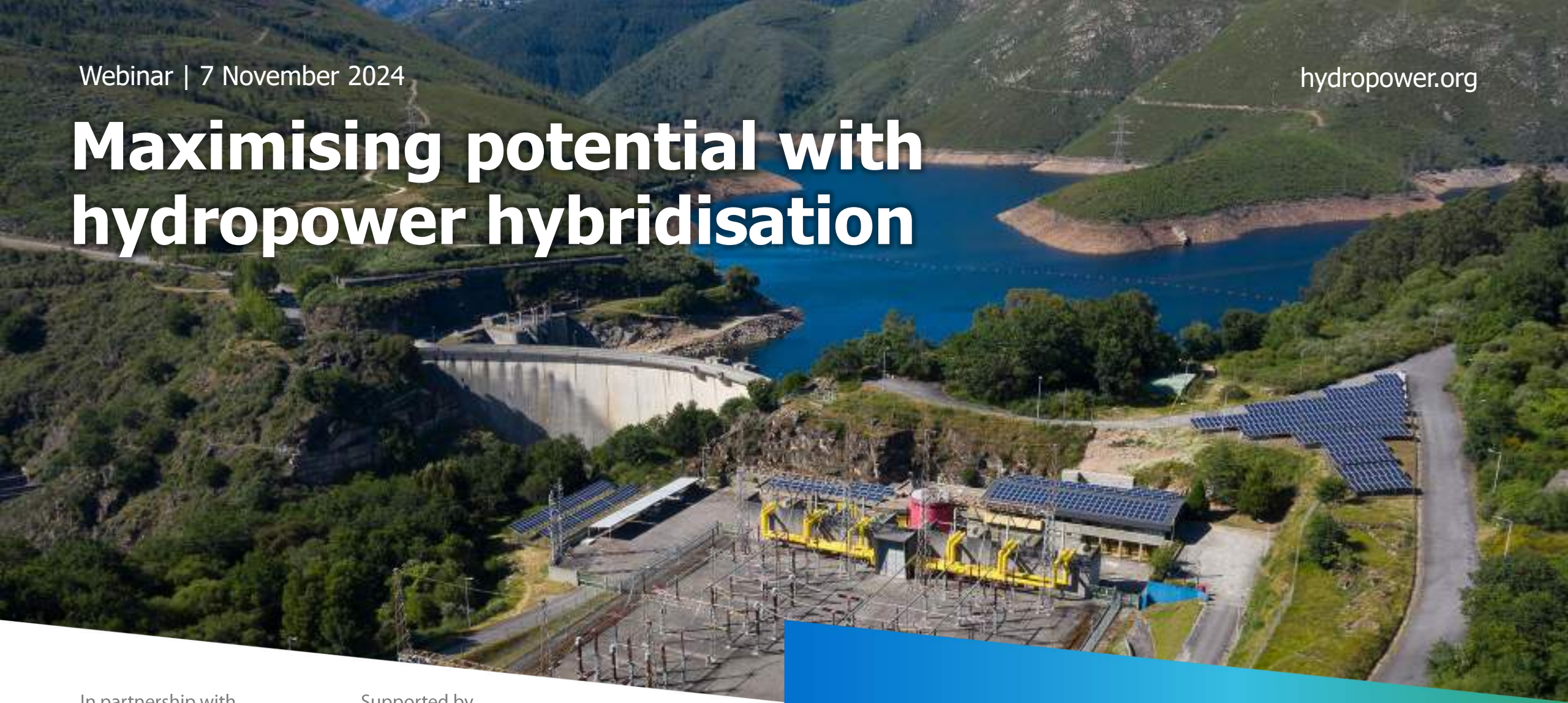
Webinar | 7 November 2024

hydropower.org

Maximising potential with hydropower hybridisation



In partnership with

SuperGrid Institute
Shaping power transmission

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iha
international hydropower association

Agenda

12.30 - **Welcome by moderator (speakers introduction and agenda)**

12.33 - **Scene set up including**

12.45 - **Case studies and discussion**

13.15 - **Q&A with the audience chaired by moderator**

13.30 - **Webinar ends**

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Shaping power transmission

Speakers

Guillaume Amodeo, Technical Business Developer, SuperGrid Institute

Quentin Boucher, Electricity Market Specialist, SuperGrid Institute

Cecilia Correa Poseiro, Energy Specialist, Inter-American Development Bank

Parveen Nanda, Executive Vice President, Greenko Group

Moderator

Matteo Bianciotto, Senior Policy Manager, International Hydropower Association

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Guillaume Amodeo

Technical Business Developer,
SuperGrid Institute

SuperGrid Institute
Shaping power transmission

Who is SuperGrid Institute ?

An independent **innovation** company

with dual expertise in **hydraulic** & **power systems**

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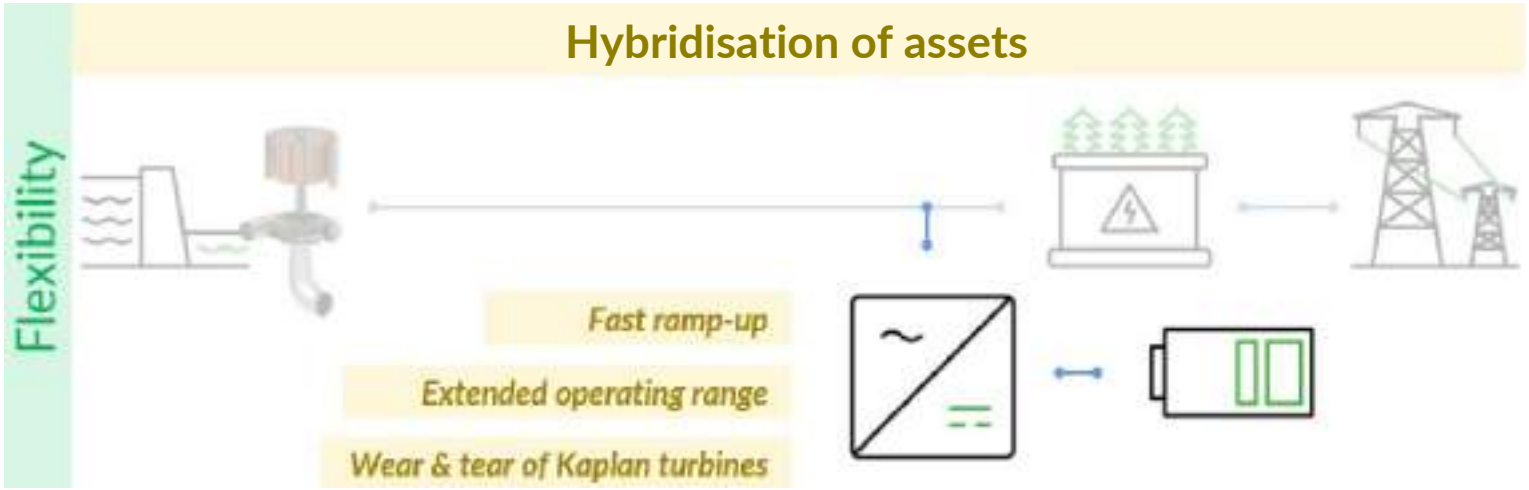
Hydropower Hybridisation



Boost
revenues by accessing new energy markets

Anticipate
the early aging of your equipment

Optimise
water management

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Quentin Boucher

Electricity Market Specialist,

SuperGrid Institute

SuperGrid Institute
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Case study PSP design for an islanded grid

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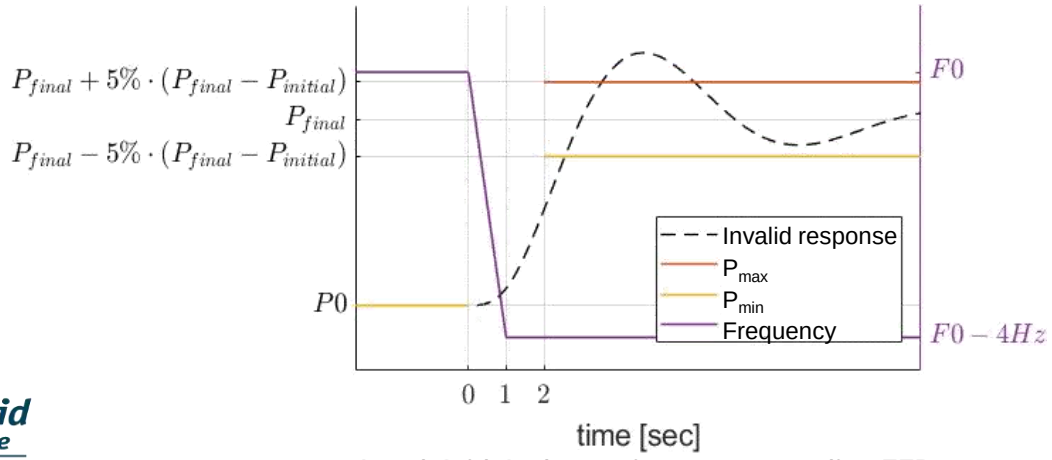
PSP design for the provision of Fast Frequency Response on an islanded grid

