RESILIENT Project

Optimising a Large-Scale European Power Network

EDF R&D · University of Pisa

Abstract

The **RESILIENT** project aims to assess the **resilience and operational performance** of future European energy systems. Starting from a large-scale European power system dataset, a detailed **PyPSA** network is built and optimised to evaluate system behaviour under multiple uncertainties. The resulting network is solved with the **SMS++** optimisation framework, making it possible to rely on state-of-the-art optimisation algorithms and significantly reduce the computational burden.

I Input dataset

The study relies on a comprehensive representation of the European power system that serves as the basis for building large-scale optimisation models with PyPSA. The dataset is based on the ENVIS2060 transition pathways in Man0euVRE (NECP Essentials v1.4, year 2030). It gathers:

8 760 h — electricity demand and RES load-factor profiles, 16 regions

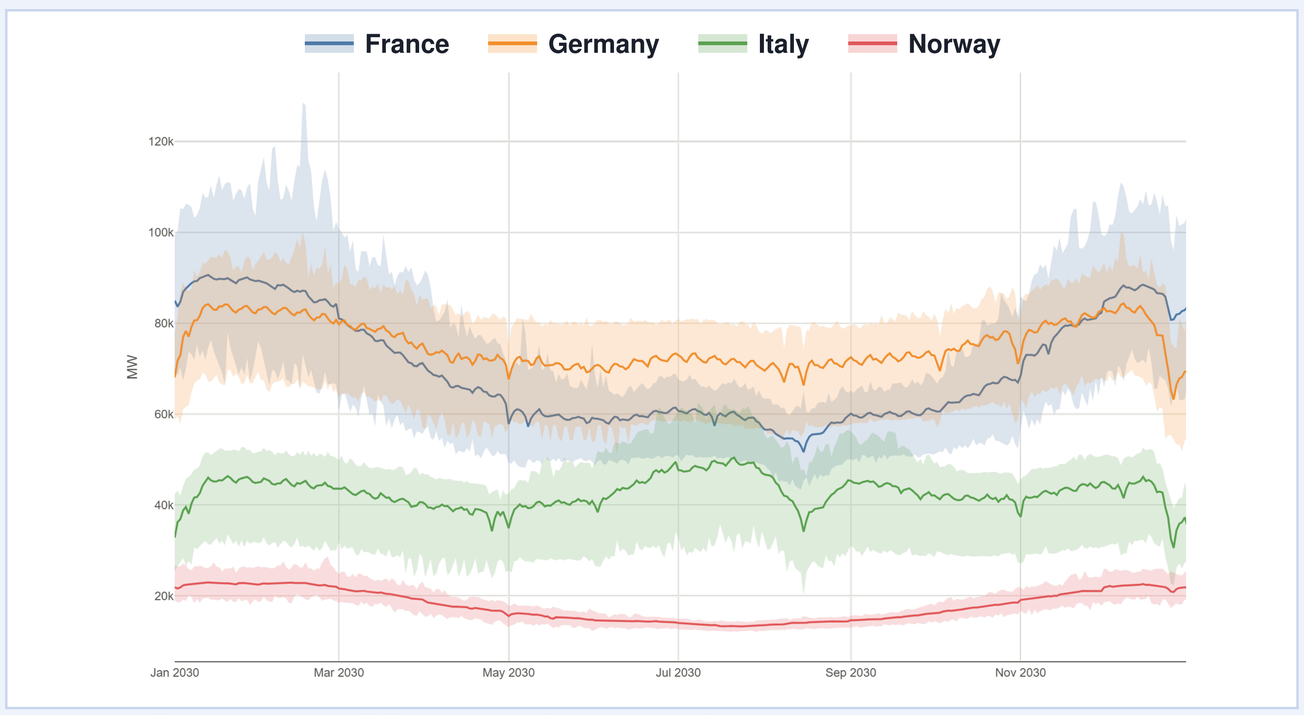
221 — generators (conventional and renewable)

