Plan de Recuperación, Transformación y Resiliencia
GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES
CDTI INNOVACIÓN
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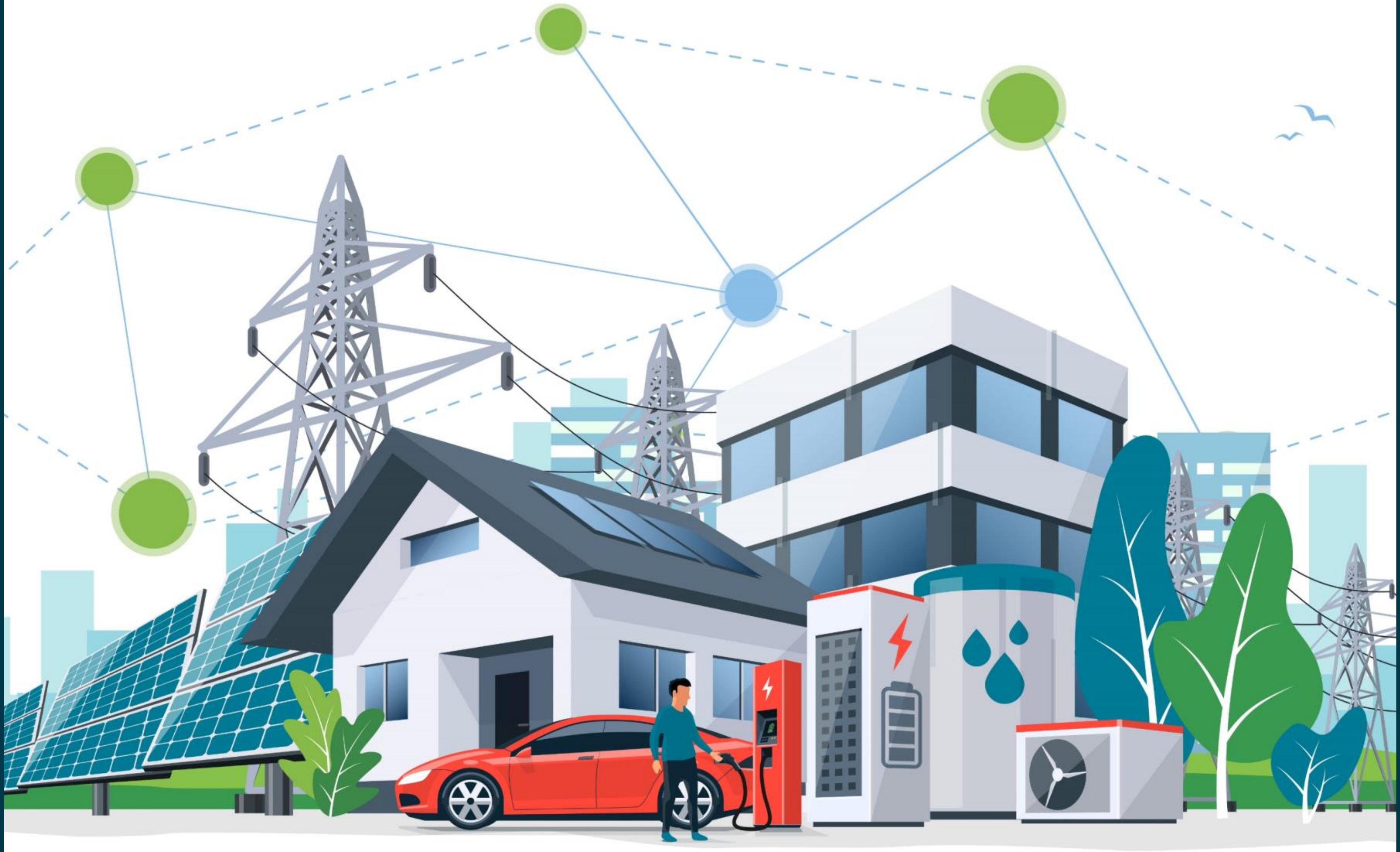
Advanced Planning Methods for Resilient and Flexible Grids

Pharoes

Manila, June 2026



Better energy models are essential towards the competitive and decarbonized electricity system needed in the 21st century

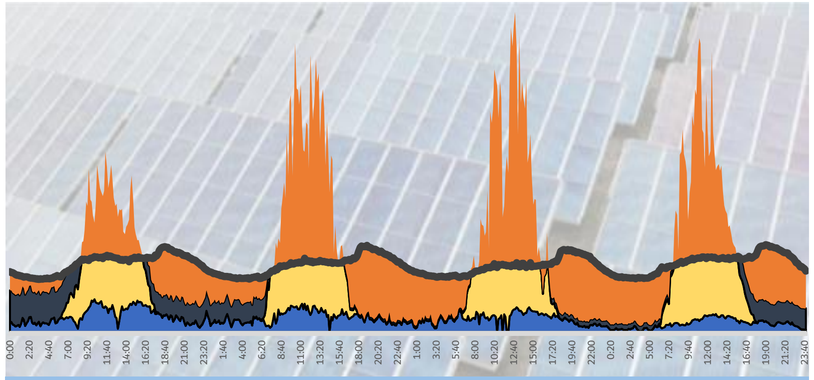
Pharoes helps its clients move from strategy and modelling to implementation

Consulting

We serve leading government agencies and corporations internationally on these services:

- **Network Planning:** Asian utility on their internal 10-year development plan
- **Business Strategy:** Optimal design solar, storage and hydropower in Europe and Latam
- **Price Forecasting:** Long term price forecasting for several investors in Asia
- **Regulatory Impact Analysis:** Impact of new taxation scheme on leading Spanish utility
- **Training and Capacity Building:** On power system planning, economics and modelling