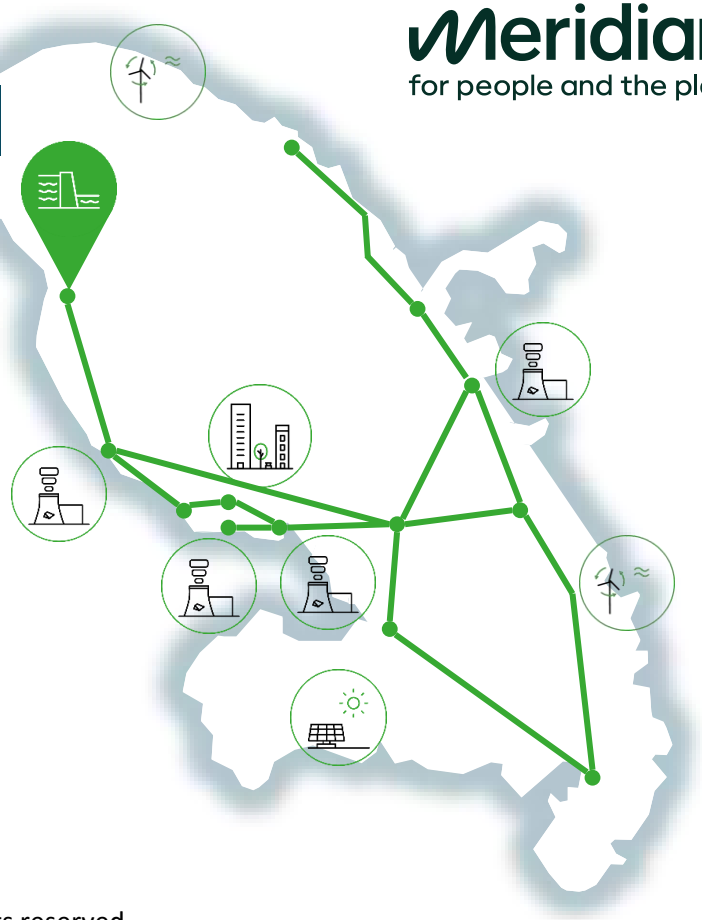
Case study

- PSP (7MW) on islanded network
- Island Grid Code requires 2 seconds response for participation in local Fast Frequency Response (FFR)



Local Grid Code requirements regarding FFR

PSP Project



Meridiam
for people and the planet

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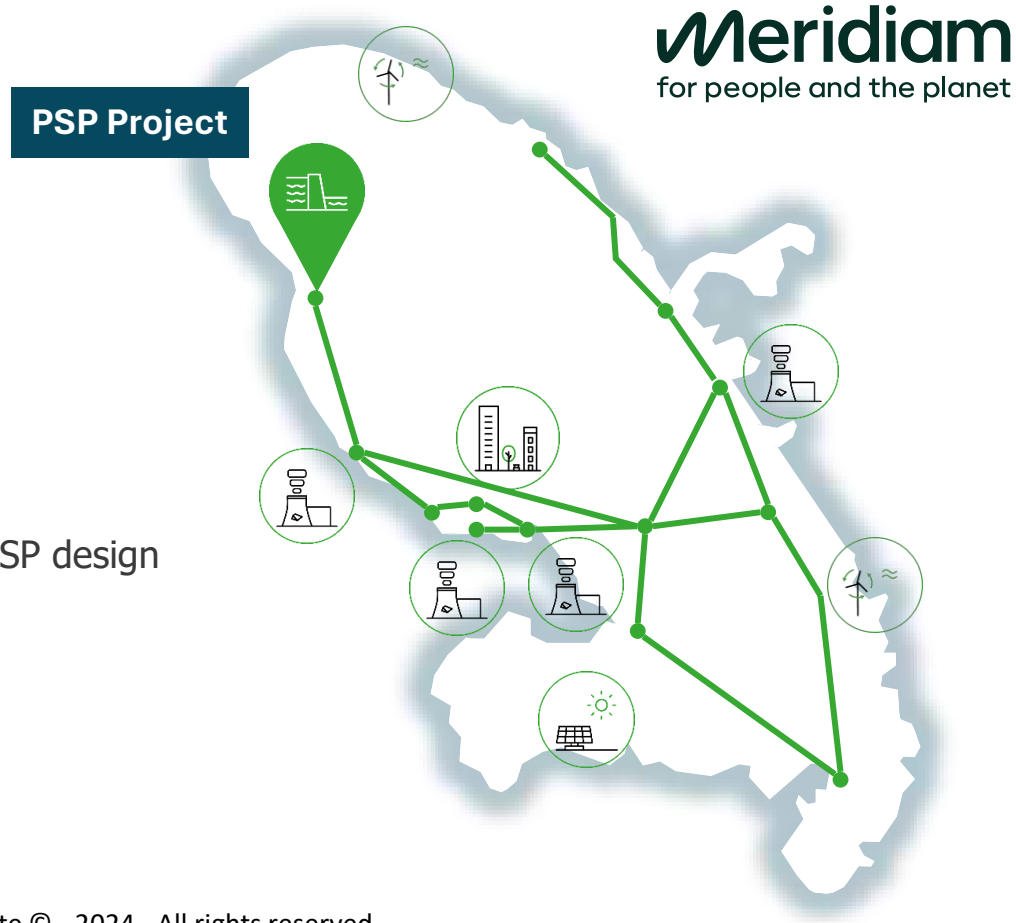
PSP design for an islanded grid

Case study

- PSP (7MW) on islanded network
- Island Grid Code requires 2 seconds response for participation in local Fast Frequency Response (FFR)

Objectives of the study:

- Build a robust business model for the PSP in this context
- Study different possibilities to provide FFR based on an existing PSP design
- Size the systems to provide *2 MW* FFR at minimal cost



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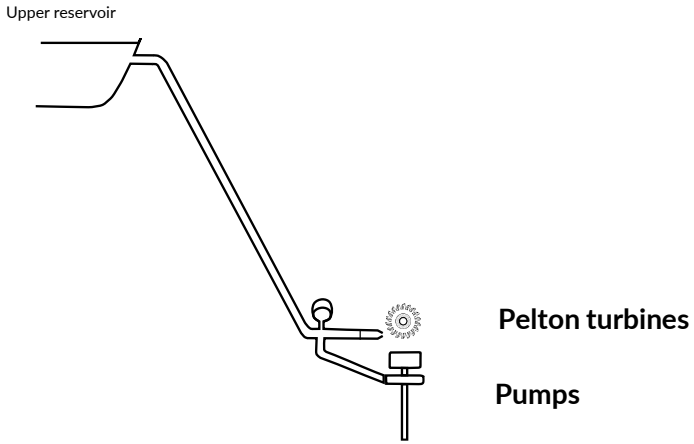
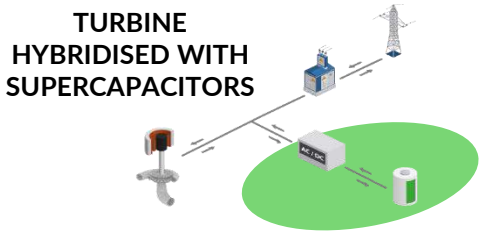
PSP design for an islanded grid

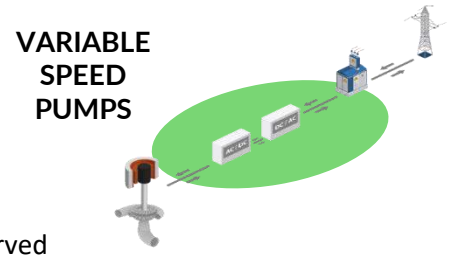
Client needs 2 MW FFR to ensure profitability of the investment

SuperGrid Institute's design provided 2 MW FFR:

- Simultaneous use of pumps and turbine – Hydraulic Short Circuit
- 800 kW FFR through hybridisation of the Pelton turbine with supercapacitors.
  - Sizing of the supercapacitors minimising costs.
- 1200 kW FFR through Variable Speed operation of the pumps
  - Use of existing equipment to minimise costs
  - Slight repowering of the pumps to provide sufficient regulation band







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PSP design for an islanded grid

