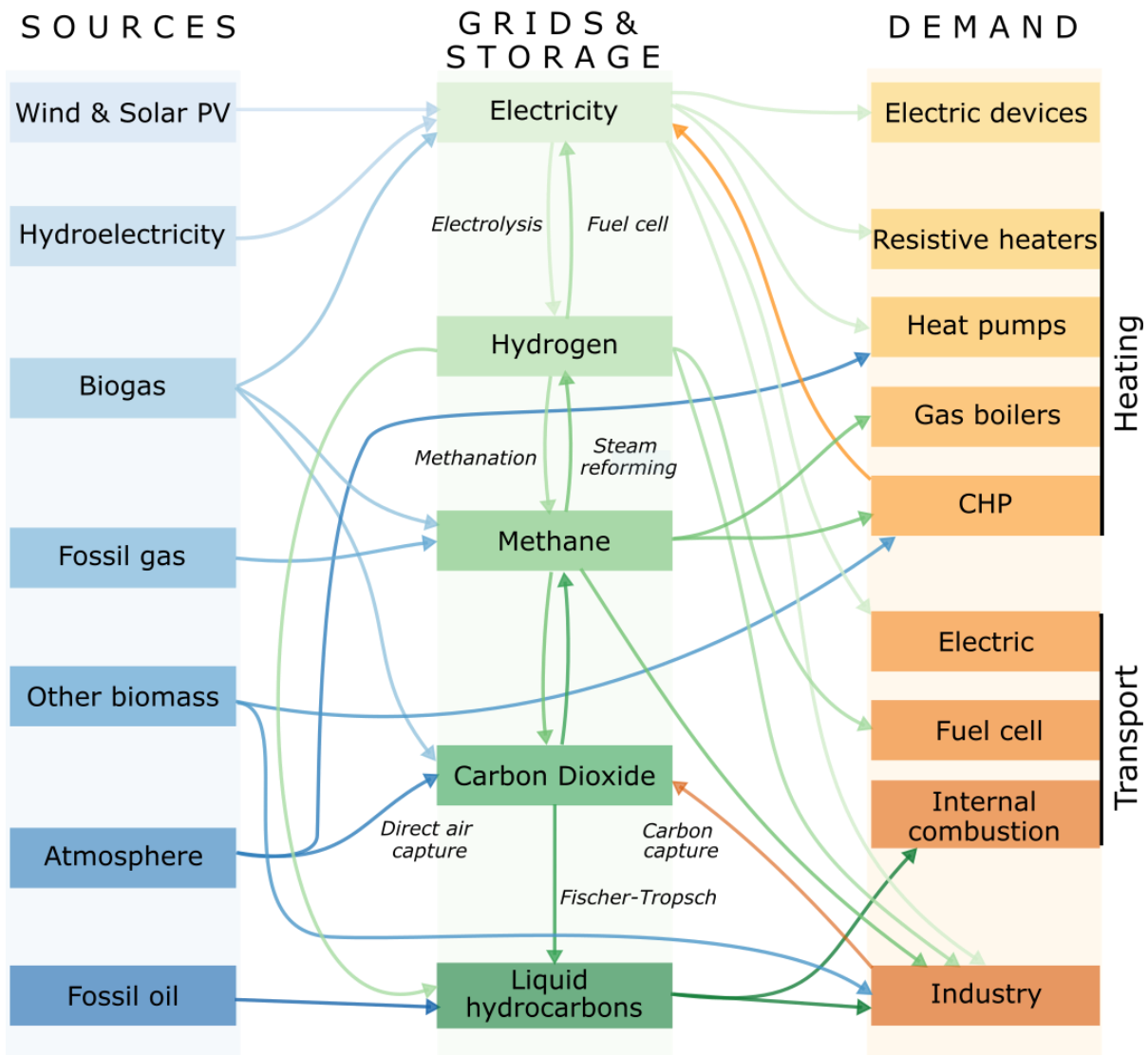
- Able to model highly renewable energy systems
- Low and net-zero emissions scenario
- Optimization of investment and operational costs

Open sector-coupled nationally tailored ESM

- Transparency, Credibility:
  - Better policy advice,
  - Increase public acceptance
- Reusability:
  - Benefit from best-practice energy system modelling
  - Contribute to community
- Collaboration:
  - Open for contributions

Open **sector-coupled** nationally tailored ESM

- Energy system get more interconnected
- => more complexity
- => more flexibility options