Solutions



Our solutions allow accurate system expansion planning, reliability analysis, operation planning and facility design:

- **CERES**: System expansion planning tool designed to support the energy transition
- **FIDES:** Quantifies electricity supply risk and helps design mitigation measures
- **KAIROS:** Unit-commitment and optimal power flow solution that simulates power system and market operation
- **HERMES:** Optimal market operation of power generation projects

Technology

We work with European TSOs in their internal technological solutions to enhance decision making conducting:

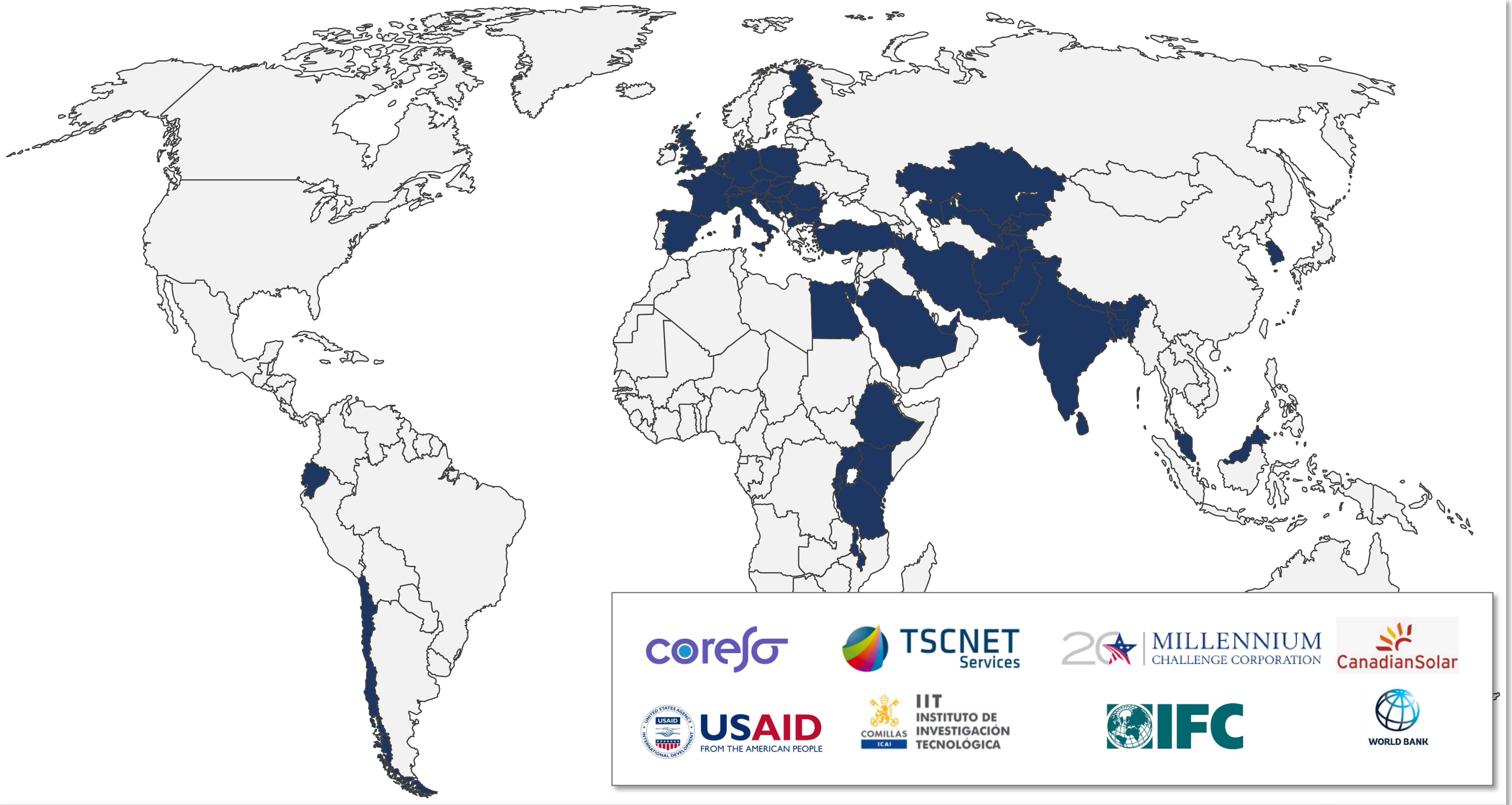
- **Custom power system solutions development:**

Our **JUNO** platform accelerates the development of **decision support solutions** in the cloud and our **DIA** technology (patent pending) allows solving **large problems** (over 100 Mn variables) in a **few minutes**

- **Technology consulting:**

We help clients identify business needs, formulate tool requirements, manage vendors and anticipate problems to ensure successful product launch

SOURCE: PHAROES ADVISORY, iSTOCK.



corelso

TSCNET Services

20 MILLENNIUM CHALLENGE CORPORATION

CanadianSolar

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IFC

WORLD BANK

Model quality determines whether grid planning decisions are robust, credible and usable for implementation

Model Quality × External Assumptions = Planning Outcome

Our focus & differentiation

Where the model makes the difference

MODEL-DRIVEN SUCCESS FACTORS

1 Technical Fidelity & Accuracy

- Avoid performing rough temporal aggregation
- High-fidelity network representation
- Operational constraints & contingencies
- Flexibility & DER modeling with ancillary services
- More accurate long-term investment signals

2 Transparency & Explainability

- Traceable and auditable methodology and code
- Interpretable drivers of decisions
- Outputs easy to explain and defend