STUDIES PERFORMED TO PROVIDE FFR IN TURBINE MODE

Transient operation of Pelton units are not suitable for FFR provision

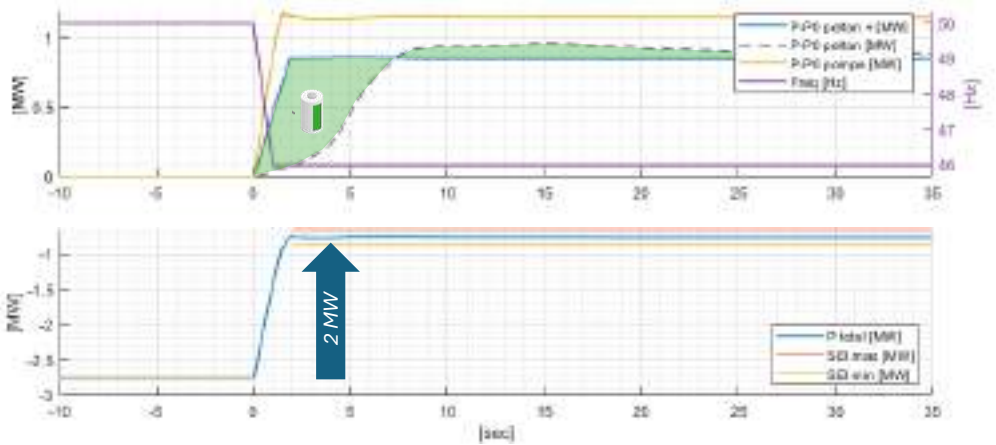
Control by a dedicated EMS (Energy Management System)

- Our EMS saves 30% on booster energy
- Optimal trajectories based on digital twin uses

We sized the booster and pre-calibrated the supercapacitors

Profitable business model for the project:

- Production shift
- System service provision



SuperGrid Institute

0-100% hybrid Pelton unit in Finland

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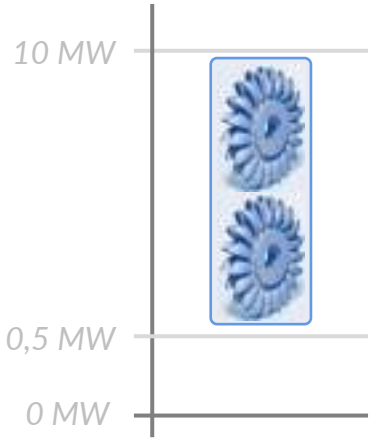
2x 5MW Pelton unit in Finland in 2022

Pelton 0-100% technology benchmark

Existing asset "Business as usual"

- 2 Pelton units of 5 MW
- Turbine mode
  - Minimum power : 0.5 MW*
  - Maximum power : 5 MW
- 1+ week's worth of water storage



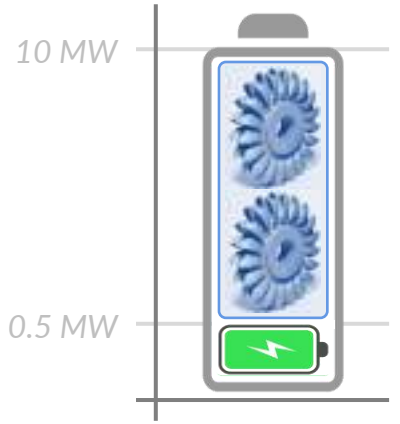
* synchroneous condenser mode : 0 MW

Optimised asset "PELTON 0-100%"

Hybridisation with a Li-ion battery

- Investment ~ 1 M€
- Max power ~ 600 kW

- Turbine mode
  - Minimum power : 0 MW
  - Maximum power : 10 MW
- Coordinated control involving Pelton units and battery energy storage system



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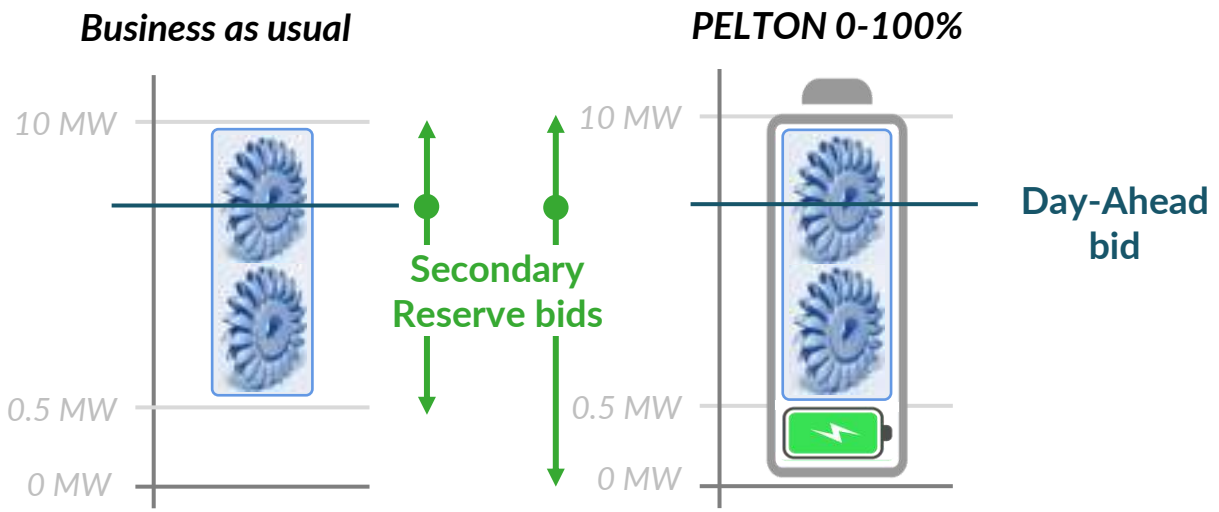
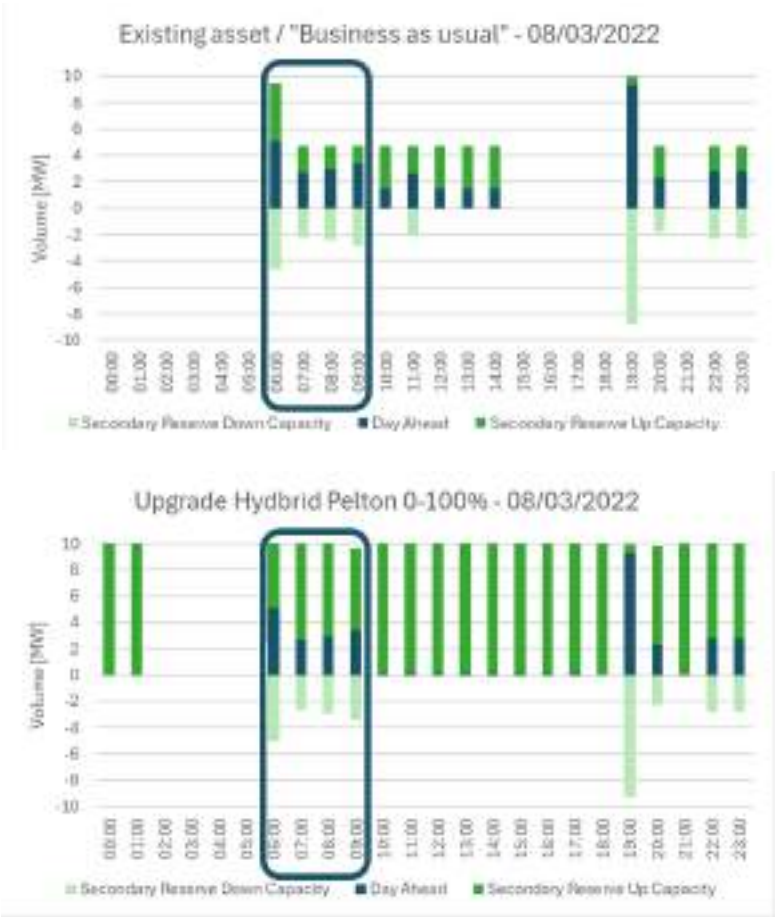
Placement difference for 0-100% technology in 2022 in Finland