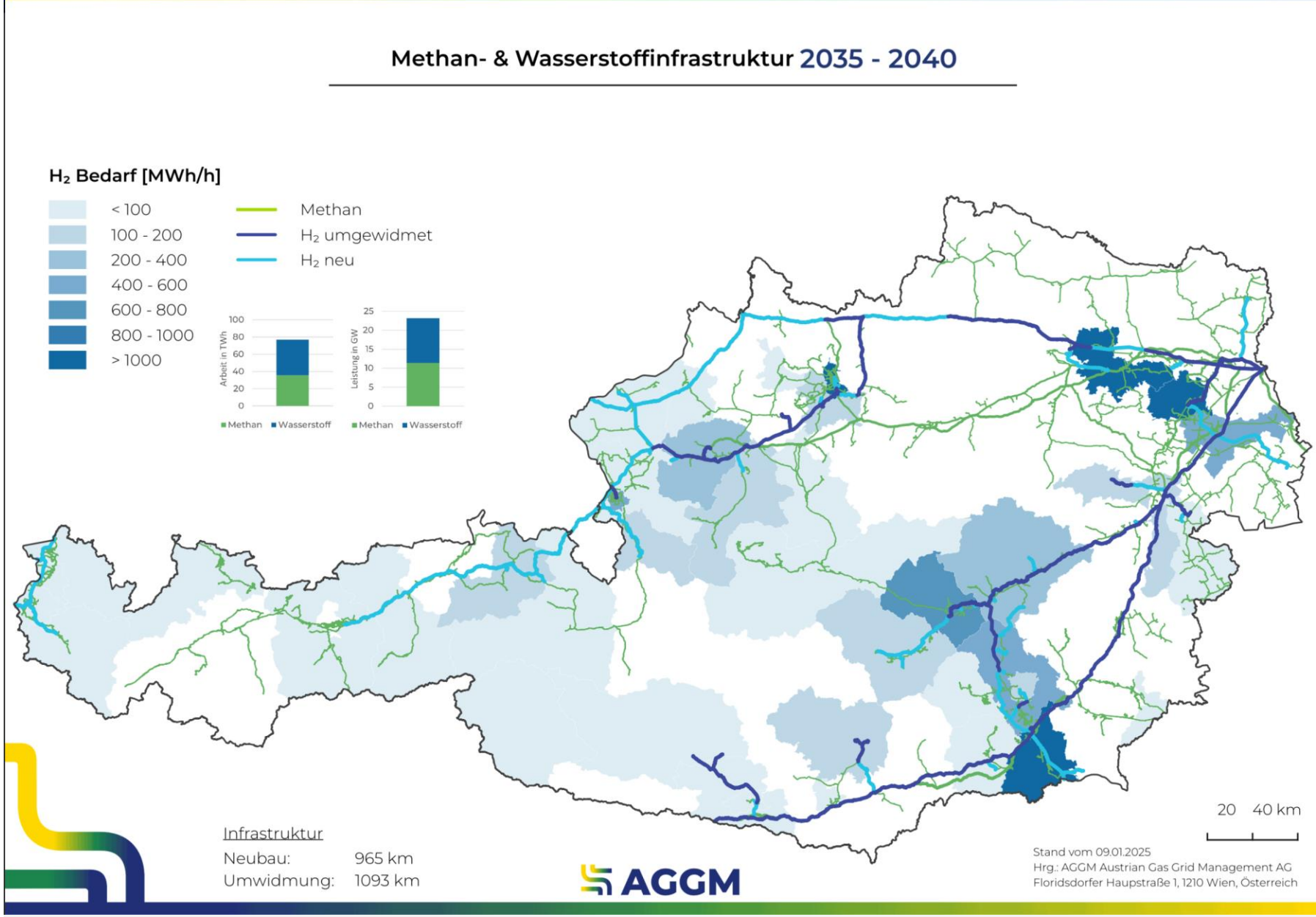
Open sector-coupled **nationally tailored** ESM

- Energy systems are highly interconnected
- Over-regional ESMs:
  - strong benefits for international energy system planning
  - limited applicability on national scale
- High country granularity
  - Spatial granularity, local geography, …
  - Country-specific inputs, …
- Realistic representation of country in international system
  - National policy frameworks
  - Import/export energy flows

AGGM Use Case

H_2 infrastructure planning

- Top-down, cost-optimal infrastructure planning approach
- Complements the H_2 Roadmap[1] for infrastructure planning
- Scale-up the hydrogen infrastructure involves significant uncertainties
- Used to evaluate a wide variety of energy transition scenarios



