Study and modelling of PV/Hydro hybridization

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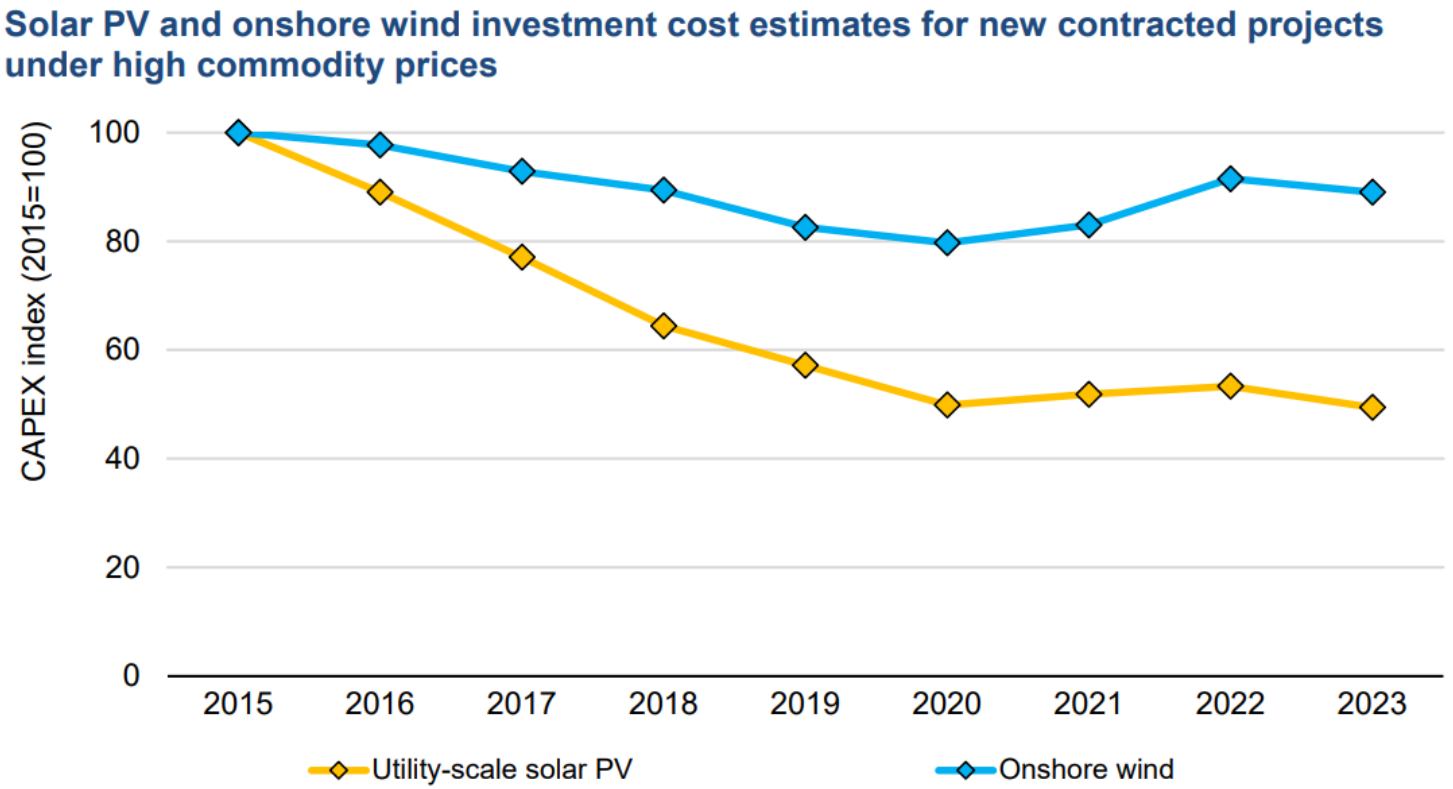
Why studying Hydro / PV hybridization ?

- Photovoltaic (PV) is a major source of renewable energy
- PV issue: **intermittence / variability** of the production
- Hybridization of PV with Hydro Power Plant is a solution to:
  - Increase de penetration rate of Variable Renewable Energies
  - Take advantage of the storage capacities of reservoir HPPs

    Intra-day variation (planned & unplanned) / seasonnal storage

Why studying Hydro / PV hybridization ?