HIGH PRICE ON DAY-AHEAD MARKET



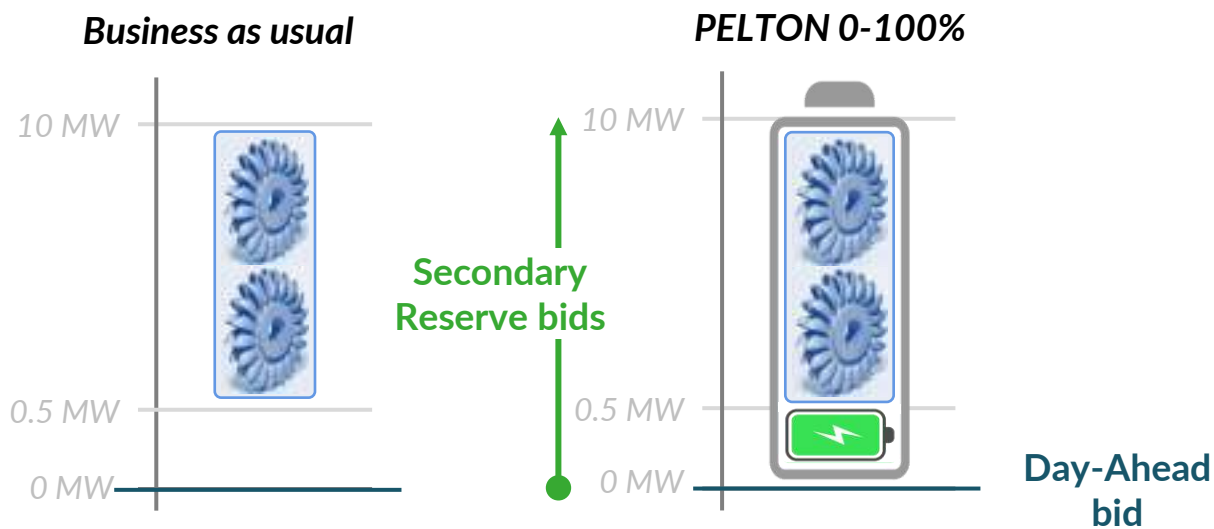


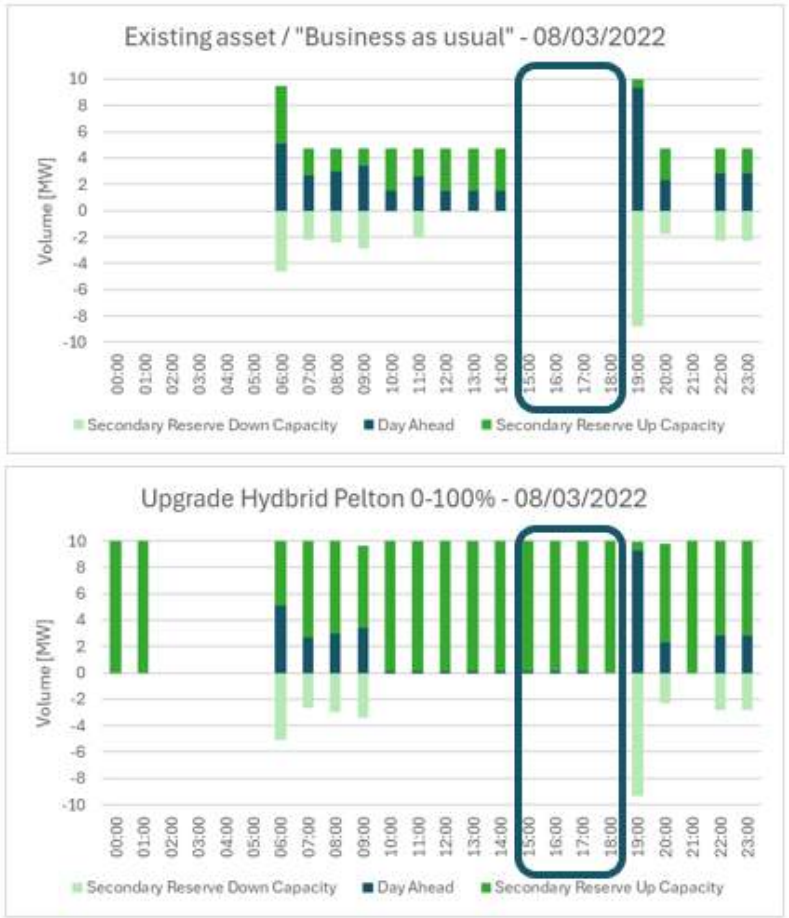
Hourly placement simulation results

SuperGrid Institute
Shaping power transmission

Placement difference for 0-100% technology in 2022 in Finland

LOW PRICE ON DAY-AHEAD MARKET



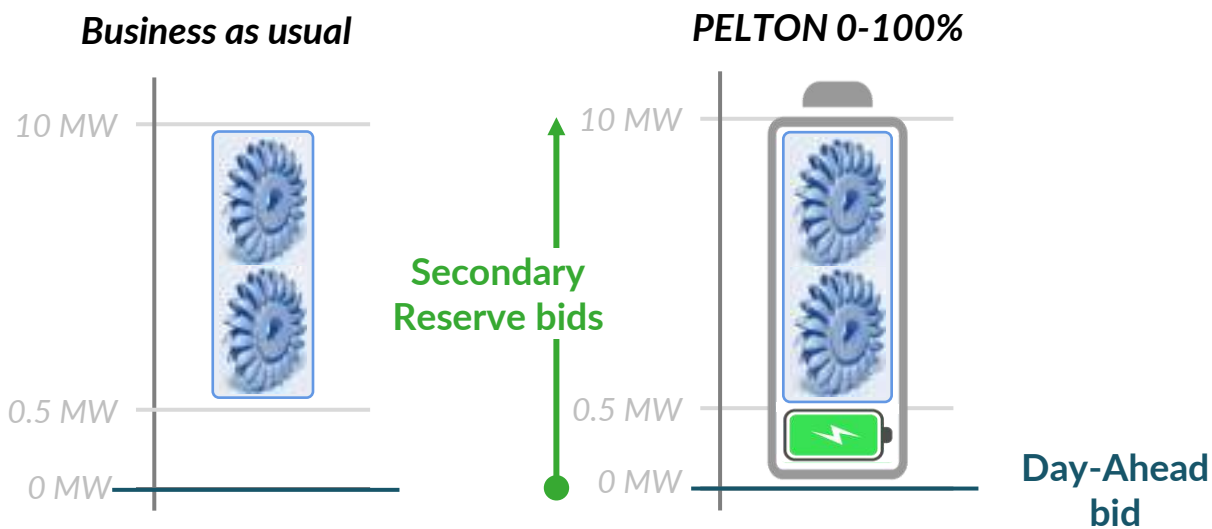


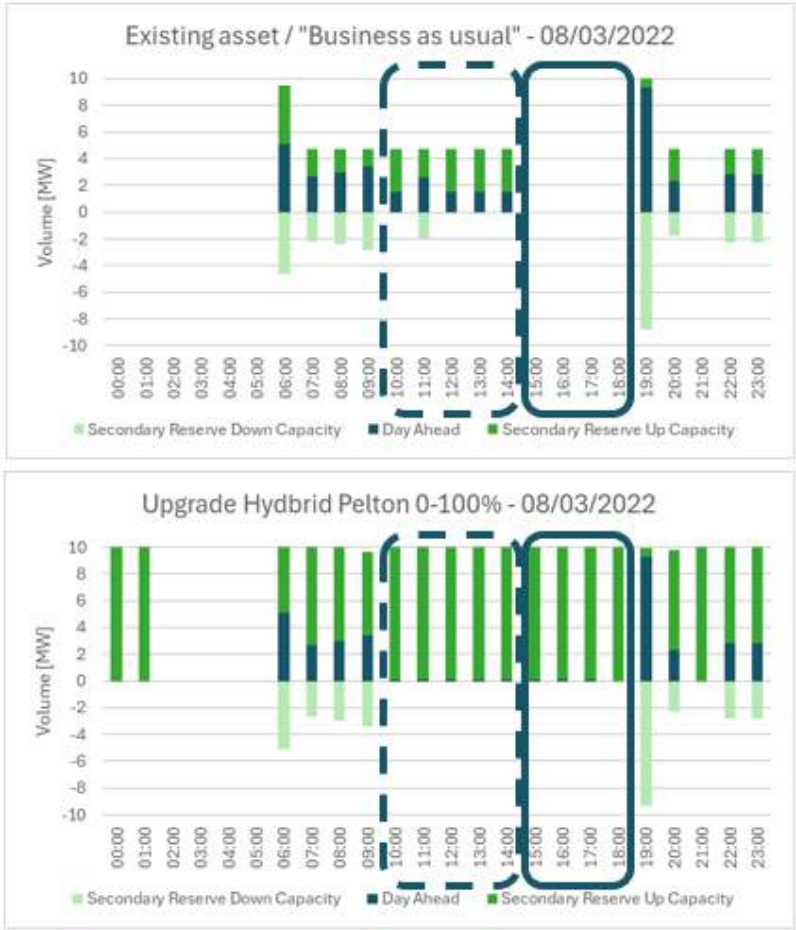
Hourly placement simulation results

SuperGrid Institute
Shaping power transmission

Placement difference for 0-100% technology in 2022 in Finland

LOW PRICE ON DAY-AHEAD MARKET





Hourly placement simulation results

SuperGrid Institute
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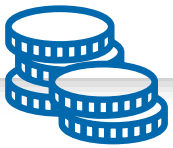
Pelton 0-100%: what's in it for you ?