3 Scalability & Operational Usability

- Faster computation at scale
- Lower lead times to obtain results
- Posible to launch several scenarios in parallel
- Designed for real-world planning

Critical external assumptions

OUTSIDE MODEL SCOPE

4 Regulation, Markets & Electrification

- Demand growth & load evolution
- DER, EV & heat electrification adoption
- Policy, regulatory and incentive frameworks
- Market design, prices & economic conditions
- Decarbonization & climate trajectory

5 Project Execution Feasibility

- Permitting & regulatory approvals
- Environmental constraints
- Public acceptance & stakeholder engagement
- Supply chain & resource availability
- Implementation timelines & execution risk

A strong planning model cannot eliminate uncertainty, but it can significantly improve the quality, robustness and usability of decisions

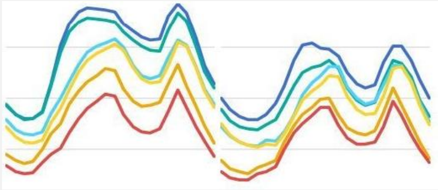
Our solution optimizes the expansion and use of renewable power networks with new agents using the computing power of the cloud

System data

- Structural data about the grid
- PSSE grid model

System conditions

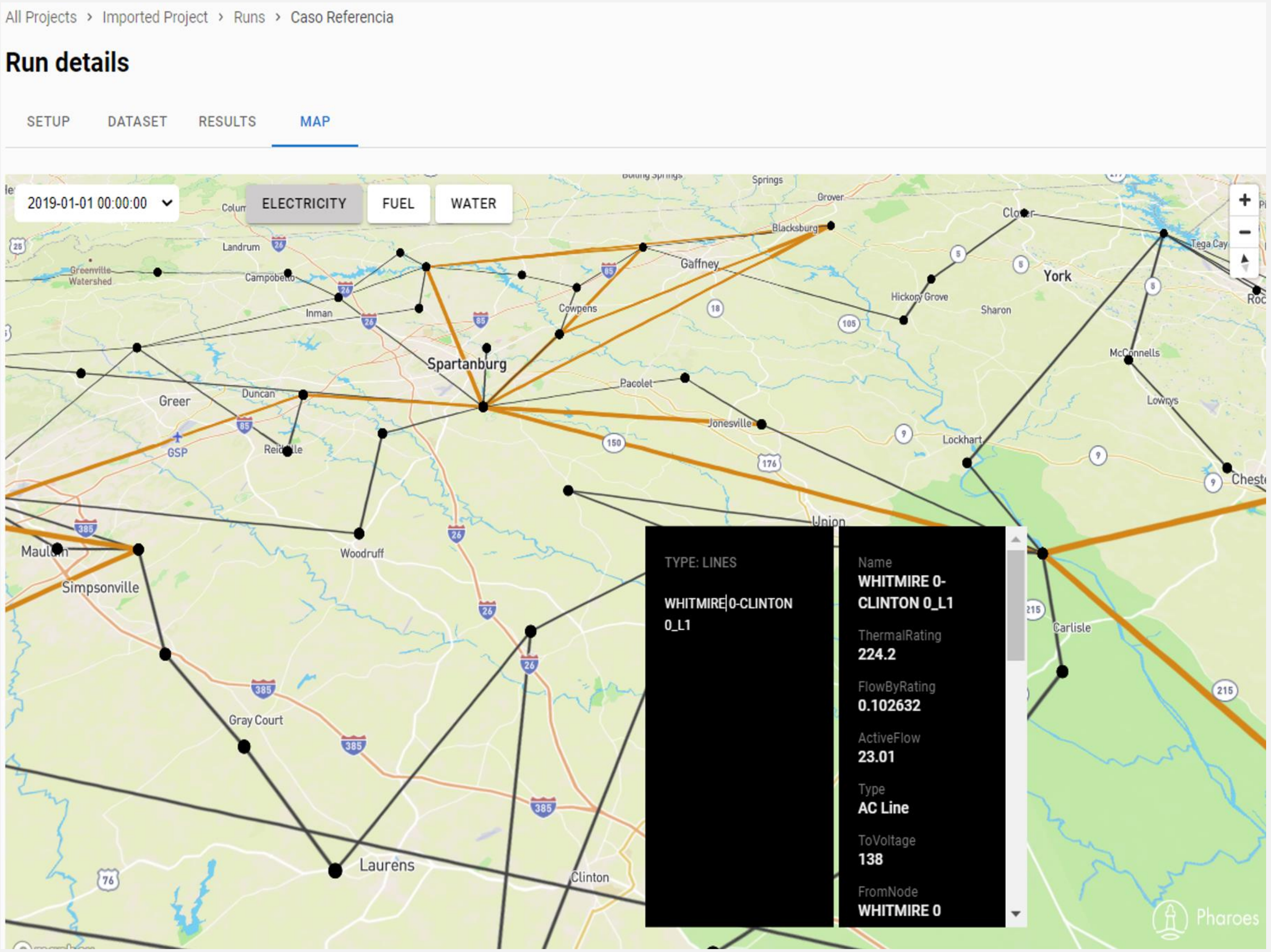
- Hourly demand and renewable profiles



Possible investments

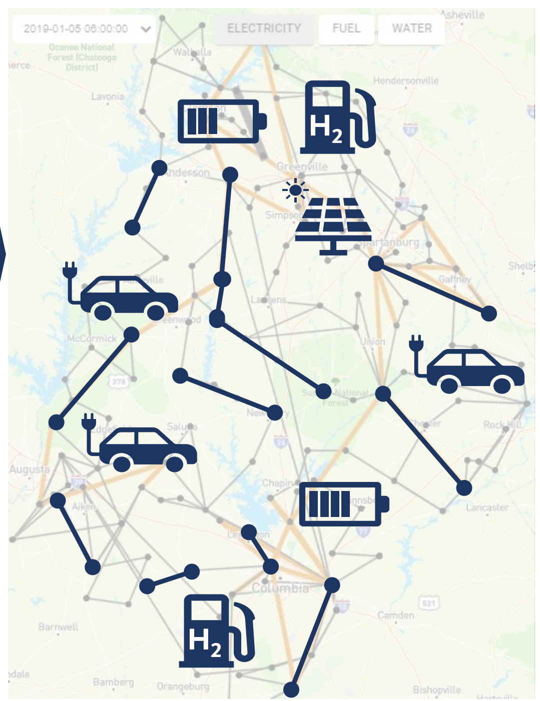
- Grids
- BESS
- EVs
- Hydrogen

Integrated network planning solution