- Dropping of PV costs since 2010
- Capacity of PV plants are increasing
- In Africa: electricity grids sometimes failing, reducing high share of VRE
- Reactivity of a HPP in line with the variability of PV plant



Source : IEA Renewable Energy Market Update 2022

Hybridization concept

Uncoordinated production

PV Production

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Hydro Production

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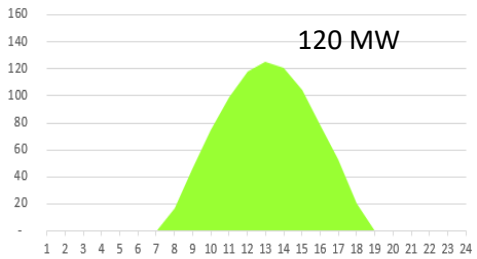
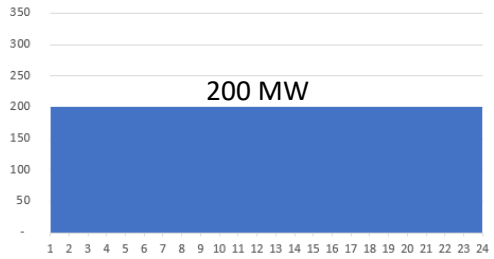
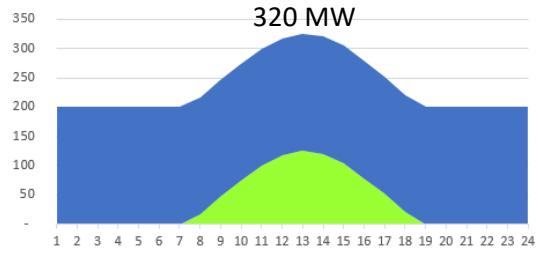
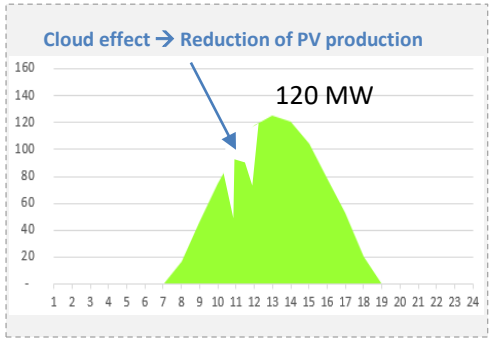






Hybridization concept
Optimization and coordination

OBJECTIVES:



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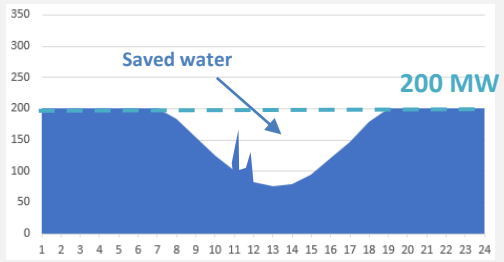
SAVE WATER FOR DRY SEASON / SEASONAL STORAGE



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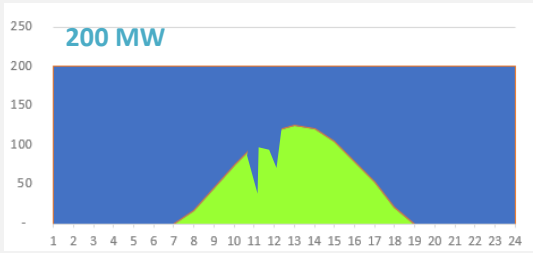
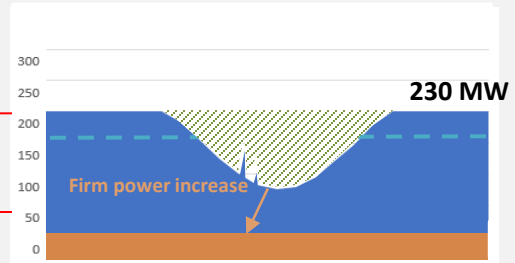