Boost revenue
on reserve markets



Preserve water
on low Day Ahead prices to benefit from good aFRR prices -from 0MW setpoint

ROI less than 5 years
to be studied case by case

SuperGrid Institute
Shaping power transmission

Cecilia Correa Poseiro

Energy Specialist,
Inter-American Development Bank

SuperGrid Institute
Shaping power transmission

Salto Grande Hydropower Complex

Case study: hybridization to optimize the plant's operation and reduce equipment wear

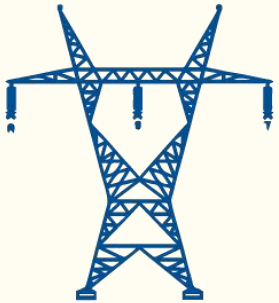
November 2024

Salto Grande Hydropower Complex

First binational project in the region (50% Argentina and 50% Uruguay)

First unit started operation 45 years ago

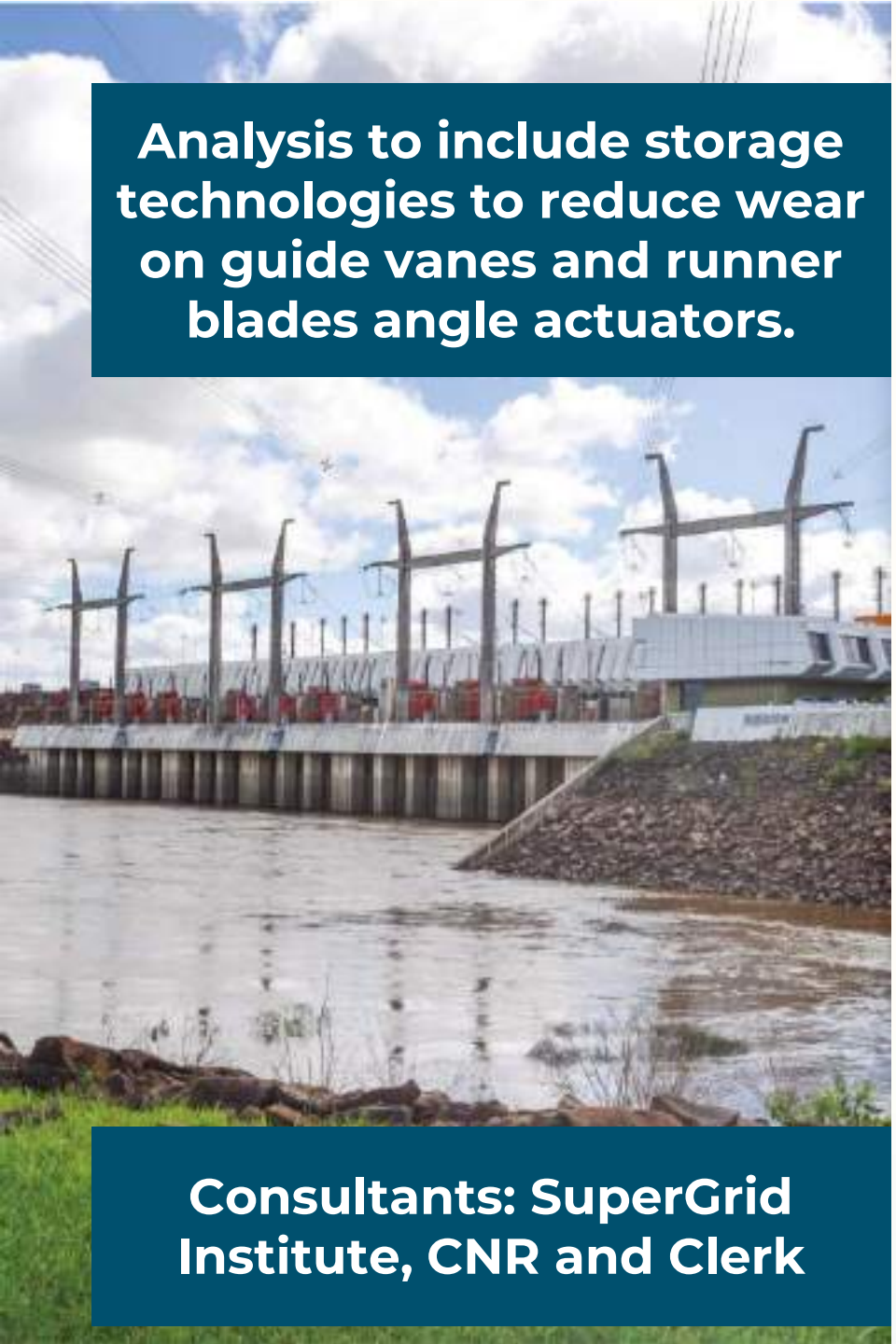
Generation
1.890 MW
14 Kaplan turbines
25,4 m nominal head
~8600 GWh/year



Transmission and interconnection
345 km of 500kV lines
4 substations
Strategic position
2000 MVA interconnection capacity

Environmental & Social commitment
Water management
Flood management
Integration of countries
Regional development

Reservoir
783 km^2
140 km length
5.500 hm^3 total volume



Analysis to include storage technologies to reduce wear on guide vanes and runner blades angle actuators.

Consultants: SuperGrid Institute, CNR and Clerk

More variable renewables integration

↓

Need for more flexibility

↓

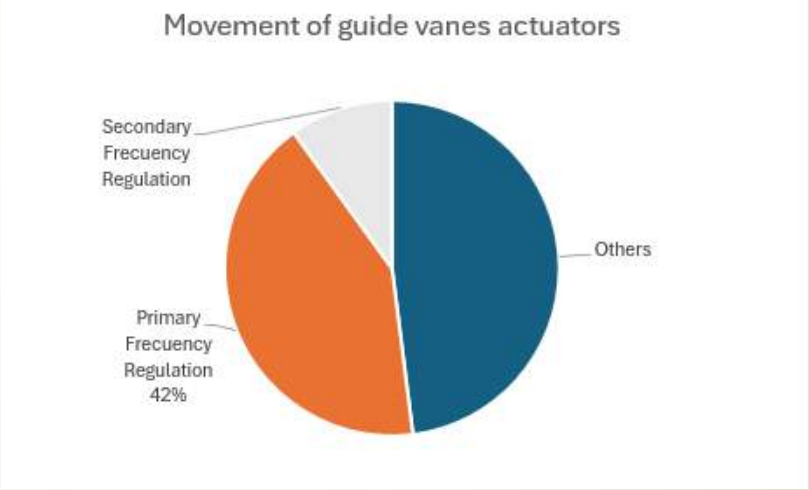
Increase importance of hydros for storage and flexibility but:

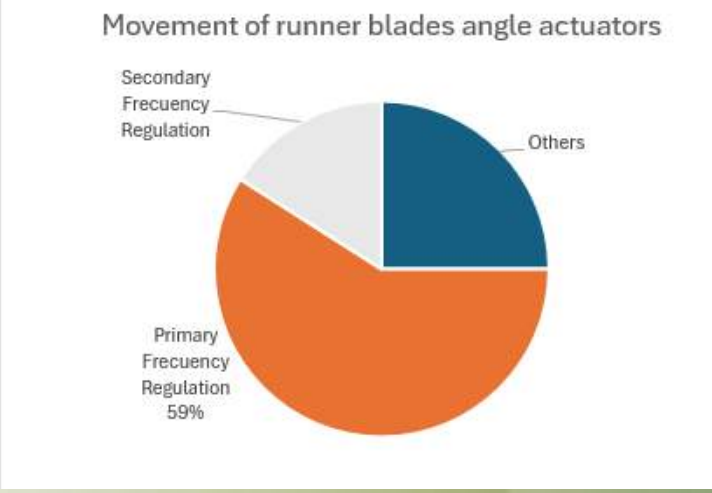
- More stresses and exposure to wear
- Power reserve for auxiliary services and affected operating points

ENERGY STORAGE to increase system flexibility & optimize use of existing hydropower plants

Justification and Scope of the Study

- Salto Grande is one of the main frequency regulators in the system, which has a high share of variable renewable energy.
- Primary frequency regulation is the main use of the actuators.
- How is frequency regulation performed in Salto Grande? double regulation: runner blade opening angle and the guide vanes.
- Objective of the study: To reduce actuator movement due to primary frequency regulation.
- Technologies analyzed: Lithium-ion batteries and unidirectional hydrogen.