Network optimization

- Optimal use of the power grid
- Formulation of new investments



Traditional planning approaches fail to jointly optimize networks and flexibility, leading to suboptimal investment decisions

Traditional tools

Transmission and distribution planning
- Needs to propose new infrastructure
- Needs to perform cost benefit analysis
- Not existing due to computational limits

Generation planning models
- Designed to propose new infrastructure
- Unsuitable for flexibility and also grids
- Needs simplifications and is very slow

Power system simulation models
- Designed to simulate power flows
- Considers isolated timestamps
- Unable to assess flexibility and storage

Our approach

Generation, transmission and distribution planning model
- Uses an economic assessment with long temporal horizon and full chronology
- Leverages parallel computing
- Uses patented acceleration technology
- Uses accurate linear PF algorithms

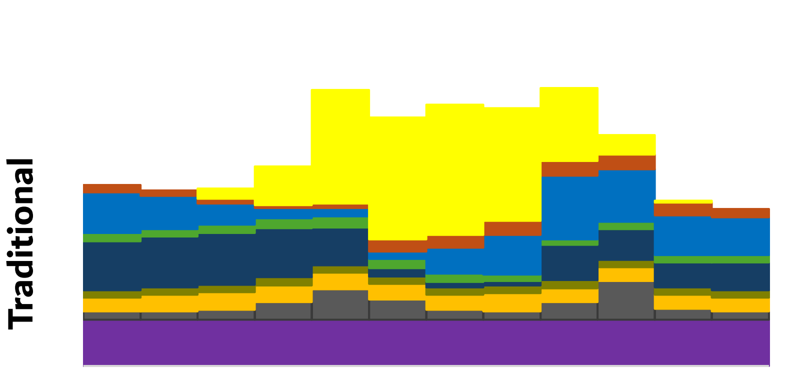
✓ Can compare grids vs flexibility
✓ Runs 20x faster than standard tools

Delivers better planning decisions

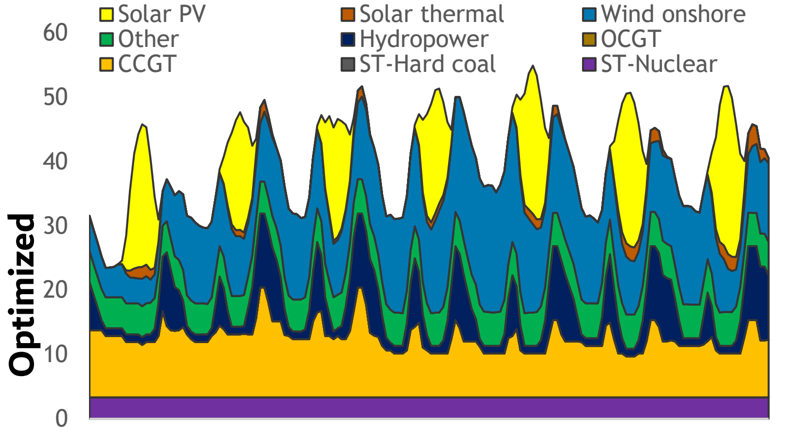
Validation with power system simulation

We use full chronology to avoid biased investment decisions that underestimate need for new power grids, storage and flexibility…