OR

INCREASE FIRM POWER

Turbine load acceptable range



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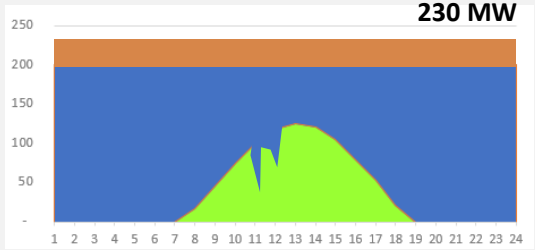


NOTE : FLEXIBILITY ALLOW FOLLOWING VARIOUS CURVES OF DEMAND, INCLUDING POWER SHIFTING AT PEAK HOURS

Overview of synergies

PV operator ≠ HPP operator

Reduction of the CAPEX (HV, access roads) → *approx. 5%*

Reduction of maintenance costs

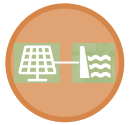
Ease to find a land

Increase of PV production in the case of a floating PV plant thanks to the water cooling effect → *approx. 3%*

Possibility to obtain fees for the interconnection of the PV plant and leasing of land

For floating PV: **conservation of the hydro resource thanks to a reduction of evaporation**

PV operator = HPP operator



Increase of the firm power, global local production and annual hydro production (optimized management of the water resource, limitation of the dry season effects,…)

Flexibility in the daily regulation of the hydro production→ interesting effect in case of different hourly electricity rates

Smoothing of the daily PV production (clouds effects)

For floating PV: reduction of evaporation

HyPV Tool

Objectives

- Determine if the hybridization can improve the hydro production
- Calculate the synergies (kWh)
- Optimization of the sizing of the PV plant to maximize synergies
- Assess the main features of the HPP to improve synergies

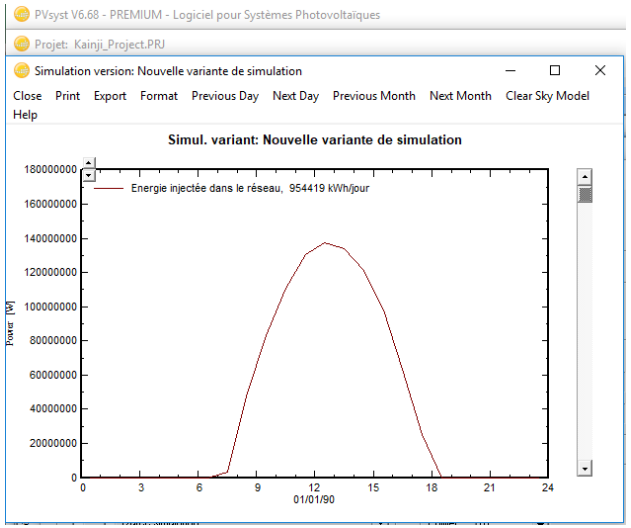
Approach

- Modelization of the operation of the HPP (hourly step)
- Modelization of the PV inputs and the hybridization with the hydro plant
- Variation of the parameters/features in order to determine the optimal configuration (PV capacity, operation of the plants, …)
- Comparison of the results between hybridized HPP/PV plants and non-hybridized plants

HyPV Tool

Input & parameters

- Shape of the reservoir (EAV curves)
- Management procedure of the hydro plant : Qout=f(Qin,H...)
- Runoffs measurements (hydrology)
- Mechanical equipment (features of the turbines)
- PV production (PVsyst)
- Meteo data: irradiation, temperature …

