TotalEnergies

Optimization and Modelling of Complex Energy Systems

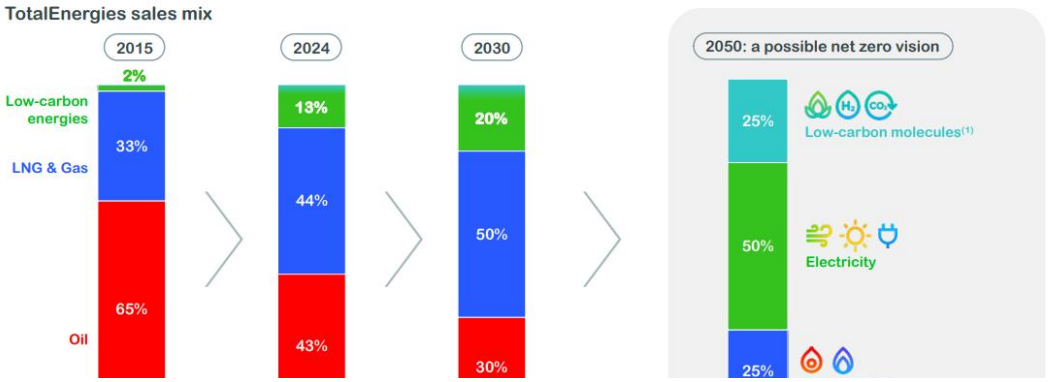
Gurobi Energy Innovation Summit

Berlin, June 2025

TotalEnergies :
Shift from Oil & Gas to Ambitious Multi Energies Company

A possible vision for a Net Zero company in 2050, together with society

TotalEnergies



TotalEnergies's ambition for renewable energies

Transition

100 GW

Target for gross installed renewable power generation capacity by 2030

Getting to net-zero emissions for all our businesses l
society, requires developing new industries, new acti
technologies in renewable energies, with the aim of e
our portfolio.

To achieve this, we are focusing on:

NEWS

CIP, TotalEnergies consortium to build 1GW renewables green hydrogen project in Mor

By Jonathan Touriño Jacobo

October 29, 2024

TotalEnergies and partners to import clean energy from Indonesia to Singapore via

TotalEnergies and partners commission Taiwan's 640MW Yunlin wind farm

Skyborn led the project's development and construction with the backing of the other partner

March 4, 2025

TotalEnergies launches "pioneering" decarbonization plan to power Culzean platform offshore UK with floating wind energy

August 29, 2024

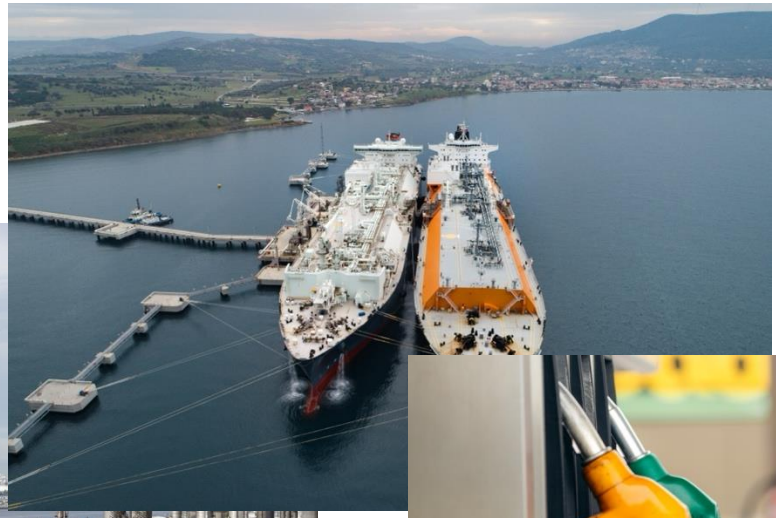
(WO) – TotalEnergies has launched a pilot project consisting of a floating wind turbine to supply renewable power to Culzean offshore platform in the UK North Sea, thus pioneering an innovative decarbonization scheme.