34 — transmission links

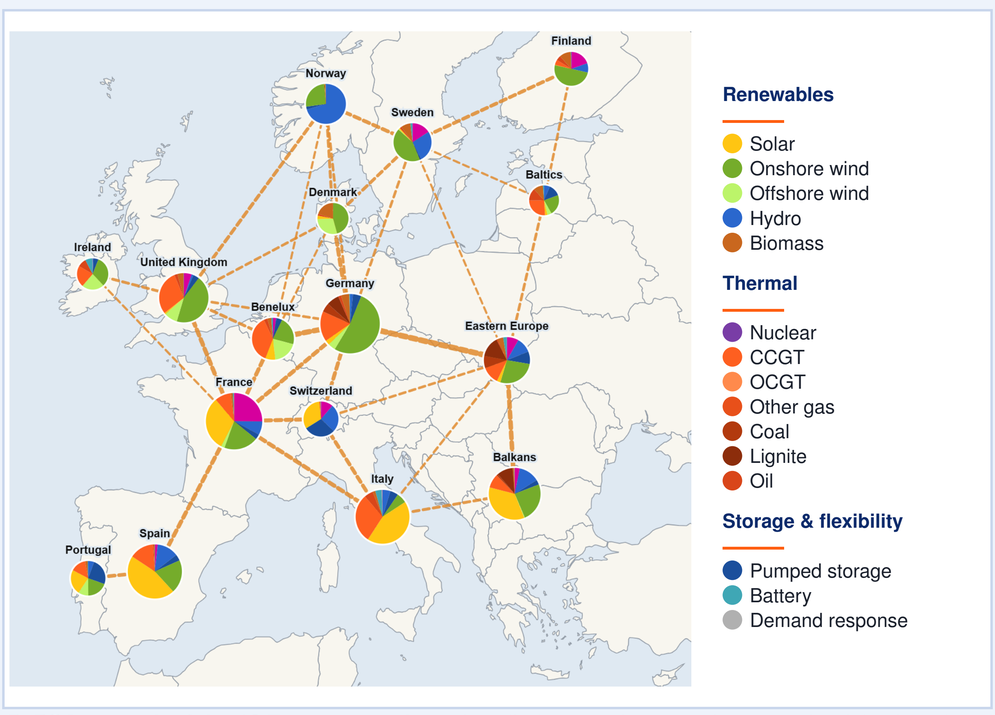
47 — electricity storage units

up to 630 — scenarios for RES generation (crossEU project) and demand

+ — technical and operational constraints

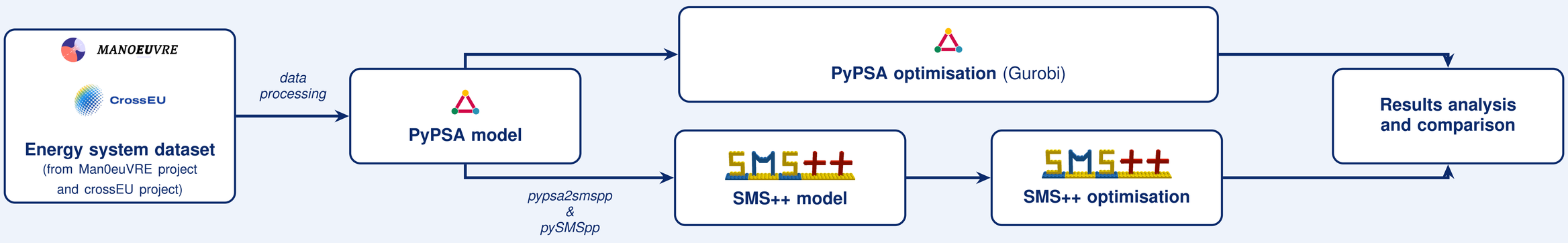


***Electricity demand (MW)** over the year 2030: central profile (line) and scenario envelope (shaded band).*



***PyPSA network of the 16 European regions**: installed generation capacity per region (pie charts) and interconnections.*

II Methodology



1 Unit commitment

Hourly scheduling of generation units and electricity storage across the 16 regions, under technical and operational constraints.

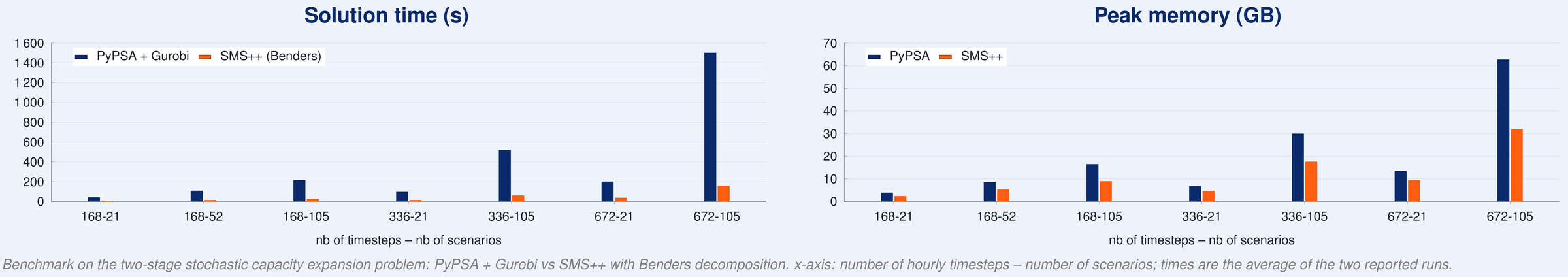
2 Two-stage stochastic capacity expansion

First stage: investment decisions on capacities. Second stage: hourly system operation for each RES generation and demand scenario. In SMS++, modelled with the *TwoStageStochasticBlock*.

Main outputs • Generation dispatch • Storage operation • Cross-border exchanges • Congestion analysis • Flexibility assessment • System resilience

III Accelerating Large-Scale Scenario Analysis with pypsa2smspp

While PyPSA provides a flexible and powerful framework for modelling large-scale energy systems, solving large collections of scenarios can become **computationally demanding**. To address this challenge, we developed **pypsa2smspp**, an interface that automatically translates PyPSA optimisation models into the **SMS++** framework. It gives access to **advanced decomposition techniques** and high-performance optimisation algorithms designed for large-scale mathematical programming.



Benchmark on the two-stage stochastic capacity expansion problem: PyPSA + Gurobi vs SMS++ with Benders decomposition. x-axis: number of hourly timesteps – number of scenarios; times are the average of the two reported runs.

5×–10× — faster than PyPSA + Gurobi on all tested instances

up to ≈ 49 % — peak memory reduction (62.7 GB → 32.1 GB)

up to 630 — RES generation and demand scenarios