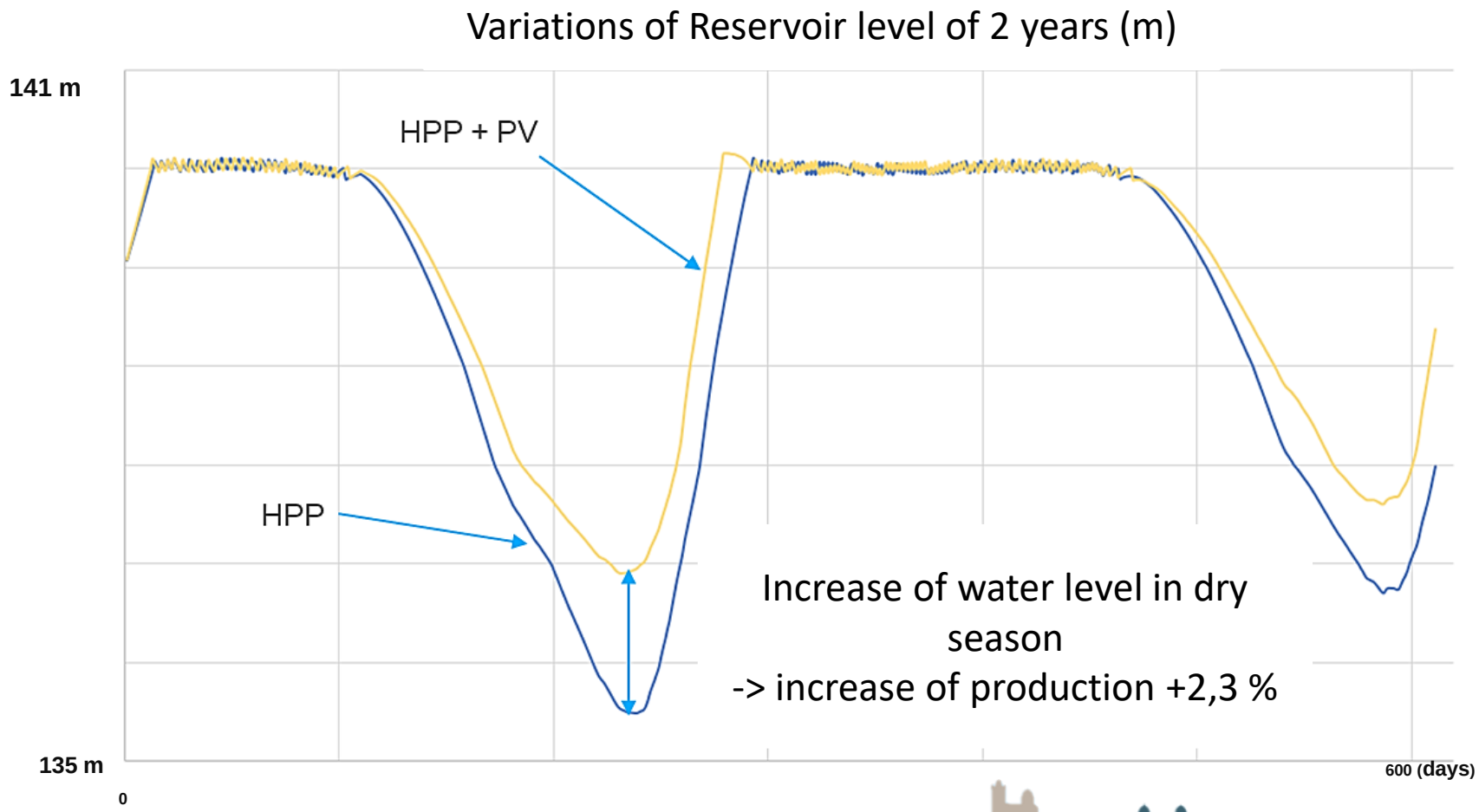


HyPV
Results on case study

- Kainji Dam 760 MW + PV Project of 600 MWc

	Average Hydro production (GWh/year)
Coupled model	2 878
Un coupled	2 990
INCREASE	+ 3,9 %

HyPV
Results on case study



Main Conditions beneficial to synergies

- Reservoir with large seasonal variations of level with an impact on available head
- Large solar irradiation, leading to important complementarity of resources
- Large installed power of the HPP (Low Plant factor)
- Financial incentives for producing energy when the demand is higher

Conclusion

- HPP and PV plants can be complementary and show synergies
- Case by case studies are necessary to evaluate the synergies
  - Resources and production
  - Grid integration
- Tractebel has the experience and tools to design and optimize such hybrid projects
  - Addition of PV energy in relation with an existing HPP
  - New power plants (with both resources)