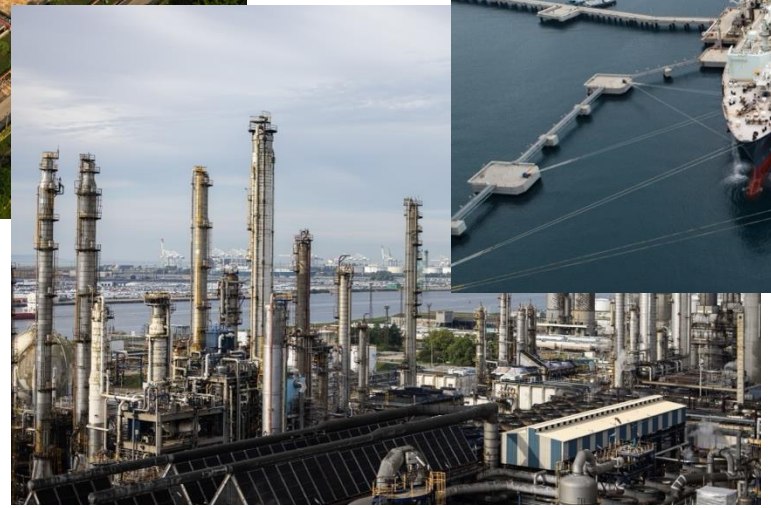
The 3 MW floating wind turbine will be located 2 km west of the Culzean platform, 220 km offshore Scotland. This turbine, expected to be fully operational by end 2025, will supply around 20% of Culzean's power requirement, thereby reducing its GHG emissions. The turbine will be installed on a modular, light semi-submersible floater hull designed by Ocergy, allowing for fast assembly and optimized costs.

Source: TotalEnergies

"This innovative pilot project aims at proving the concept of hybridization of power generation on an offshore facility, by integrating the generation of renewable electricity from a floating wind turbine with the existing power generation from gas turbines. It also aims at qualifying a

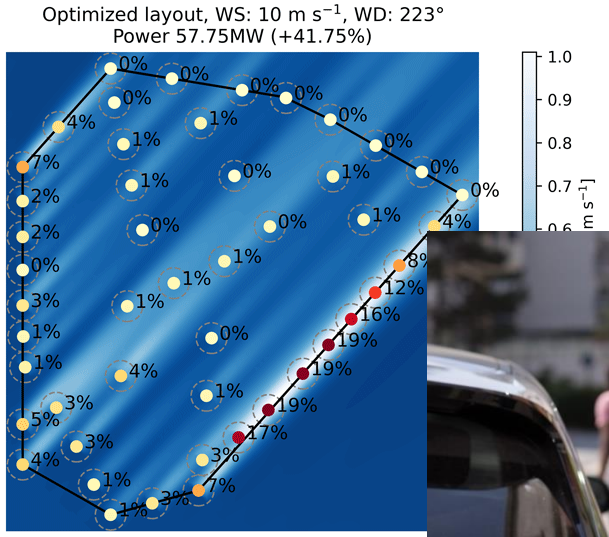
TotalEnergies : Historical use of Optimization & Operations Research