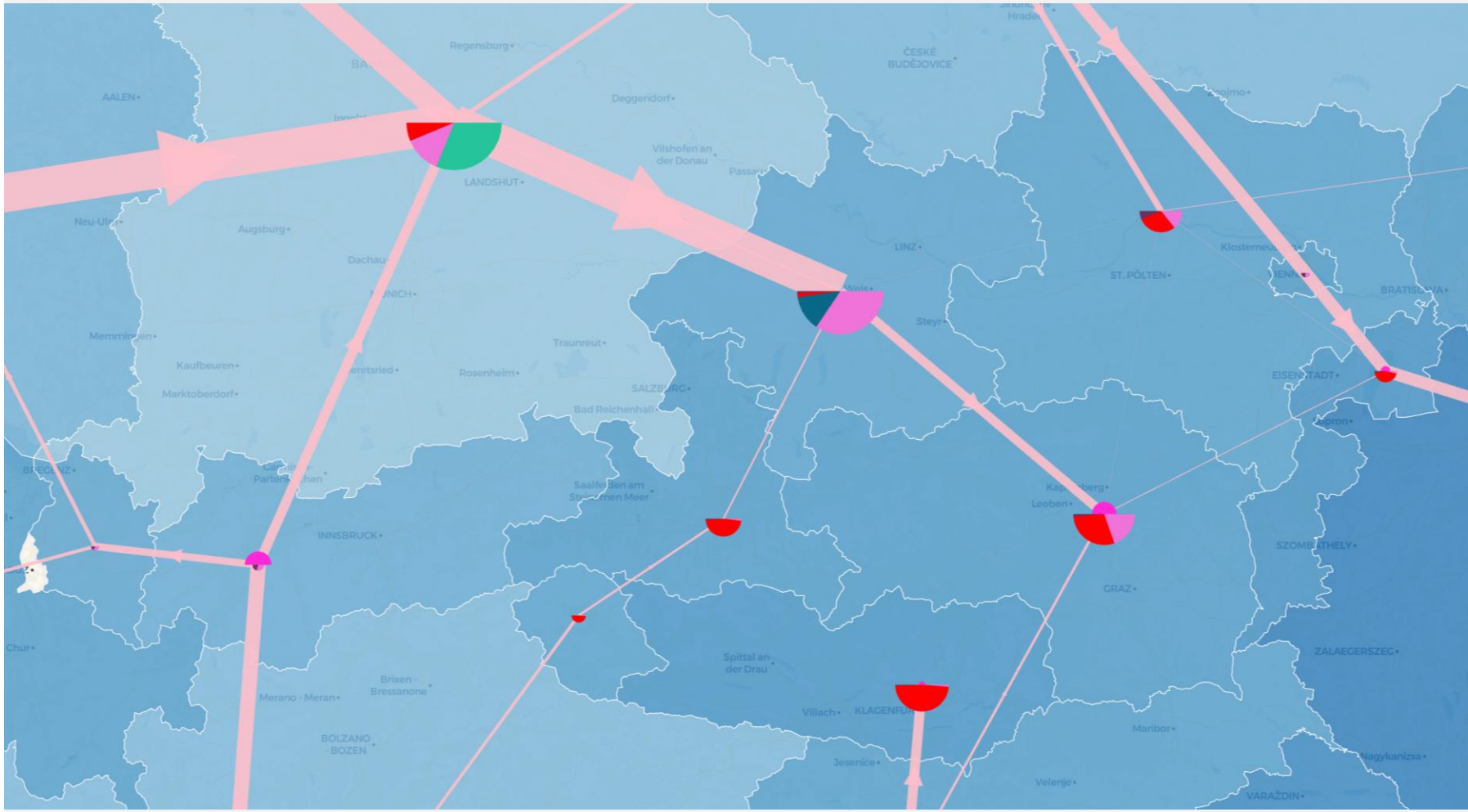
[1] https://www.aggm.at/energiewende/h2-roadmap/

PyPSA-EUR/DE

Results 2040

- Austrian infrastructure inadequately represented at high resolution
- Topography is not captured at all
- Unused retrofitting potential for CH_4 pipelines

Preliminary H_2 Infrastructure Results for Interregional Yearly Net Energy Flow (MWh/a) in 2040 at Medium Spatial and High Temporal Resolution[2]



[2] PyPSA-AT forked from PyPSA-DE, clustered to 10 regions in AT, without model adaptations

PyPSA-AT

A freely licensed, open-source energy system model for Austria in the European context

No freely licensed model exists for cost optimal infrastructure planning at the required scales.

PyPSA Ecosystem: Strong foundation, but Austria-specific updates are essential.

- **AT updates required:** brownfield infrastructure, demand progressions, and political goals / policies
- **Model calibration & validation:** base-year calibration and myopic expansion validation needed
- **Long-term maintenance & compatibility:** AGGM provides stable TSO use case for ongoing upkeep
- **Open-source advantage:** contributions welcome on github.com/AGGM-AG/pypsa-at

Soft fork of PyPSA-DE / PyPSA-EUR

- High temporal resolution
- Possibility for high spatial resolution
- Co-optimization of investment and operational costs
- sector coupled ESM

Nationally-tailored inputs and data

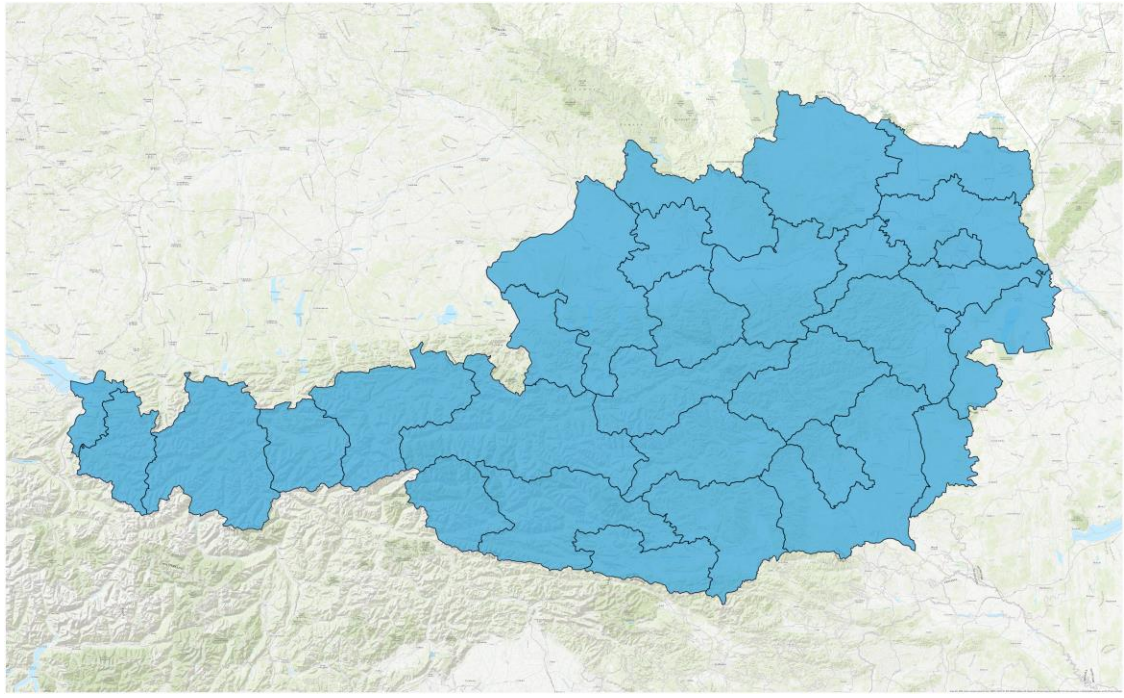
- International datasets: limited intra-country granularity
- Limited information on
  - Infrastructure siting, demand patterns, brownfield infrastructure

