Energy grid modeling for SWEET-SURE

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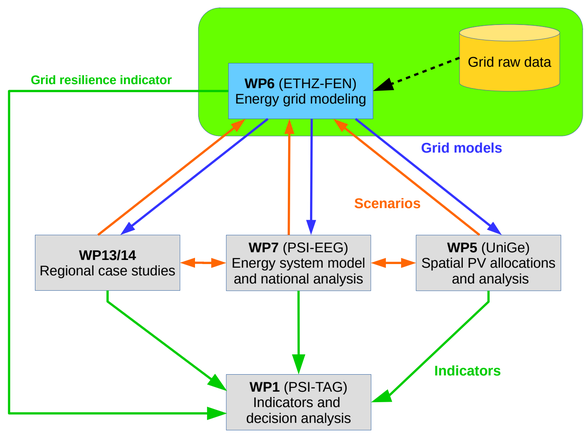
Introduction

- **Background:**
  - Energy grids impose boundaries and constraints on energy transition scenarios.
  - SURE model analysis requires adequate grid model representation.
- **Focus of this work:**
  Develop aggregated models of the transmission grids for
  - Electricity: from bottom-up European linear DC power flow model
  - Gas: from detailed European nonlinear gas flow model
- **Benefit:**
  - Simple grid representation allow hard coupling with other models
  - Detailed grid model available for refined studies (in particular security indicators)

Interaction with other SURE work packages

- WP6 performed interviews for need identification of each SURE partner.
- Main coupling with SURE Energy System model.
- Potential coupling with other SURE work packages.
- Detailed models also needed to compute technical resilience indicators.



Electricity grid model

- **Data**:
  - Nodal grid model used includes the transmission grid of Switzerland and 18 other European countries [PyPSA]
  - Generation, loads and renewables through regionalization of ENTSO-E TYNDP Scenarios
  - Plausibility check with Swissgrid's published network expansion plans
- **Approach**:
  - Nodal DC power flow modeling and representation of loads and generation
  - Combination of sparse DC-power flow models for full year simulation and Power-transfer-distribution-factor (PTDF) models for optimization-based model aggregation
  - Zonal Aggregation using flow-based model of European inter-zonal grid capacities and Swiss NTC import/export capacities
  - Aggregation of Switzerland into NUTS-2 regions

Gas grid model

- **Data**:
  - Public model of the European Network of Transmission System Operators for Gas (ENTSO-G) [SciGRID]
  - Model includes pipes, border points, compressors and storages (related study within SURE)
  - Monthly time series for gas trades at all European border points, published by IEA
  - Plausibility checks with Swiss gas utilities (GAZNAT)
- **Approach**:
  - Modeling using 1-dimensional steady-state flow equations for non-ideal gases.
  - Fast solution of nonlinear flow model using dedicated Newton-Rhapson solver.
  - Model application to compute simplified import/export/flow limits for gas network for hard coupling with other SURE-models
  - Model can be extended for potential repurposing to hydrogen pipelines

Procedure for European flow-based modeling

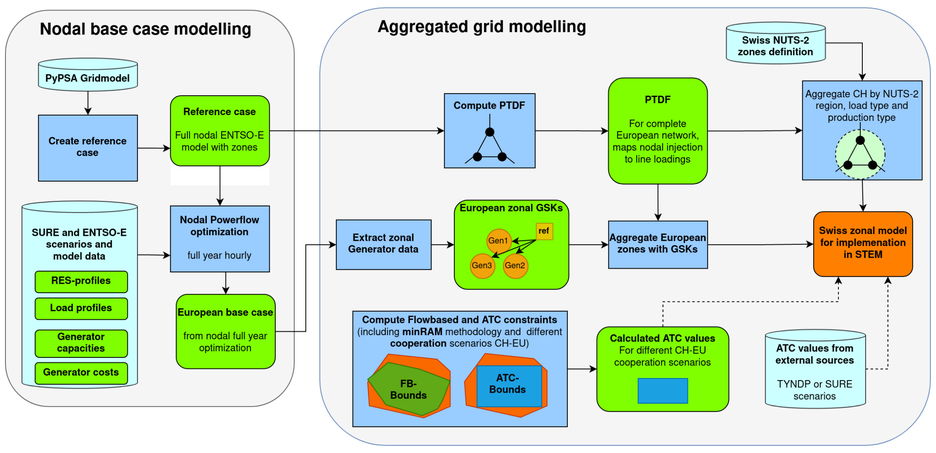
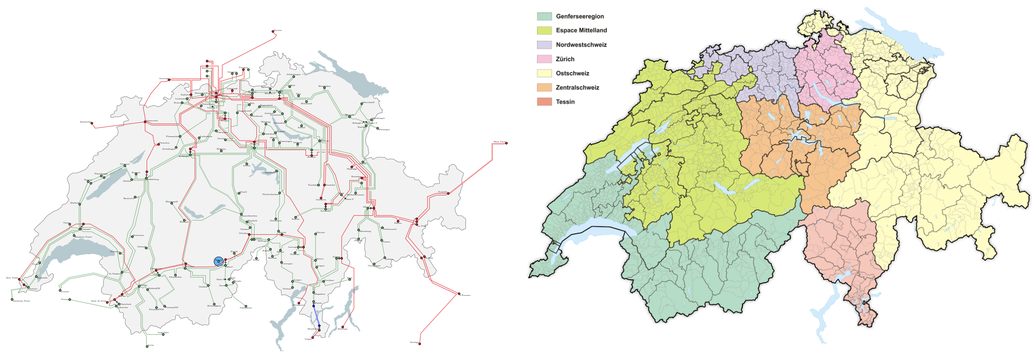


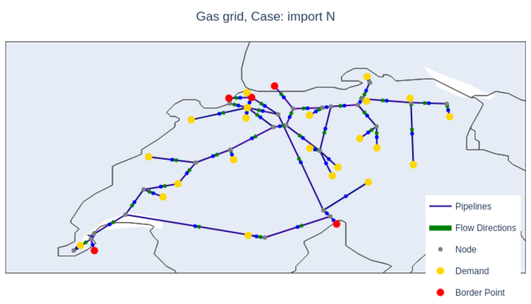
Illustration of European Gas grid model

Swiss electricity model



Nodal and aggregated regional model

Simulation example of Swiss gas grid model



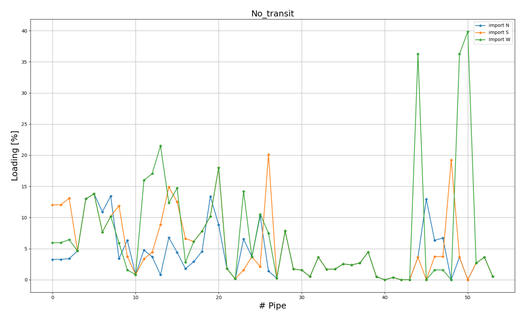


Illustration of simulation results and pipe loading for different import directions

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