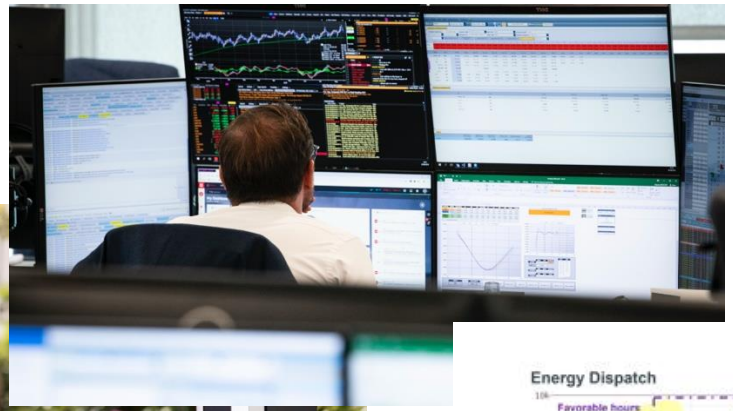


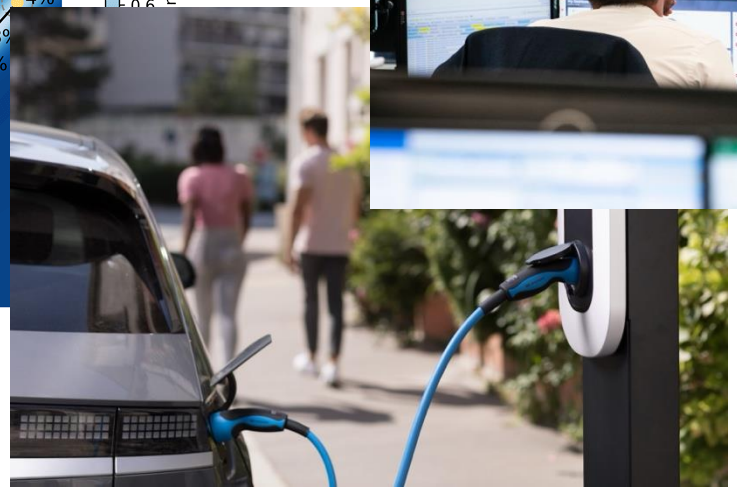


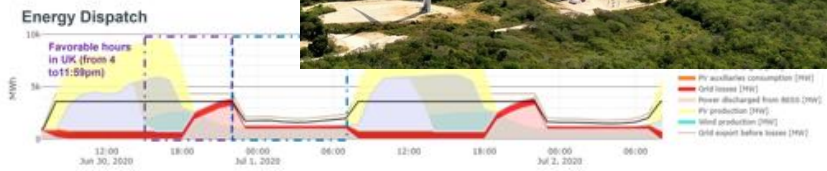
Wells planning, blending mix product, heat integration, LNG shipping schedule, refueling gas stations logistics,….

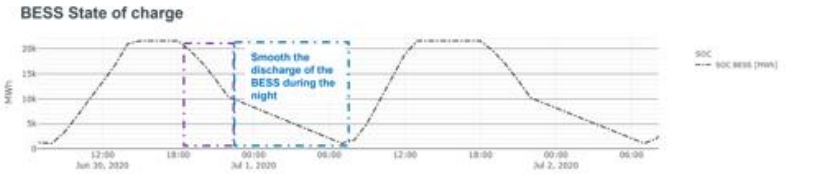
TotalEnergies :
New use of Optimization & Operations Research











Layout optimization, EV charging planning, Power Trading, BESS Revenues Stacking, Energy Management System, Design….

TotalEnergies :
Shift from Oil & Gas to Ambitious Multi Energies Company

Multi-energy company's strategy

The company has defined a multi-energy strategy :

- **Reduce its environmental footprint of its historical activities** (such as CO2eq emissions over scope 1, 2 and 3)
- **Develop new business opportunities** (massive power production from renewable energies and new low-carbon fuels production)

Complex systems to design and evaluate

- Multi-energy systems rely on **multiple technologies of production and storage of power/heat/material** with **specific features and operating philosophies requiring the mobilization of lots of expertise among many topics** and entities
- Due to this complexity, studying accurately the technical & economical performances of such systems can **take a long time,** which can be **costly for BUs**

INTERNAL PROJECT IS AN ANWSER TO THIS CHALLENGE WITH THE MAIN OBJECTIVE TO :

Develop optimization models for sizing & control of multi energy hybrid systems*

TotalEnergies:
New challenges for new applications

Asset Decarbonization

Kashagan - Kazakhstan

- Operations: **Minimize CO_2** to reach carbon neutrality in 2060
- Sizing: **Minimize NTC over 30 years**

Grid Connected Flexible Assets

XLinks – Morocco / UK

- Operation: **Maximize energy export** under specific TSO's requirements **from 3 to 11 pm,** time shift and cable losses
- Sizing: **Minimize LCOE over 25 years**

Green H2/ derivatives production

EnergHyze - Netherlands

- Operations: **Maximize Green H_2 production** following RFNBO regulations
- Sizing: **Minimize NTC of Green H_2** to multiple off-takers with specific individual constraints **over 20 years**

100+ other studies realized since 2022 for various Business Units

What does TotalEnergies in-house optimization tool?

Optimal management of intermittent energies from sizing to operations of multi-energy systems