- National data
  - Infrastructure information, industry demand, renewable potentials, …
- National policy frameworks
  - net-zero targets, technology phase-out pathways, national emission constraints, …

High spatial granularity

- Over-regional models: coarse national-scale spatial aggregation
- Processing of highly resolved inputdata
- Infrastructure needs between regions

- 2 clustering options:
  - AT 10: NUTS 2
  - AT 30: ~NUTS 3

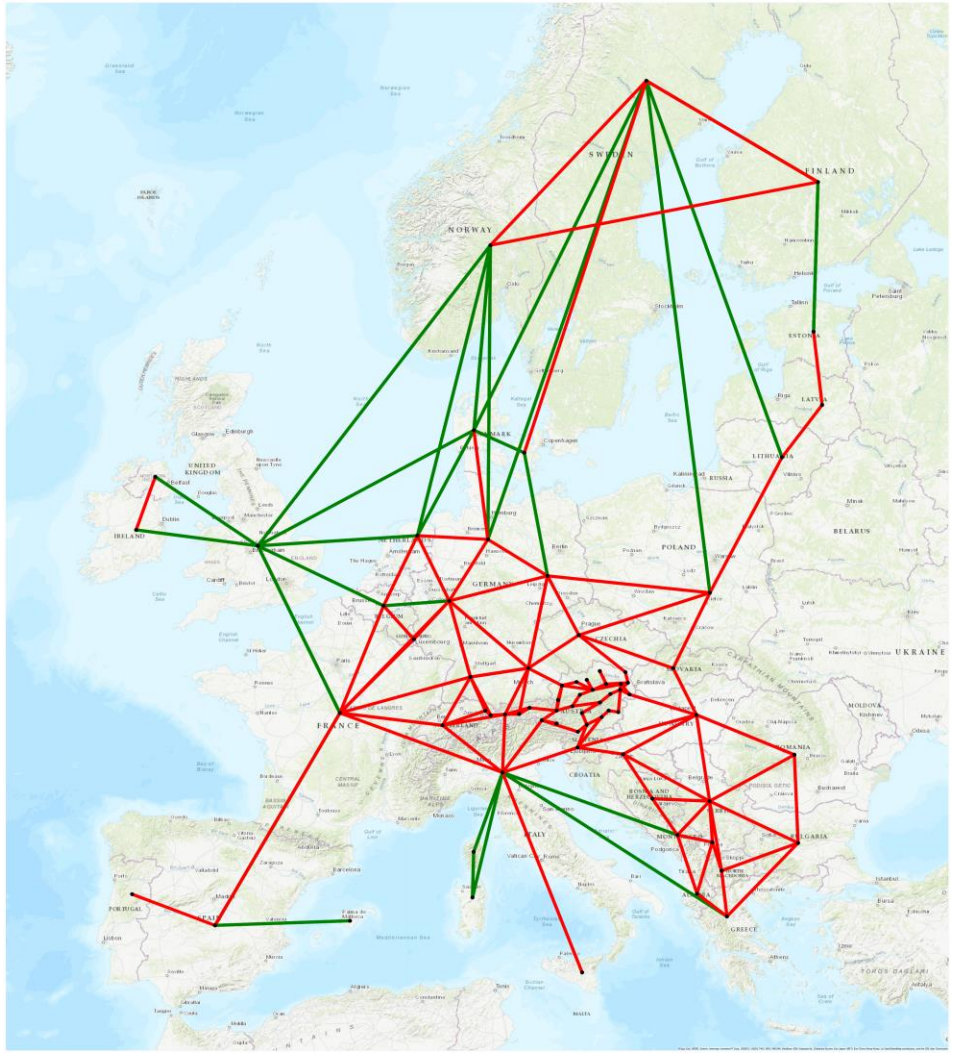


Embedding in European energy system

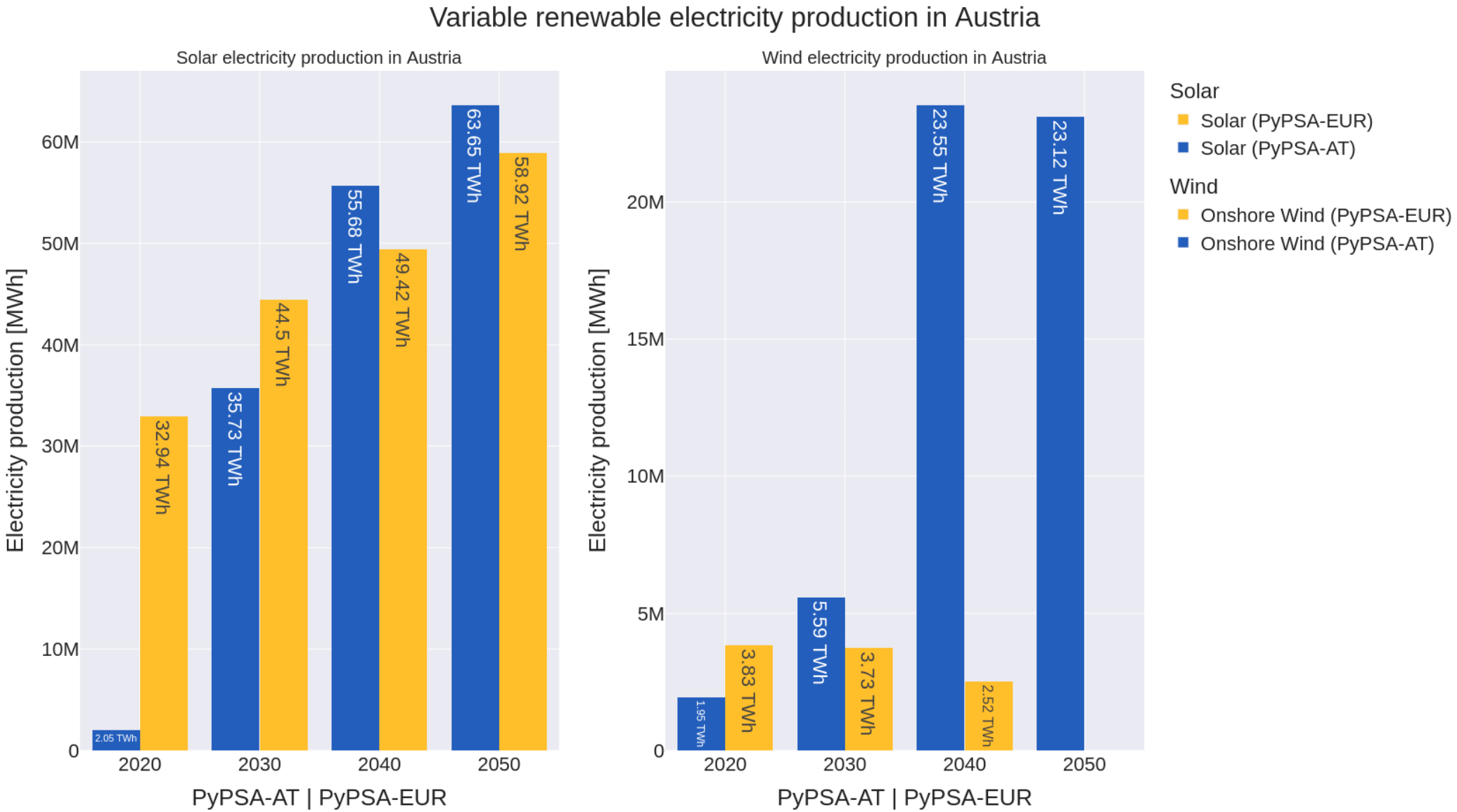
- Energy systems are highly interconnected
- Over-regional ESMs – optimize entire system
- Results may not be applicable on national scale

- AT as a unit embedded in a system

  instead of a collection of regions



Embedding in European energy system



Model calibration

- European Energy Balance for AT
- Based on international Standards

PyPSA-AT - development

- Currently under development
  - Technology representation, renewable gases, national emission accountings, European embedding
- Open for contribution

Thank you!

Resources

[1] United Nations Environment Programme, *Emissions Gap Report 2025: Off Target - Continued Collective inaction puts Global Temperature Goal at Risk*. United Nations Environment Programme, 2025. doi: 10.59117/20.500.11822/48854.

[2] T. Brown, “What are open energy models and what can they contribute?,” presented at the Agora PyPSA-SPICE Launch, Dec. 08, 2025.