Temporal representation

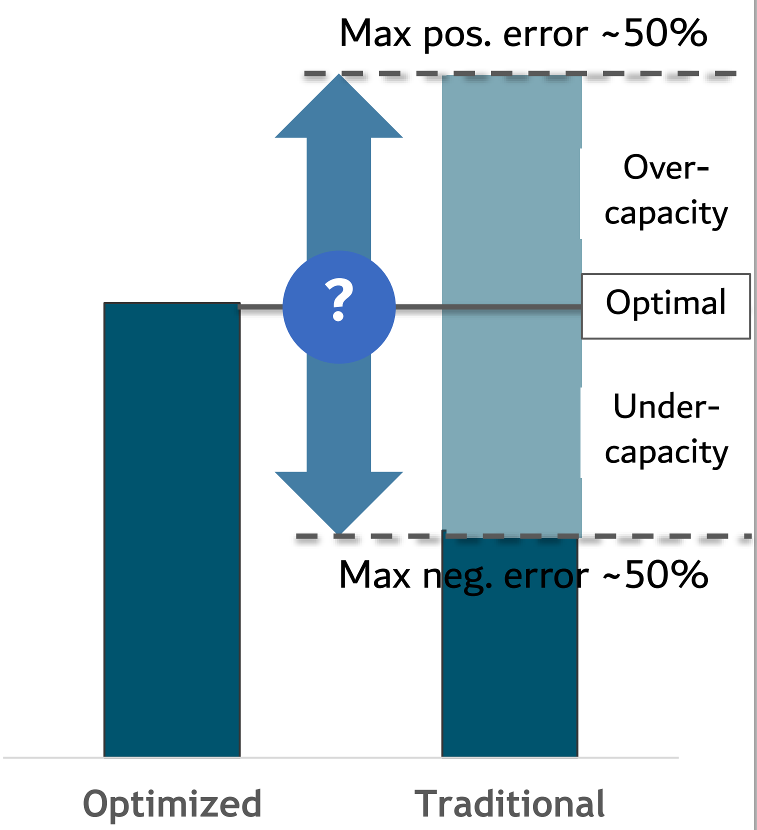


Representative days



Full chronology

Error in network and storage planning



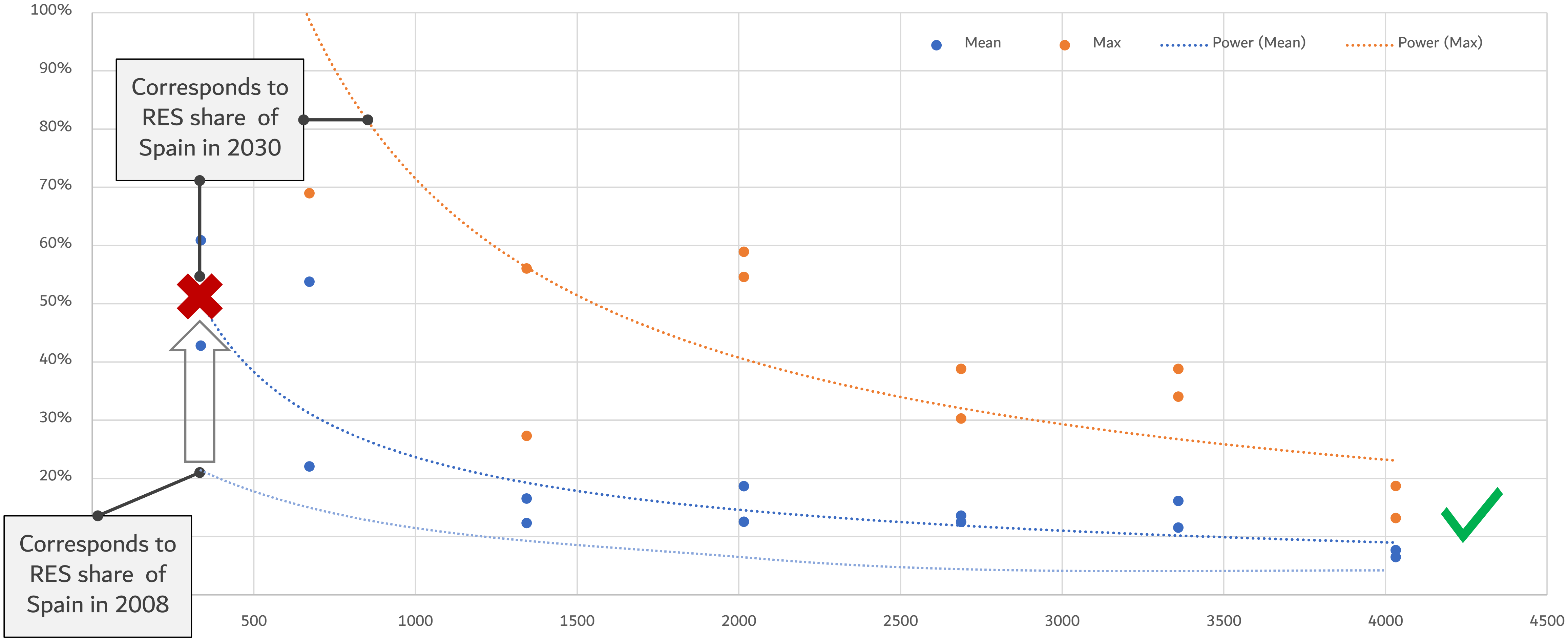
Using typical days leads to large errors

Example use cases

- Determines cost-optimal **expansion & maintenance** schedule of generation, transmission and storage facilities
- Selected use cases:
  - **Reduce grid capex** with distributed gen., battery stor. & demand response
  - Quantification of the **cost of delays** of reinforcement measures
  - **Optimal location** of portable **battery storage** to improve reliability during peak season or maintenance works
  - **Tariff design** to facilitate the transition to smart grids avoiding cross-subsidies

…because the widely used representative days/weeks create large errors in network and storage planning, even when the overall energy mix looks correct

Power-law approximation of the relationship between representative blocks and NPV distortion under k-medoids clustering



NOTE: "A Decomposition-Based Framework for High-Fidelity Multi-Year Power System Planning: Quantifying the Economic Distortion of Temporal Aggregation", Pharoes, 2026 (unpublished).

Additionally, we produce climate resilient expansion plans such that the system can withstand extreme weather and outages in a cost efficient manner