It is a service for Technical teams & Business Units

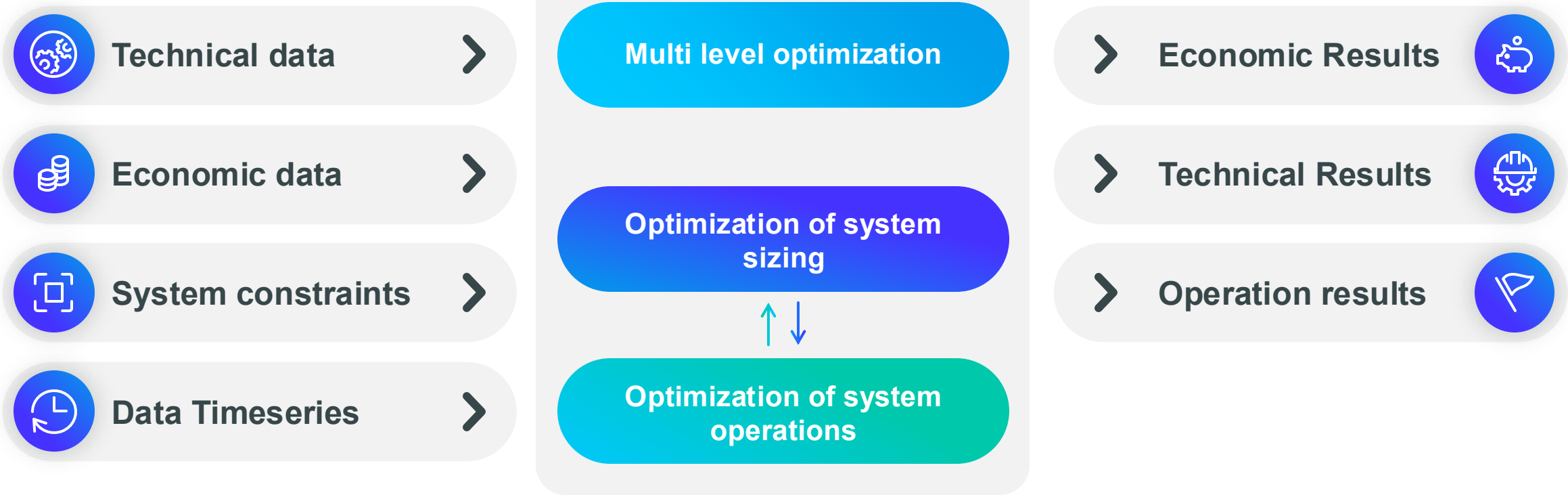
It is a web application *(4000+ queries in last 6 months)*

TotalEnergies

It is a virtual lab for innovation on optimization

It will be on-site calculation core (EMS)

Calculation Methodology



Why internal solution?
Technical and Managerial Challenges

Many requirements to fully attend to the company's needs

Limitations of existing commercial solutions

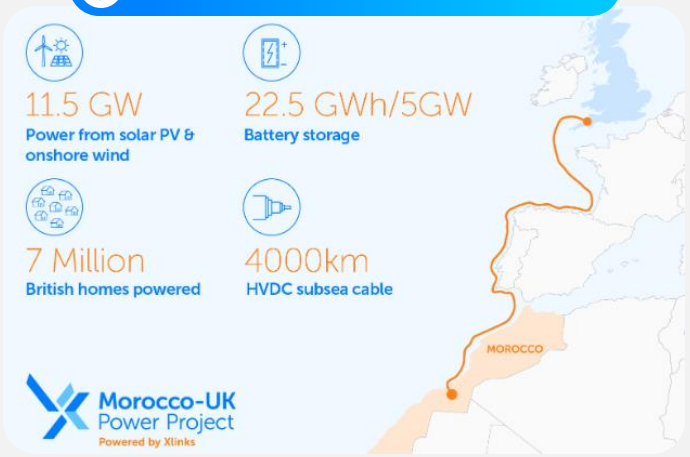
Providing a strong competitive edge to the company