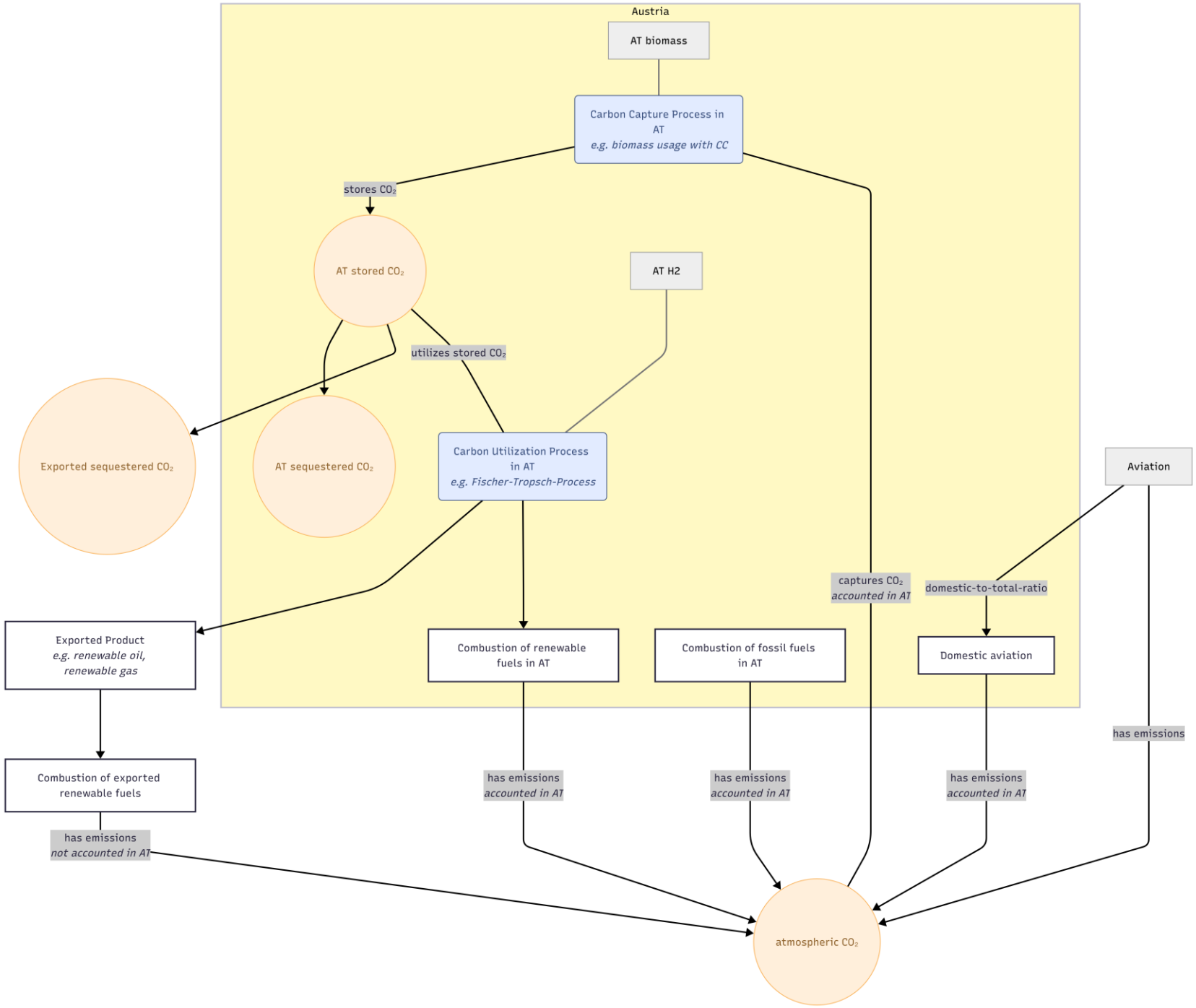
Pictures

“One day's carbon dioxide emissions from above - high res still from 'CCS: a 2 degree solution' (film)” by Carbon Visuals, CC BY 2.0