Technologies analyzed

Lithium-ion Batteries:

- Characterized by power and energy
- Respond to both high and low demands
- Hydraulic system challenge: Ensure the battery's state of charge is within an acceptable range and acting as much as possible
- Sizing approach: Optimal balance between power and energy to reduce actuator movement

Electrolyzer – Hydrogen production (H2):

- Characterized by power (assuming no limitation on H2 storage)
- Only responds to excess energy (energy consumption and associated H2 production)
- Hydraulic system challenge: Operate above the control band while the electrolyzer consumes energy
- Sizing approach: Optimal power to reduce actuator movement

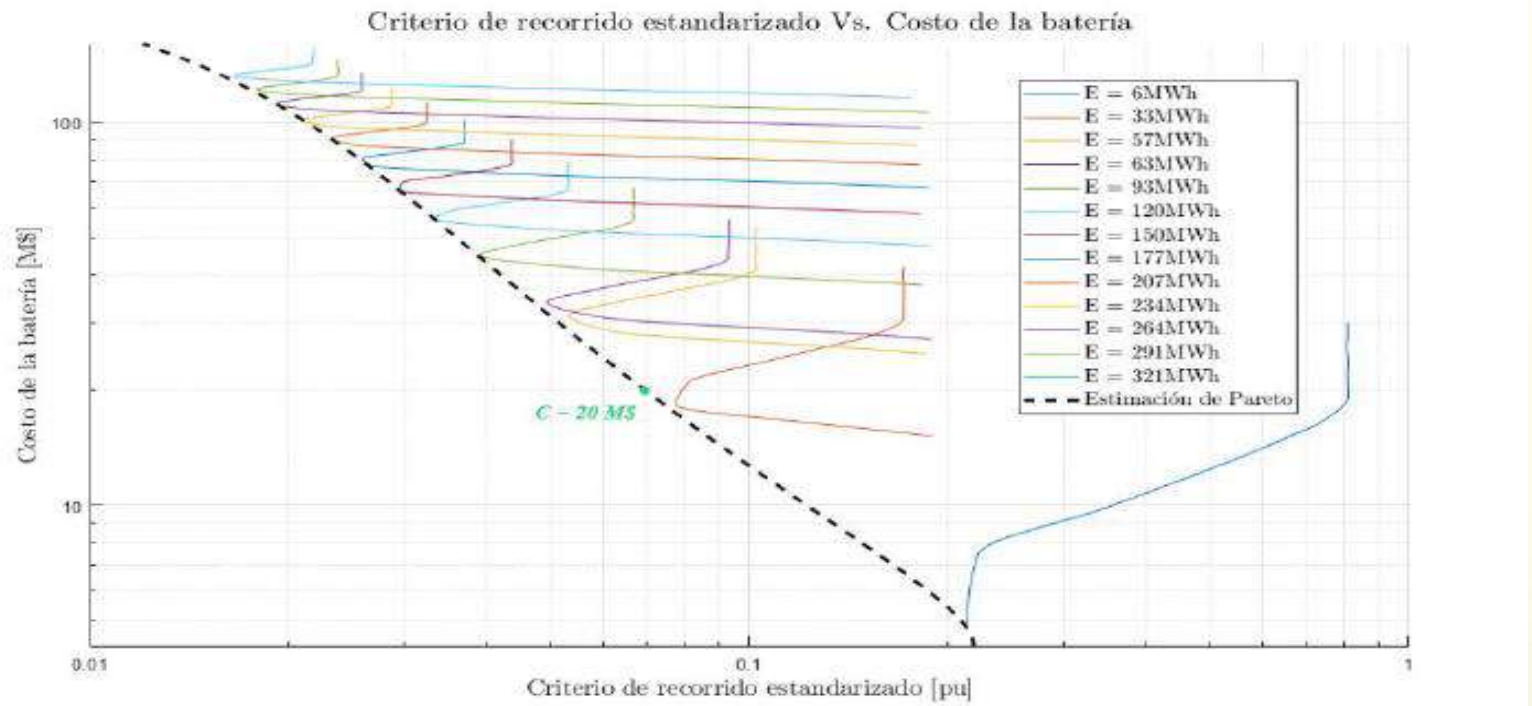
Source: Consulting report RG-T2923-P007 conducted by SuperGrid Institute, CNR, and Clerk.

Lithium-ion batteries:

Simulation: 942 pairs [Power-Energy] considered, and 156 pairs selected between [17 MW - 6 MWh] and [346 MW - 321 MWh].

For a given reduction for actuator movement, there is an optimal Power/Energy pair.

Reduction in actuator movement due to primary frequency regulation between 90% and 99%



Frente de Pareto de la reducción del recorrido de los actuadores en la regulación primaria mediante una batería de Li-ion

Example:

- **Reduction:** 93% reduction in actuator movement related to primary regulation (normalized movement criterion to 0.07)
- **Battery:** Estimated cost of around US$ 20 million; Energy (E) = 41 MWh; Power (P) = 55 MW

Source: Consulting report RG-T2923-P007 conducted by SuperGrid Institute, CNR, and Clerk.

Hydrogen Electrolyzer

Reduction in actuator movement due to primary frequency regulation between 60% and 99.5%

Simulations with Different Sizes of Electrolyzers:

- Nominal capacities ranging from 10 MW to 300 MW

Evaluation of:

- Cost of the electrolyzer
- Water consumption
- Energy consumption
- H2 production

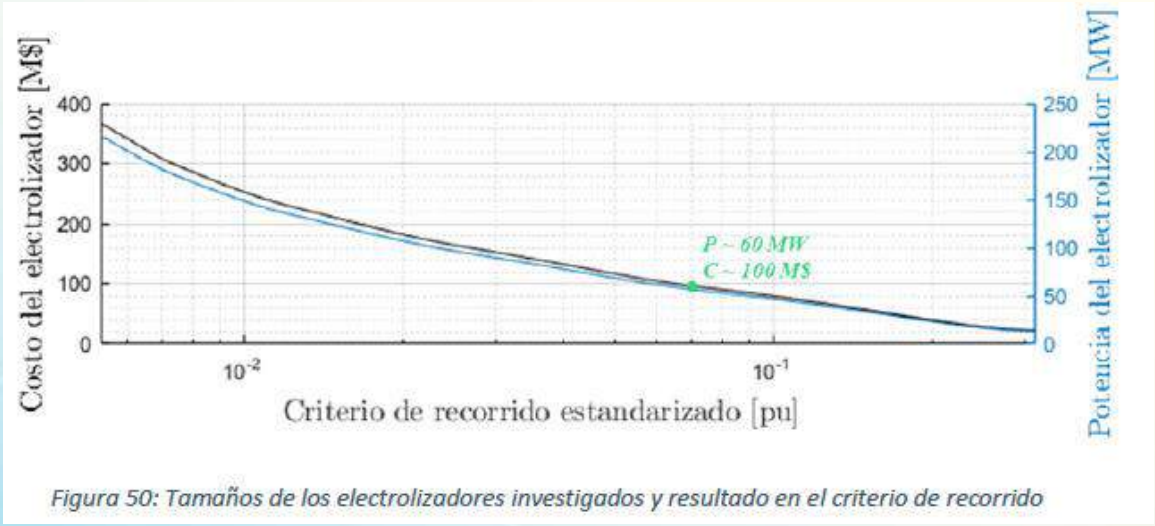


Figura 50: Tamaños de los electrolizadores investigados y resultado en el criterio de recorrido

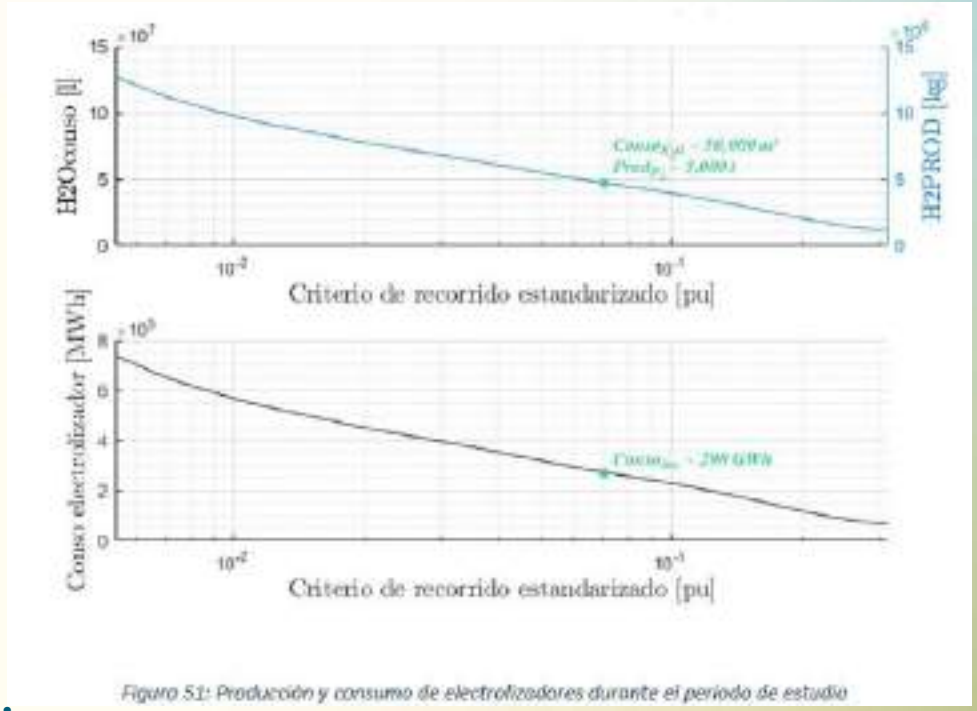


Figura 51: Producción y consumo de electrolizadores durante el periodo de estudio