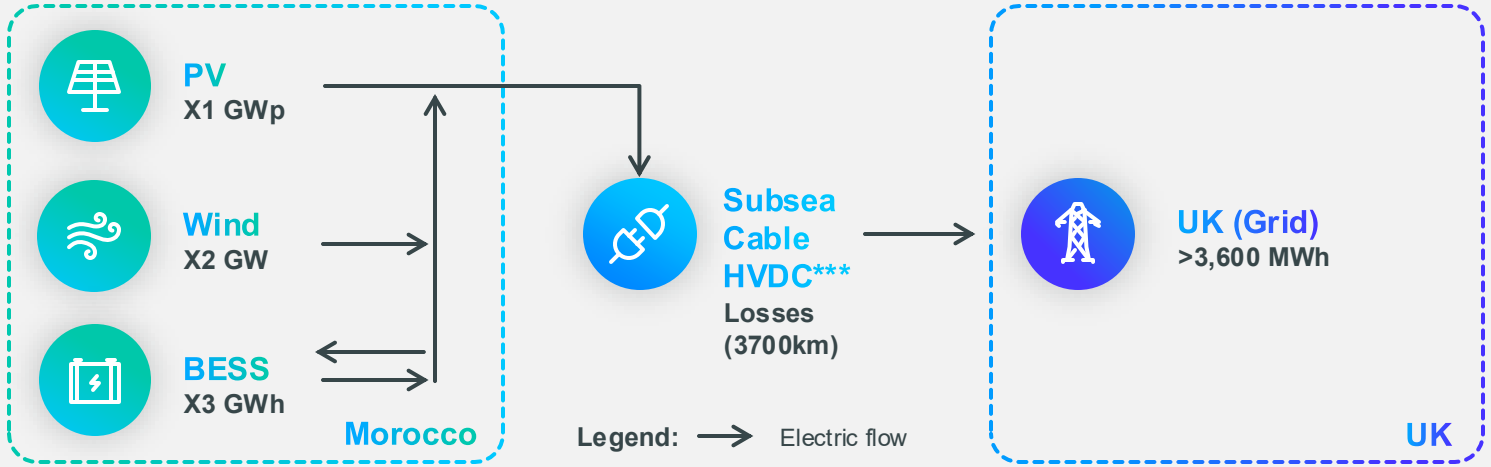
Benchmark done by third party
ranked among best compared to 65+ commercial solutions

Focus on XLinks project

Context

Click here for further information





Challenges

Validate/ Challenge proposed sizing to ensure an export of **3.6 GWh over 20h+**

Avg. yearly export = 97% Load Factor (LF*) between 3 & 11 pm considering time shift (daily and seasonal)

Operations:
Maximize energy export (MWh)

Sizing:
Minimize LCOE** ($/MWh)

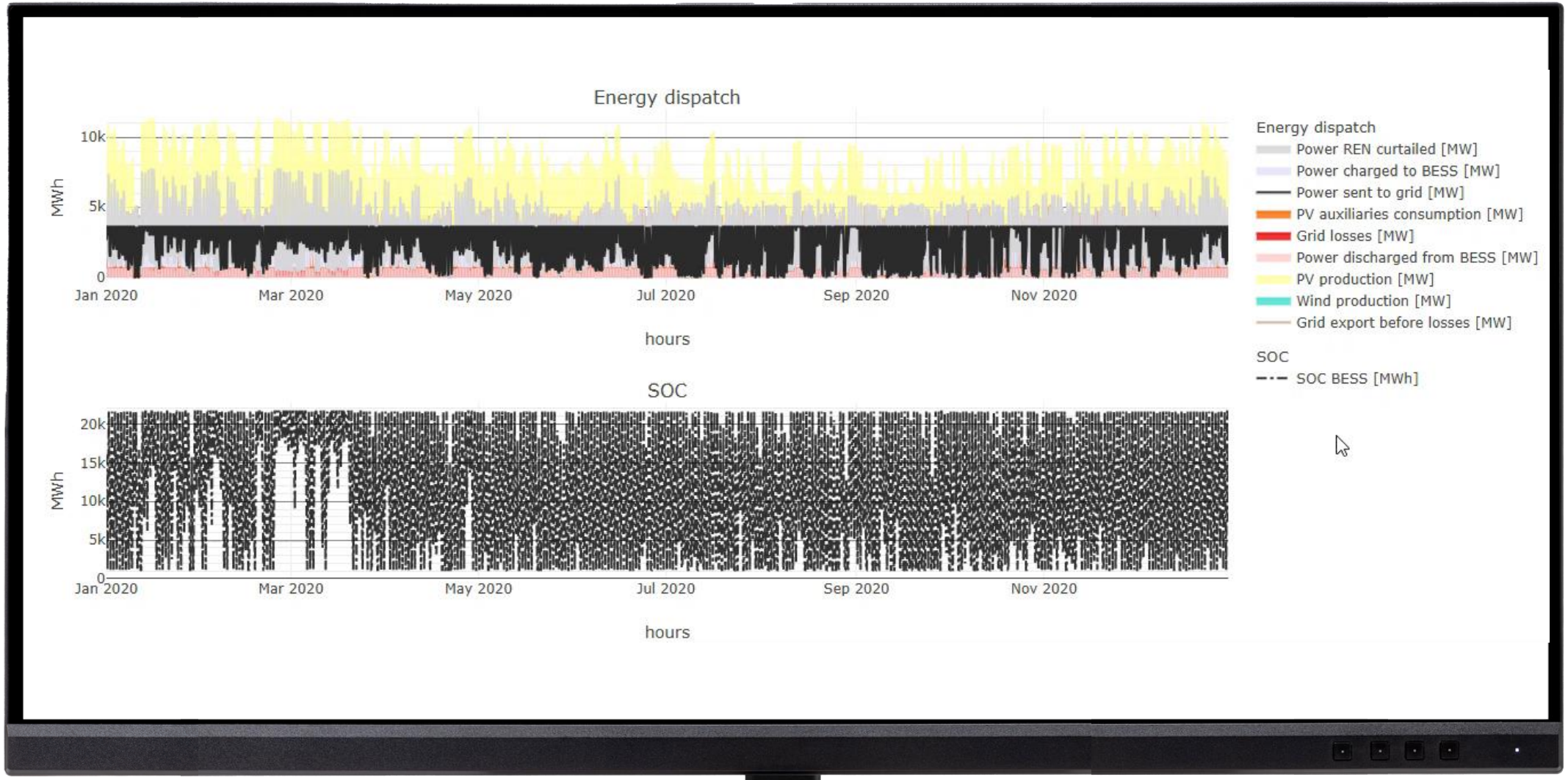
*LF: load factor calculated based on the maximum export power (3,600 GW)