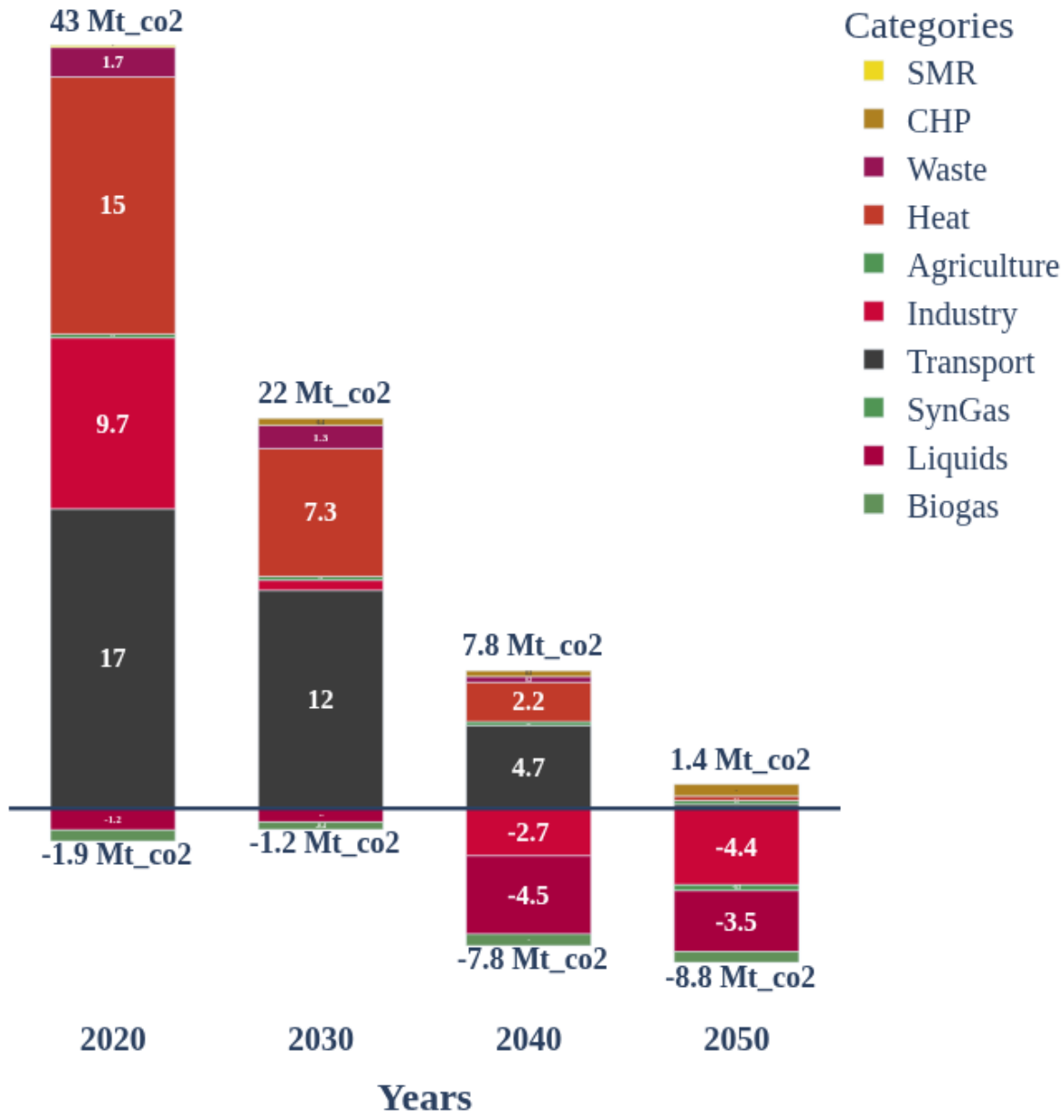
Easy-Peasy-AI, online: https://easy-peasy.ai/ai-image-generator/images/humorous-cartoon-software-developers-conversation-coding-languages

PyPSA-EUR read-the-docs online documentation: https://pypsa-eur.readthedocs.io/en/latest/

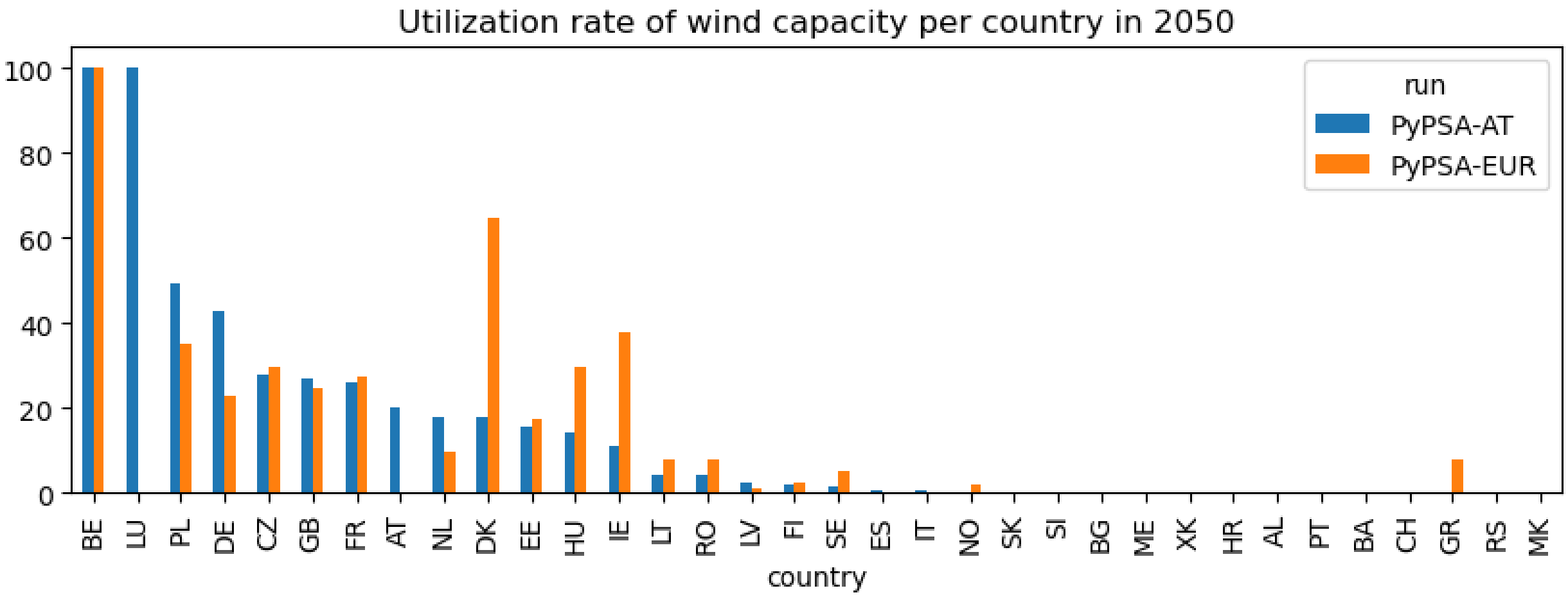
Abbie Trayler-Smith / Panos Pictures / Department for International Development, online: https://www.flickr.com/photos/dfid/4058016979/in/album-72157622638698348/