Example:

•**Reduction:** 93% reduction in actuator movement related to primary regulation (normalized movement criterion to 0.07)

•**Electrolized:** Estimated cost=US$ 100 million; Power (P) = 60 MW; Energy Consumption~ 26GWh/month (~4% of Salto Grande generation); 450 ton/month of H2

Main conclusions:

- The participation of primary frequency regulation in actuator movement is significant.
- Both alternatives (batteries and electrolyzers) are feasible for significantly reducing actuator movement. These values might even be underestimated due to the data considered.
- It is necessary to evaluate the economic benefits associated with reducing actuator movement to assess the project's economic feasibility.
- For hydrogen, it is essential to evaluate:
  - The local market for green hydrogen and price prospects
  - The interest of countries in affecting the electrical production of the Salto Grande Hydroelectric Complex

Thank you

Cecilia Correa
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November 2024

Parveen Nanda

Executive Vice President,
Greenko Group

SuperGrid Institute
Shaping power transmission

hydropower.org

Integrated Renewable Energy & Storage Projects (IRESP)

Malana II Hydro Project in Himachal Pradesh

1 Greenko at a Glance

Greenko decarbonization Strategy

Energy Transition and Decarbonization Solutions for Electricity and Industrial Markets

2012 **2015** **2019** **2021**

"Large scale Clean-Tech IPP"

Electricity

Commercialization and Execution of Renewable Energy Projects at Scale

- Project Origination
- In-House Design, Engineering & Project Management Capability Build-Out
- Execution of Large-Scale projects (>500MW)
- Complex & High Value M&A situations

"Cloud Storage Services Specialist"

Electricity and Industrial

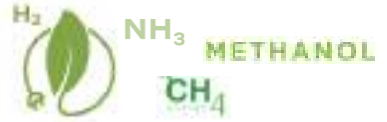
Globally Competitive Long Duration Energy Storage

- Lowest Cost Long Duration Storage asset creation – 100GWh scale
- Decarbonization Solutions for Power Markets – Peak Power, Flexible Energy, Storage services
- Energy Solutions for Industrial Decarbonization Markets – Firm RE Power

"Decarbonization Solution Provider"

Industrial and Global Energy Markets

Engineered Green Molecules



- Lowest Cost Green H2 offering globally
- Green H2 and associated engineered molecules for Industrial feedstock decarbonization

GKO Impact

~35% Capacity Growth

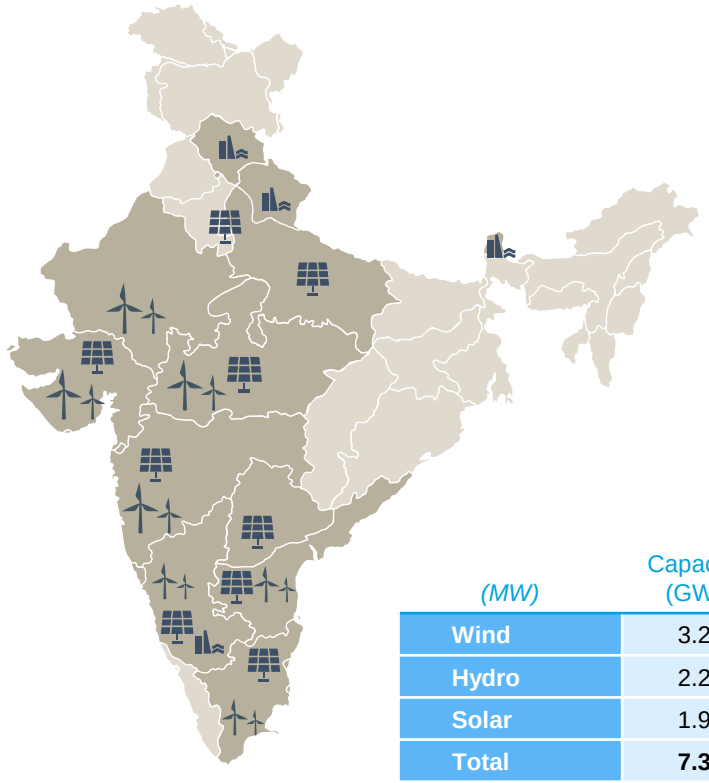
~20-25% Market share by 2030

~40% share of the Green Molecule Market by 2030

Greenko Group: Asset Base Overview

Diversified portfolio of Assets

Geographic Diversification



(MW)	Capacity (GW)
Wind	3.2
Hydro	2.2
Solar	1.9
Total	**7.3**

Wind Hydro Solar

Resource Diversification

>2,800 km of transmission lines

19 million tonnes of CO_2 avoided annually

~2,200 turbines in Hydro & Wind projects

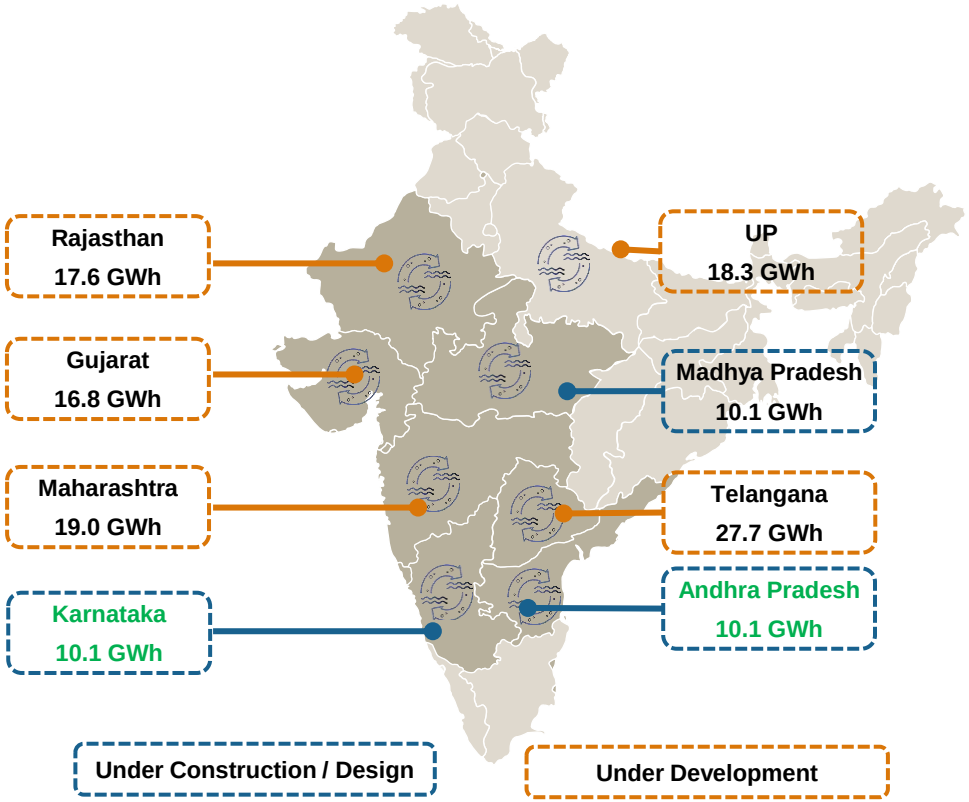
6.5 Mn modules + **~2000** invertors

High Value-High Barrier Asset Creation Ethos

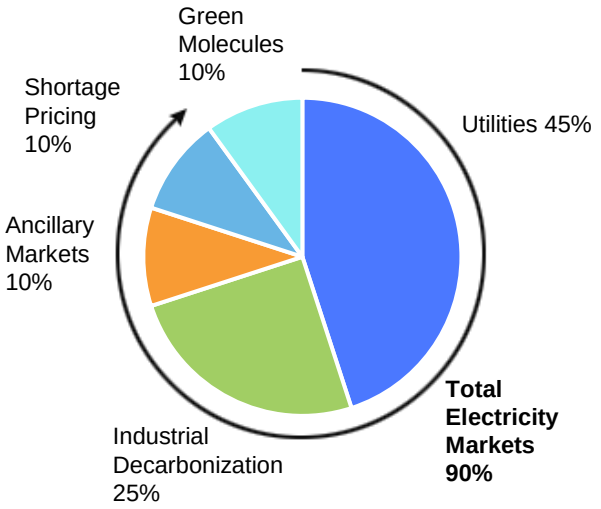
Building World's Largest Energy Cloud

100+ GWh of Daily Energy Storage Cloud

Connected Digitized Cloud Solutions



Revenue Stack



Rayala Wind Cluster in Andhra Pradesh

2 | IRESP- Greenko

Andhra Pradesh IRESP: Layout

Project details and illustrative site layout (Andhra Pradesh)

