FF4EuroHPC Success Story

Robust Power System Maintenance Planning via Stochastic Optimization and HPC

Organizations

Artelys is a French SME specializing in applying data science, artificial intelligence, mathematical modelling, and numerical optimisation to the analysis of power systems. In particular, Artelys has developed a strong expertise in the simulation and optimisation of energy networks and conducts studies for clients all along the energy value chain: utilities, system operators, regulators, public institutions, etc.

INRIA-Aviz Team is a worldwide renowned research group specializing in big and unstructured data visualization. INRIA also provides the HPC resources for this project.

End User

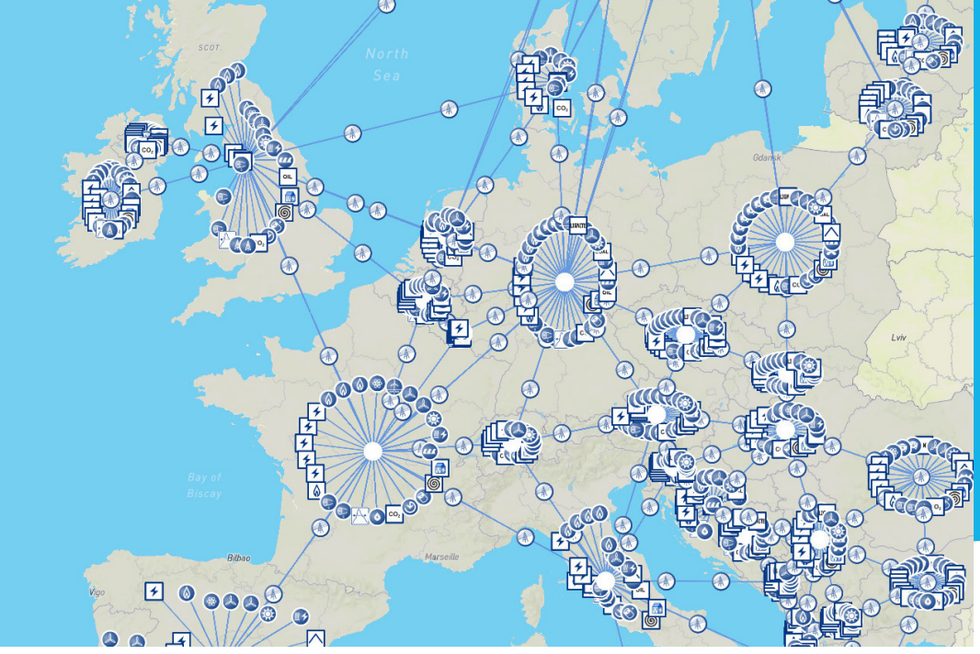
Artelys
OPTIMIZATION SOLUTIONS

HPC & Technology Provider

Inria

The Challenge

Shutting down a power plant or transmission line for maintenance likely means having to rely on more expensive energy sources or external energy providers. Some factors can only be reliably planned a few days ahead or are just purely random but they all add stress to the power network and can make satisfying demand harder to guarantee. Moreover, as the installed capacities of renewable energy sources grow and electric mobility options are deployed, the overall system becomes more subject to uncertainties. As such it is of prime interest to develop tools to ensure that maintenance plans are prepared for a number of scenarios. While many clients of Artelys would benefit considerably from such tools for robust power system analyses and optimization, this was beyond the SME's capabilities.



Industry Sector
Manufacturing

Technology used:
HPC,
Monte Carlo Simulations

The Solution

Solving the problem required creating a representative data set for the European power system. It was necessary to simulate and optimise massive scenarios, and cope with the resulting high-dimensional results. For every candidate maintenance plan, various plausible, yet unknown scenarios were generated including climate data and random outages on assets. Thousands of generated scenarios were simulated in parallel. Due to the several-hour duration of every single European-wide simulation and the memory required, an HPC cluster with 1,280 cores was used to perform computations. The results of simulations were then combined to compute Key Performance Indicators for maintenance plans. After computation, KPIs could be analysed using the interactive visualisation tool developed. During computation, the KPIs were then fed back into an optimisation model which computed the next candidate maintenance plan. This process was repeated, in a greedy approach, until all potential plans were exhausted or until convergence was achieved in the case of local optimisation. The selection of the best scenarios could be guided by various criteria such as minimisation of costs, CO2 emission, or maximisation of social welfare.

The Impact

The approach developed through this project will help power producers and transmission system operators schedule their maintenance in a manner that is resilient to uncertainties. By finding optimal maintenance timing, they will reduce the risk of having to resort to external market players or minimize this cost, thereby saving millions in revenue, and reducing the risk of potential demand curtailment situations. Furthermore, optimal scheduling of maintenance can prevent the need to resort to more polluting assets to compensate for the limited availability of other power generation assets.

Through the experiment, Artelys has gained the ability to conduct quantitative prospective studies on behalf of their clients for a large number of scenarios that cover these uncertainties. A prototype of the solution has already been used successfully in a commercial project. Moreover, further investments into these capabilities are foreseen. It is expected that the experiment results will contribute directly and indirectly to as many as €4 million Euros in revenue in the upcoming years through performing this new type of prospective study. Without the HPC-based solution, facilitating and improving existing studies was previously impossible as a competitive edge to enhance the current line of business.

The experiment also opens the possibility for Artelys to bundle the HPC-based optimisation with their portfolio of optimisation software available to more advanced customers, allowing them to reach out to more clients. Such computationally expensive combinatorial optimisation gives Artelys a keen edge over its competitors.

This work also has societal impacts as it will help key players to make better use of the power system, which in the end sums up to better usage of renewable energy generation resources and a lower cost of electricity.

Benefits

- Estimated additional sales of up to €4 million over the next 5 years.
- HPC-based computational tools enable 3 quantitative studies per year (previously infeasible) and accelerate and improve up to 5 other studies per year.
- Improved calculation capabilities in Artelys software for experienced users.