**LCOE: Levelized Cost Of Electricity

***HVDC: High Voltage Direct Current

Focus on XLinks project

Operational: Hourly Results

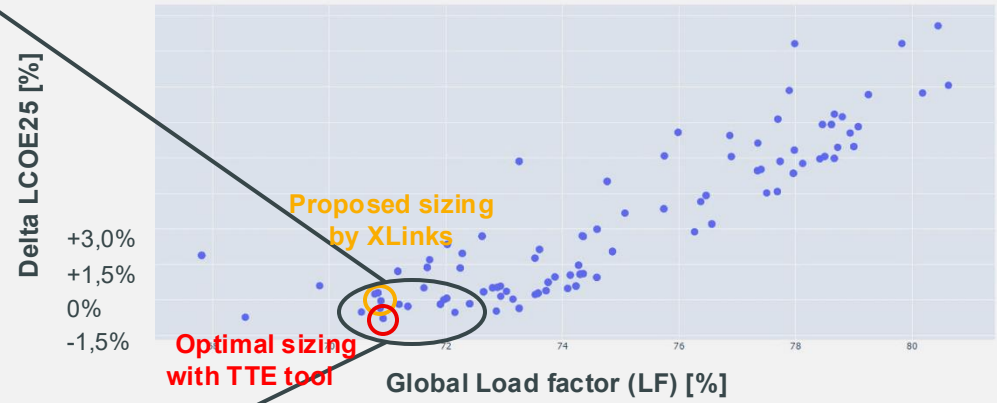


Focus on XLinks project

Sizing results

XLinks sizing optimization results					
PV (GWp)	Wind (GW)	BESS (GWh)	Delta ref LCOE25 (%)	LF* Global (%)	LF* favorable hours (%)
8.5	**3.2**	**23.8**	**-0.70%**	**70.9**	**97.6**
7.7	3.2	23.5	-0.70%	68.6	97.2
8.6	3.5	23.5	-0.42%	72.2	97.7
8.6	3.1	24.3	-0.42%	70.6	97.8
8.4	4.0	22.3	-0.42%	72.9	97.2
8.6	4.0	22.3	-0.28%	73.3	97.3
8.5	3.1	24.5	-0.28%	70.9	97.9
8.5	3.2	24.5	-0.28%	71.3	98.0
8.4	3.3	24.3	-0.14%	71.2	97.9
8.2	3.7	23.5	-0.14%	71.9	97.6
8.4	3.7	23.5	-0.14%	72.4	97.7
		…			
7.5	4.0	22.5	0	70.9	97.1

175 sizing have been evaluated and **96** were satisfying the export constraints (LF>97%)



Study to other similar projects such as one between Indonesia and Singapore:

Click here to find out more

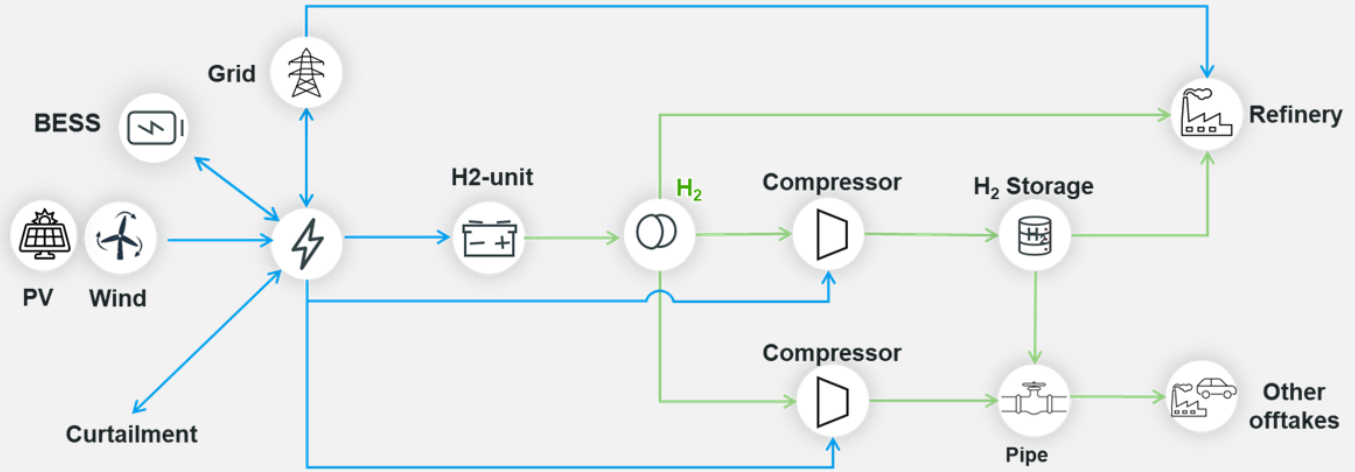
*LF: load factor calculated based on the maximum export power (3,600 GW)

Focus on Green H2 project

Context

Challenges

- Control on the hydrogen delivery demand:
  - Annual demand of H2
  - Minimum/Maximum hourly and/or daily demand
  - Maximum hourly and daily variations (ramps on the delivery)
- **External electric load** can be added, to include balance of plant consumption
- **RED-3 regulation** (RFNBO rates, with target % of RFNBO rate at both hourly and annual demand)
- **Multiple external offtakers**, with pipeline characteristics as backbone storage



Operations:
Maximize operational cost ($)

Sizing:
Minimize LCOH ($/tons)

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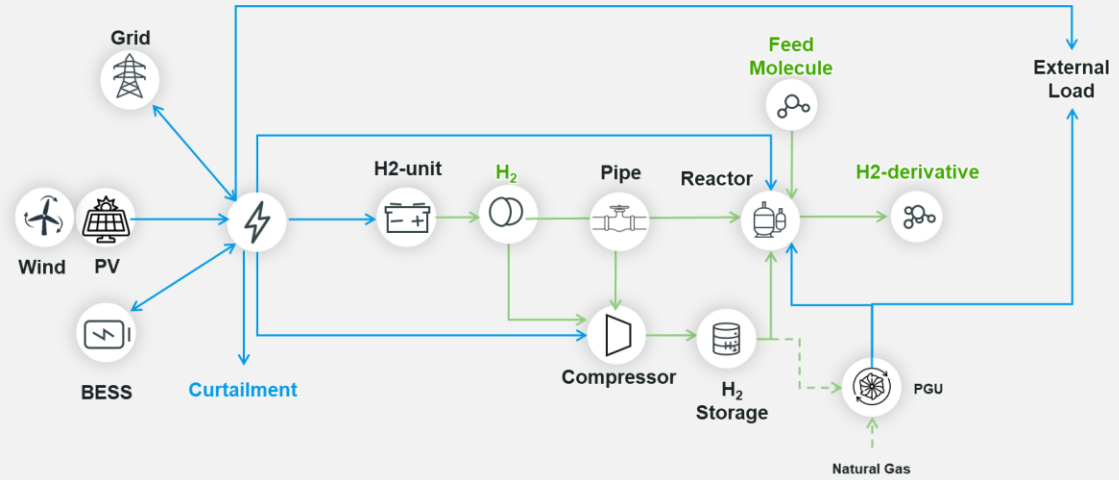
Focus on Green H2 project

Context

Challenges

- **Specific conversion reactor operating philosophies** depending on the technology of conversion
- Limitation of periodically stars and stops
- Multi-trains operations for the conversion reactor
- **Specific constraints** to supply the reactor only with the grid or REN power