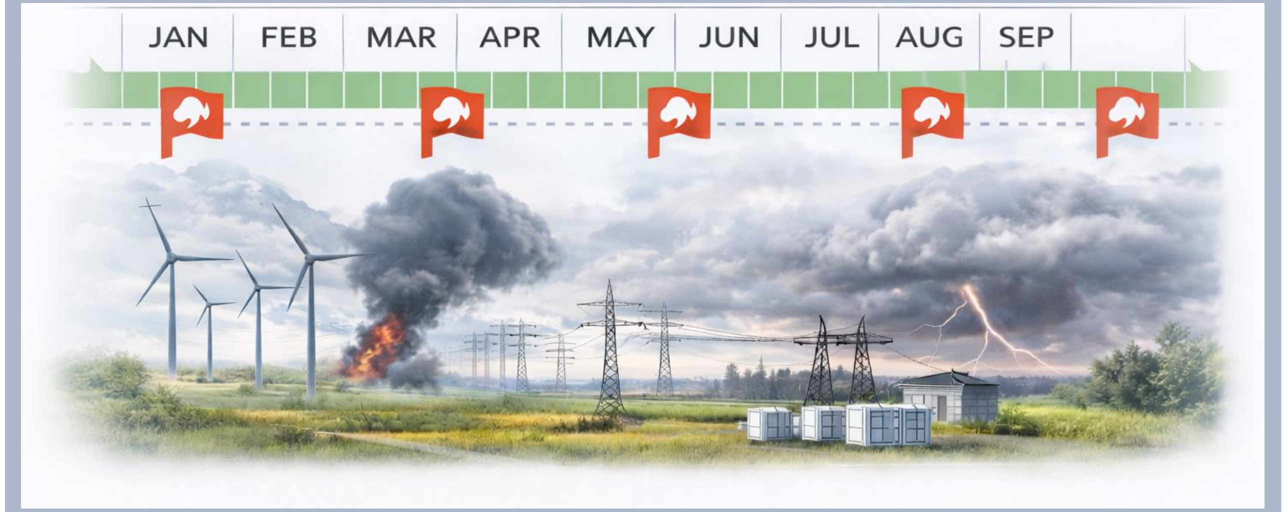
Scenarios to withstand

Normal operation

N-k contingencies

Extreme climate

One full chronology optimization including stress events

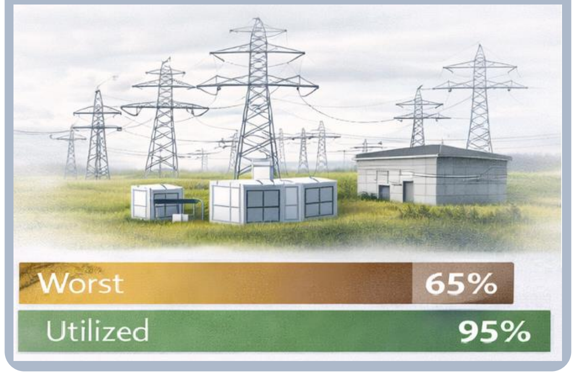


- **Normal operation over full chronology with reliability req**
Investment and operation decisions are optimized across the time horizon considering contingencies and climatic events
- **Correct modeling of storage and flexibility**
Storage and flexibility allow resolving grid congestions during normal and extreme situations optimizing network use
- **Robust optimality under stress situations**
Cost efficient expansion plans that allow coping with N-k outages and extreme weather

Grid expansion plan

Ensures cost-efficient **resilience** amid extreme climate and outages:

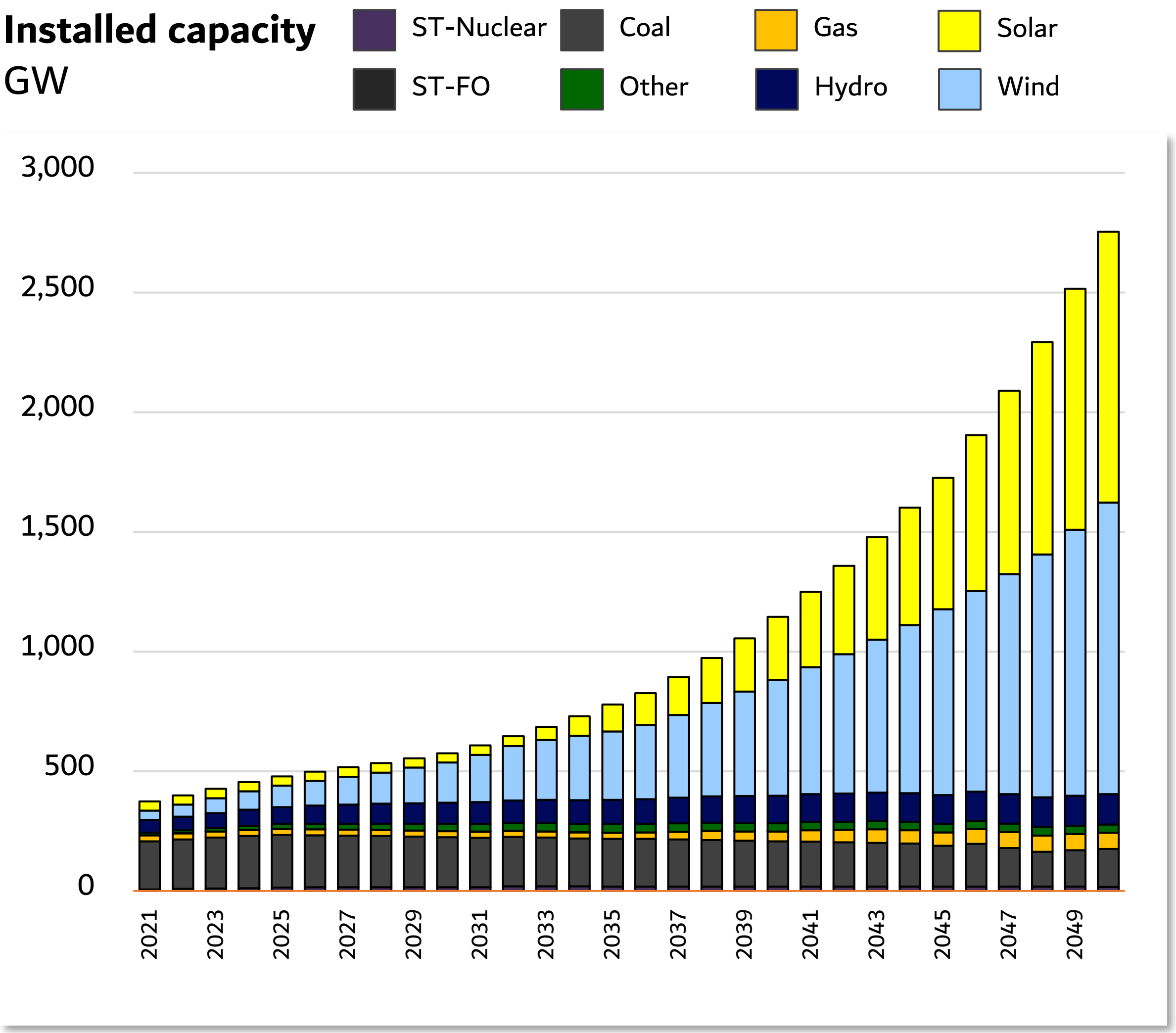
- **Withstands** typhoons, heatwaves, storms, and multi-outage events
- **Evaluates the use of flexibility** before building new assets