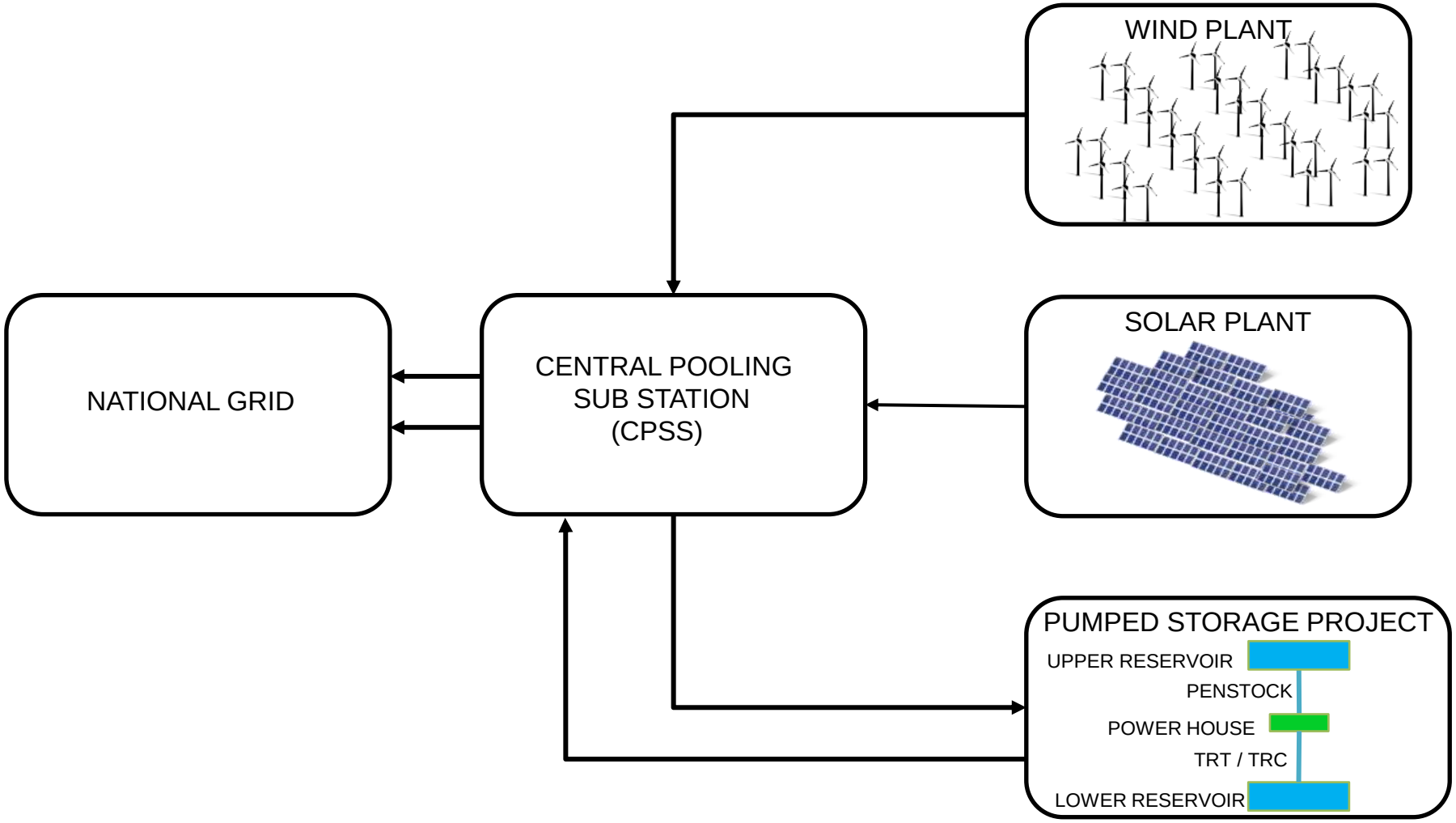
Location

1680 MW PSP in near Kurnool, Andhra Pradesh

Details for RTC project

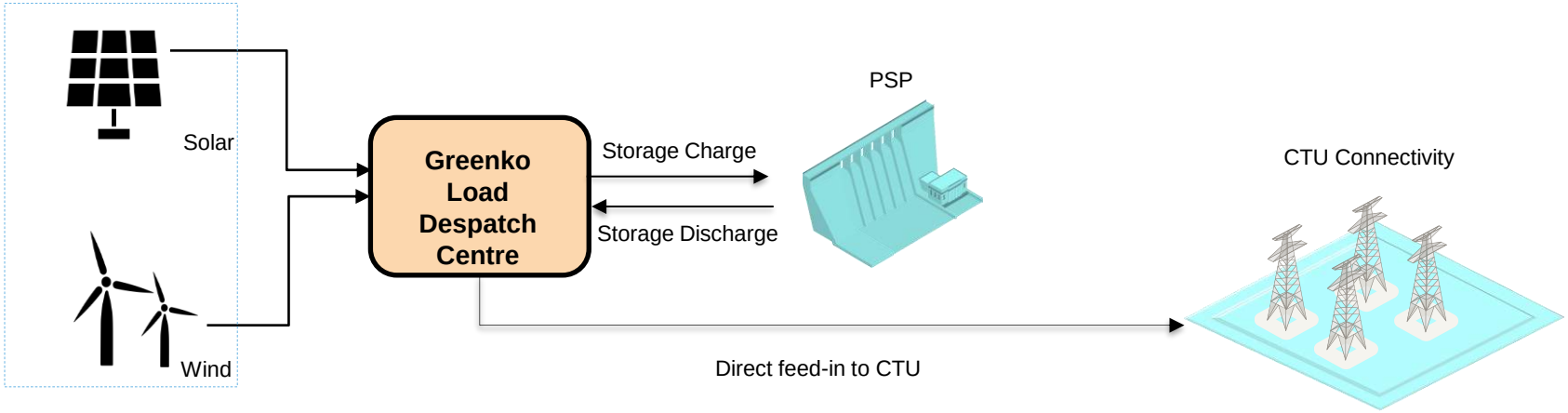
- Solar + Wind: 3000+ 550MW
- Storage: 1680 MW
- Key Features:
  - Caters to all 4 product offerings
  - Commissioning by end of 2024

SCHEMATIC ARRANGEMENT OF IREP



GKO 3.0 – Greenko Load Dispatch Centre
Intelligent Energy Platform

Greenko Load Dispatch Center (GLDC)



GLDC

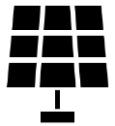
- Greenko Load Dispatch Centre (GLDC) to be modelled on control architecture of regional and state load dispatch centers (SLDCs) which manage national grid infrastructure
- Energy generation from Solar, Wind and appropriate charging/discharging of PSP to be regulated as per PPA commitments
- Would consist of physical energy management, energy regulation, voltage management equipment along with SCADA based control software
- Functions as the intelligent energy platform overlaying the core physical asset infrastructure and controls the energy flow system
- Energy load modeling and system analysis of GLDC is being carried out by PRDC based on which equipment to be procured from the likes of ABB / GE / Siemens along with software layer to ensure effective integration of multiple systems

Integrated Renewable Energy with Storage Project (IRESP) - Overview

Storage Solutions enable efficient absorption of renewable energy penetration

IRESP

Solar



Wind

Pump Storage Solutions –GWh

Key Product Features / Services Offered

1. **Round The Clock (RTC) Power**
2. **Base + Peak load servicing**
3. **Storage Services + Ancillary services**
4. **On-Demand Schedulable Energy Servicing**

Thank You

Audience Q&A

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Thank you

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