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

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Motivation

Austria has committed to achieving Net Zero greenhouse gas emissions by 2040, with an intermediate target of attaining a 100% renewable electricity supply by 2030 in national balance [1]. These goals demand a comprehensive transformation of the Austrian energy sector. Achieving this transition requires both, a robust understanding of the current energy system and potential decarbonisation pathways. Such pathways are crucial to accurately estimate infrastructure requirements, future demand for energy carriers, remaining carbon emissions and the pace of transformation, to name a few. In this context, energy models are used to support planning and decision-making.

While a wide range of energy system modelling frameworks currently exist, they vary significantly in their scope, including the sectors they model, the degree of sectoral integration, spatial resolution, geographical coverage and level of detail. For Austria specifically, existing national models are limited with respect to spatial and temporal resolution or the integration in the European energy system. There are also European sector-coupled models, but these are not detailed enough to tackle Austria-focused questions. In particular, this includes the need for thorough information on future energy infrastructure (such as hydrogen networks, CO_2 pipelines, renewable gas systems or electricity transmission lines), the integration of detailed national policy goals and frameworks and the ability to realistically model the transition from existing energy systems to Net Zero in high spatial detail.

We here propose to close these gaps by extending the modelling landscape with an energy system model tailored to Austria's specific needs, embedded within a broader European context, providing the granularity and comprehensiveness required to generate profound insights into the aforementioned aspects of the energy transition. Our approach, building upon existing experiences (see [2]), will contribute to a deeper understanding of pathways to achieving Austria's Net Zero targets and contribute to informed, actionable policy recommendations.

Methods

To address these challenges, we extend the existing system modelling framework PyPSA-EUR [3] and build upon the methodologies introduced in PyPSA-DE [2] to develop PyPSA-AT, an Austria-specific framework. The model is designed to provide a detailed representation of Austria's energy system within its European context, focusing on three key aspects: i) accurately reflecting Austria's current energy balance, ii) integrating detailed information on brownfield infrastructure, renewable energy potentials and Austrian policy frameworks and iii) realistically capturing energy trade flows with neighbouring countries.

To achieve these improvements, the following methodological steps are proposed: Through the creation of a comprehensive comparison framework for validating the model's energy flows with Eurostat energy balances, consistency issues of the current energy flows are identified. National data on brownfield infrastructure and renewable energy potentials from various open sources and studies are integrated into the workflow. The model's spatial resolution is refined to 30 regions inside Austria, largely based on NUTS 3 Regions. Figure 1 shows the default spatial representation of the modelling area with Austria split into 30 regions and one region minimum per each other European country. Germany, as most important trade partner, is represented by five regions while France, Italy and Spain are split into multiple

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regions in order to accurately represent respective islands. Additionally, energy trade flows with neighbouring countries are constrained to reflect Austria's role in the interconnected European energy network. Once these elements are incorporated, the model is calibrated to better align with Austria's energy balance.

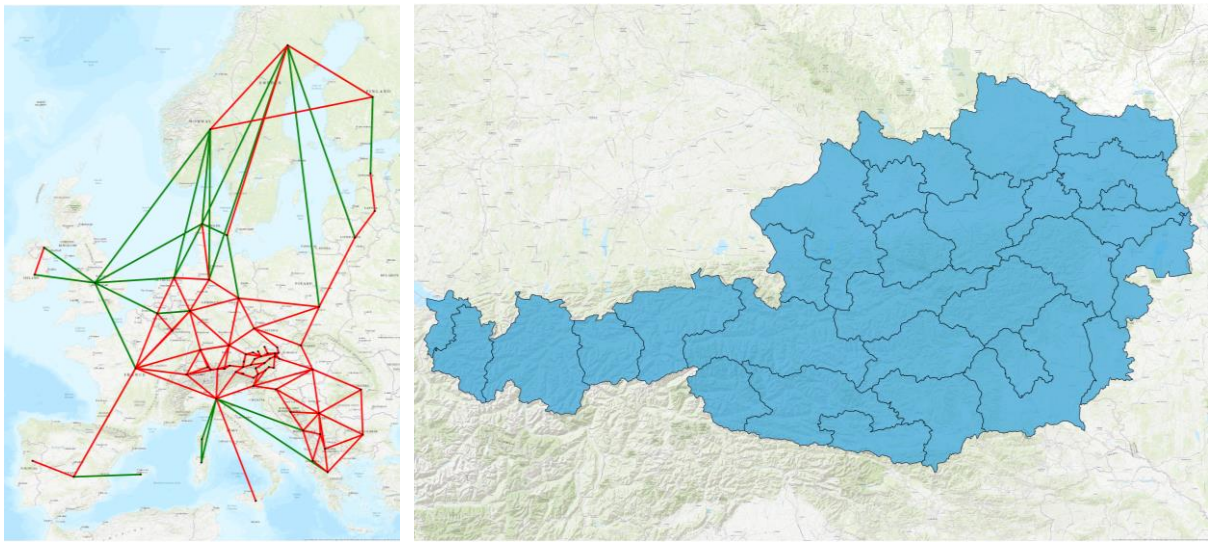

Figure 1: left: Schematic representation of the model topology; black dots: buses; lines: AC (red) and DC (green) lines; right: clustering regions inside Austria

Open-source contribution and Community impact

The PyPSA-AT model is built as a soft fork of the PyPSA-DE codebase, a sector-coupled energy system model for Germany, which itself is based on the PyPSA-Eur framework [4]. This approach allows PyPSA-AT to benefit from upstream developments in these codebases. On the other hand, our extensions and adaptions, which include new workflow steps and enhanced functionalities, are designed to be integrated into the broader PyPSA ecosystem, contributing to the global and European energy system modelling community.

PyPSA-AT will represent the first freely licensed sector-coupled energy system model for Austria with high temporal and spatial resolution, embedded in a European context. As the project will be completely open source and will only rely on open data, it will not only provide valuable insights into Austria's energy transition but also serves as a resource for the wider energy system modelling community, fostering collaborations and intercomparison of scenario results.

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