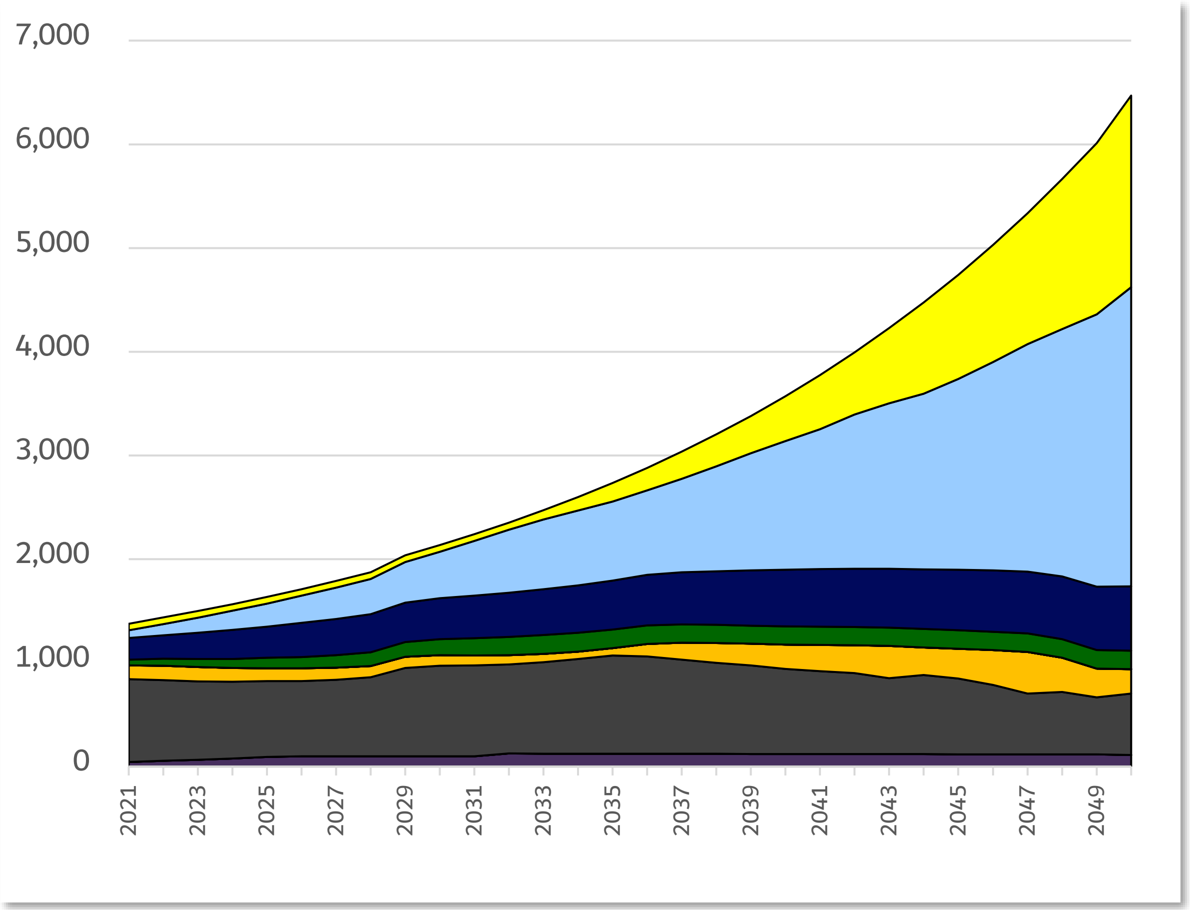
We have worked extensively in the region, especially in India, on long term power system planning where renewables and flexibility play a large role