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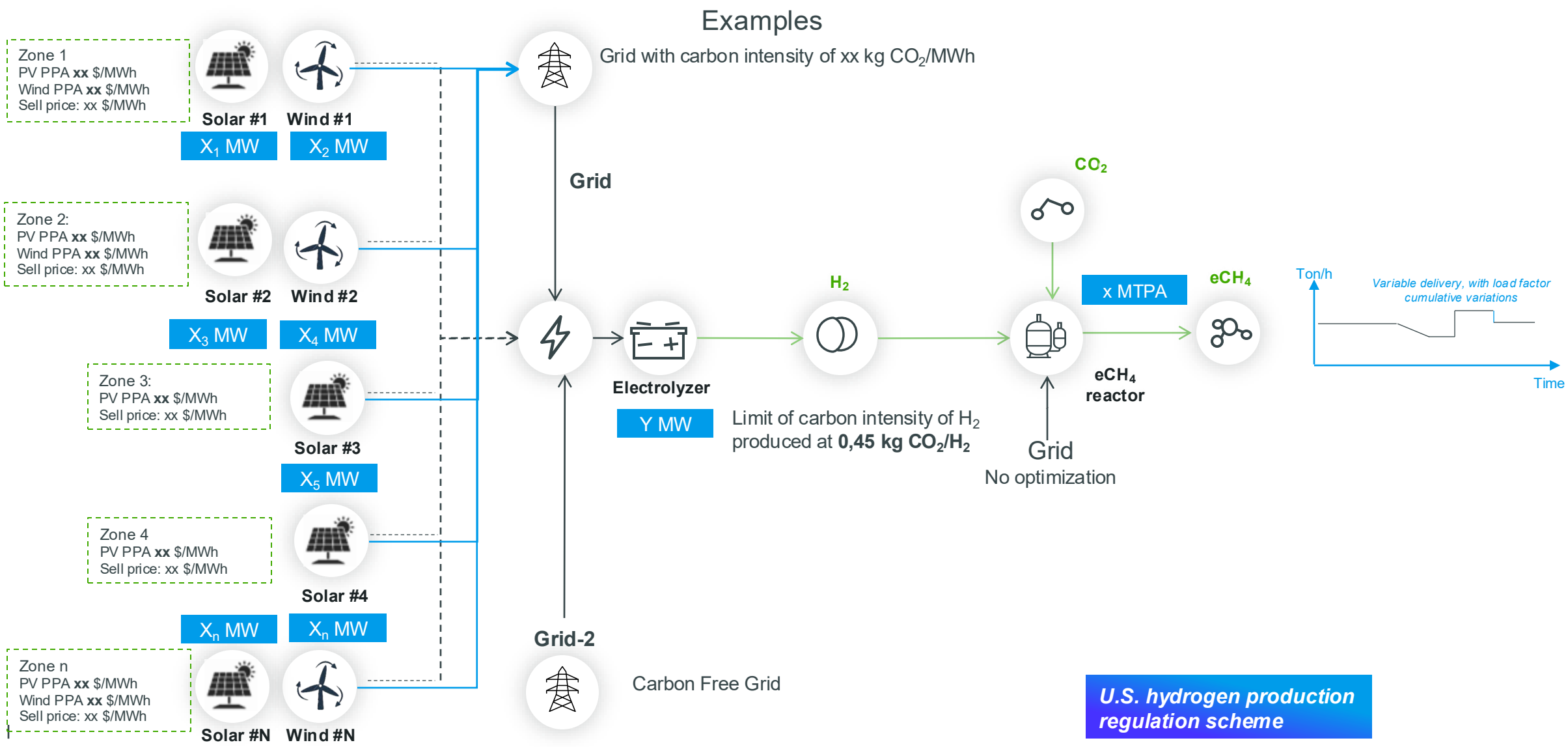
Focus on Green H2 project



U.S. hydrogen production regulation scheme

Technical Challenges

Increase in complexity:
- Multi clusters
- Multi-stacks / trains
- Multi phasing (BESS repowering)
- Multi services/revenues
- Nonlinearity (degradation, efficiency,..)

Explore more advanced algorithms:
- Combination of Metaheuristics
- Machine Learning / Reinforcement Learning
- Stochastic/Robust Optimization

2025-30

Technical Challenges
Long term research

Manage uncertainties to improve results robustness

Improve Computational time vs. Accuracy

TotalEnergies

Let’s collaborate together