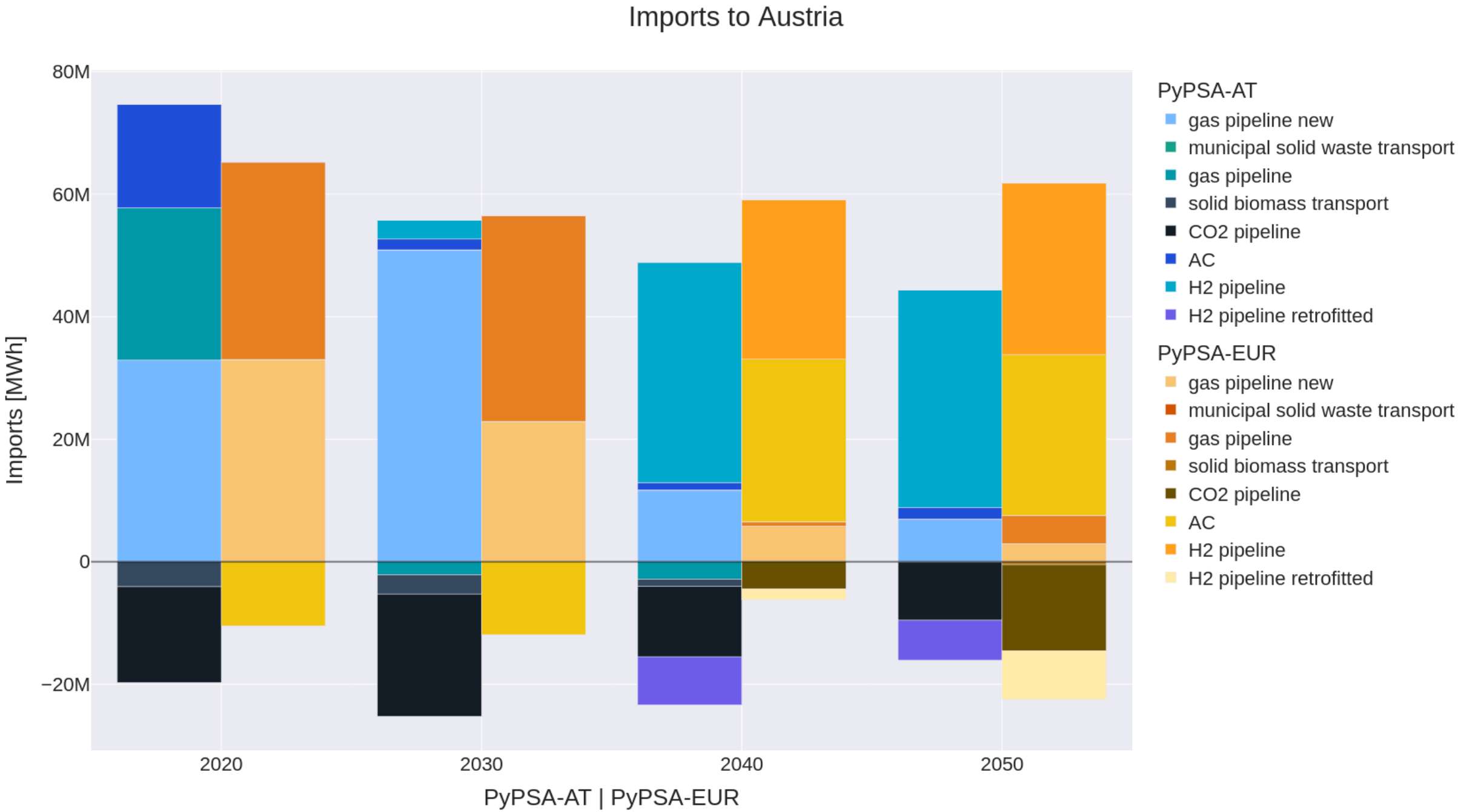

Austria
AT biomass
Carbon Capture Process in AT
e.g. biomass usage with CC
stores CO_2
AT stored CO_2
AT H2
utilizes stored CO_2
Exported sequestered CO_2
AT sequestered CO_2
Carbon Utilization Process in AT
e.g. Fischer-Tropsch-Process
Aviation
captures CO_2
accounted in AT
domestic-to-total-ratio
Exported Product
e.g. renewable oil, renewable gas
Combustion of renewable fuels in AT
Combustion of fossil fuels in AT
Domestic aviation
has emissions
Combustion of exported renewable fuels
has emissions
accounted in AT
has emissions
accounted in AT
has emissions
accounted in AT
has emissions
not accounted in AT
atmospheric CO_2

Carbon Dioxide Balance Austria in Mt_co2



Wind utilization rate PyPSA-EUR vs. PyPSA-AT




Imports to Austria
80M
60M
40M
20M
0
−20M
Imports [MWh]
2020
2030
2040
2050
PyPSA-AT | PyPSA-EUR
PyPSA-AT
gas pipeline new
municipal solid waste transport
gas pipeline
solid biomass transport
CO2 pipeline
AC
H2 pipeline
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