Several projects developed for global investors

Installed capacity
GW

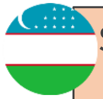


System dispatch
TWh

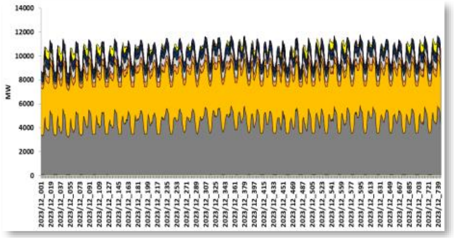
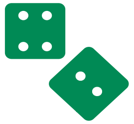
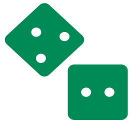
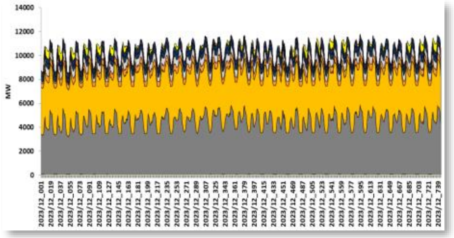
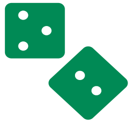
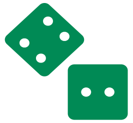
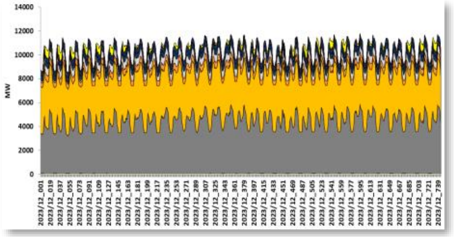
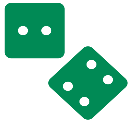
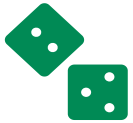
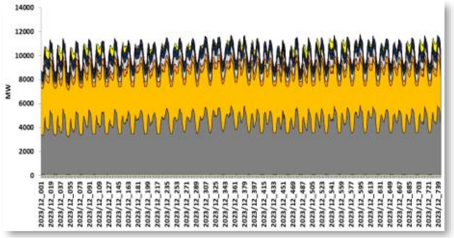
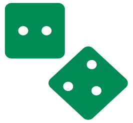
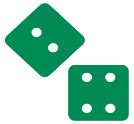


SOURCE: Pharoes Advisory

We have also worked in Central Asia to develop strategies to keep unserved energy low during extreme cold spells in winter



Study to identify measures to reduce winter load shedding

Actions	Schedules	Outages	Weather
Nothing new			
Essential			
Reasonable			
Last resort			

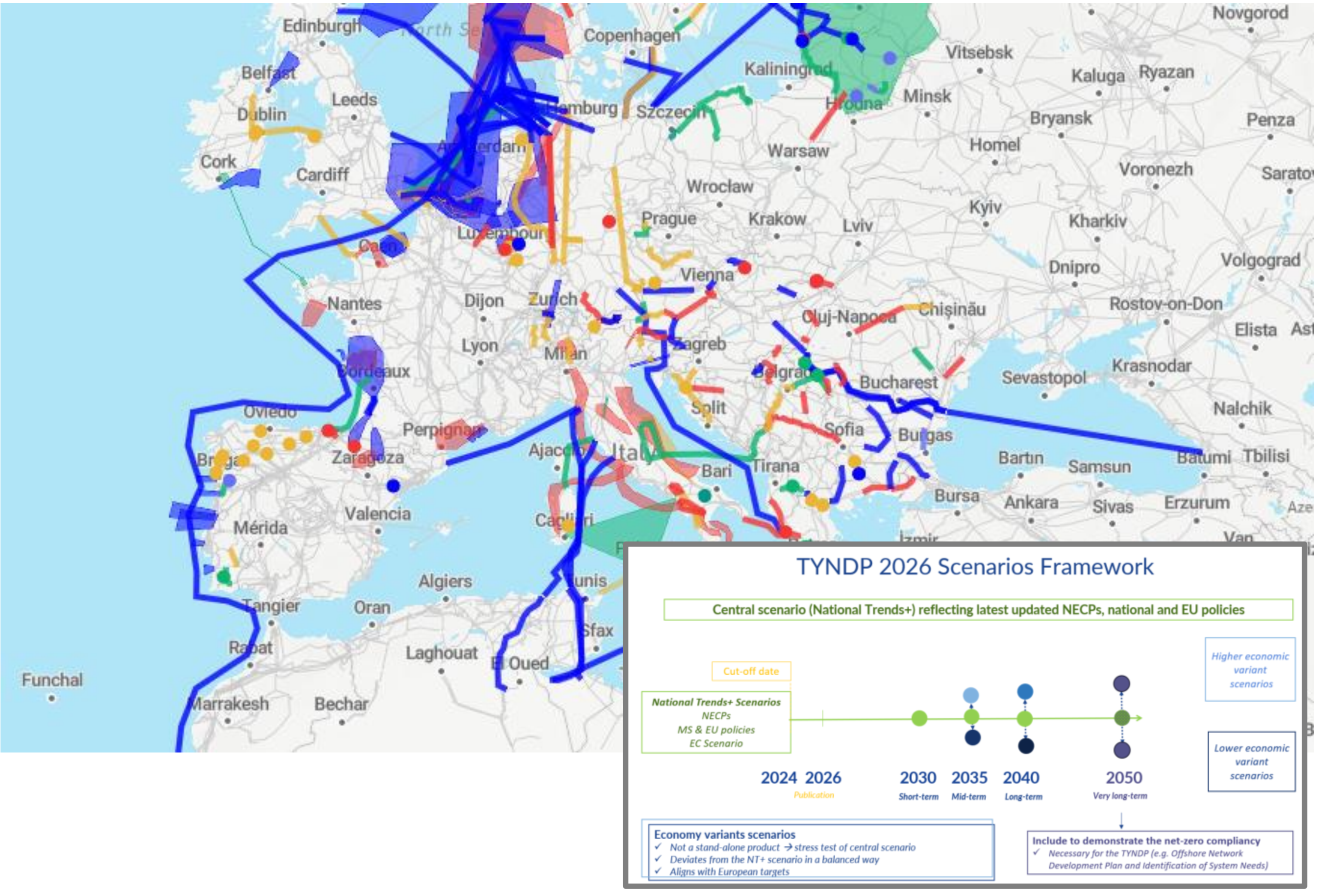
Possible values of energy not served, % of demand

SOURCE: Pharoes Advisory

NOTE: Unserved energy from October 2023 to March 2024 as a share of total demand.

We have demonstrated that long-term planning studies can run across continents with full chronology while reducing runtime by 10x

Execution time and time savings, hours



Execution time and time savings, hours

NOTE: The runtime for DIA accelerated Benders with the advanced solver is an estimate, based on bottom-up extrapolations. Full system testing is currently underway.

Thank you!

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