Combining SOLAR PV power plants and wind farms:

Enel Green Power
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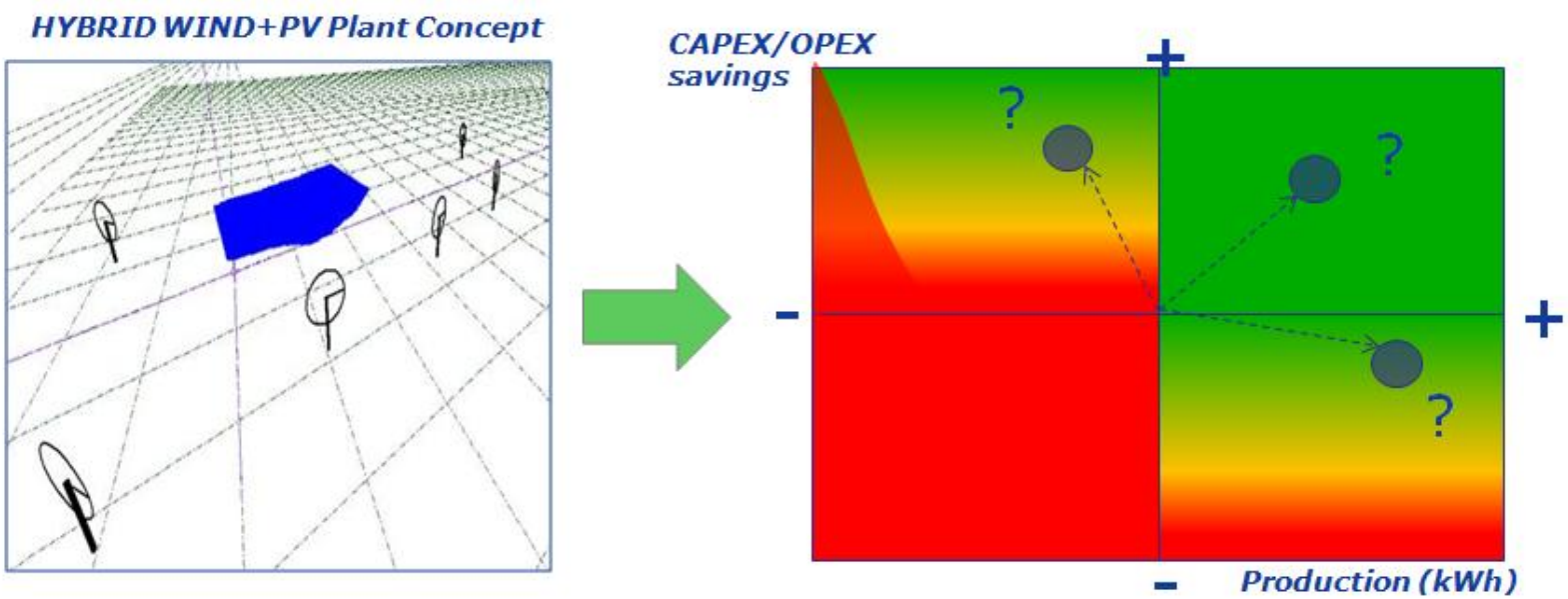
Hybrid Wind-PV Plant

Introduction

A wind site presents surfaces left free by a wind farm structure to install a complementary PV plant.

⇒ **Synergies** due to the cost reduction (grid connections, authorization, access road, electrical paths) and the stabilization of the energy production.

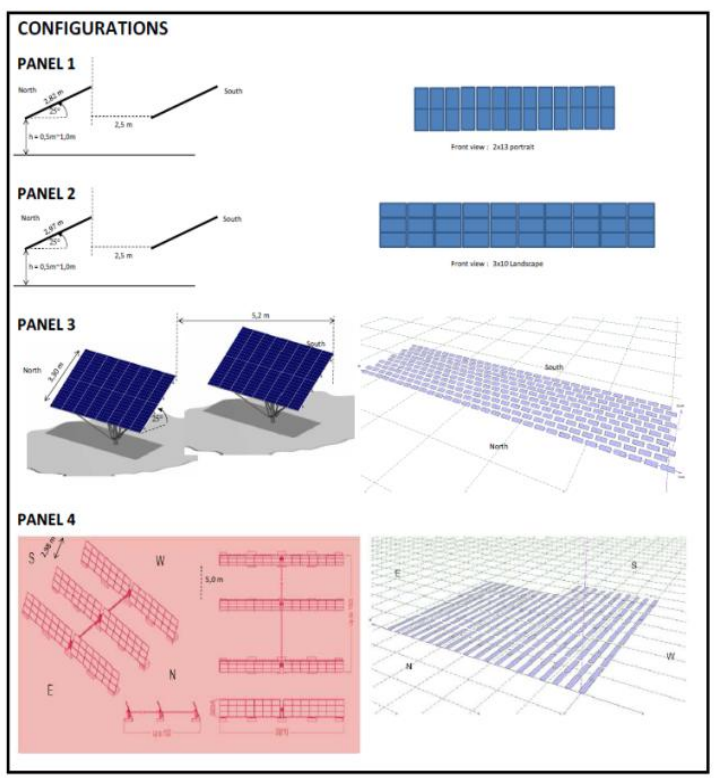
⇒ Possible **decrease of load factor for both power plants.**



Hybrid Wind-PV Plant

Mutual interactions

The integration of PV plant in a wind farm site generates a wind speed reduction and a wind profile disturbance. Consequently, the **wind farm energy production decreases**.



$$z_0 = 0.5 \frac{h \cdot S}{A_h} \cdot P$$

Where

h: height

S: cross section facing the wind

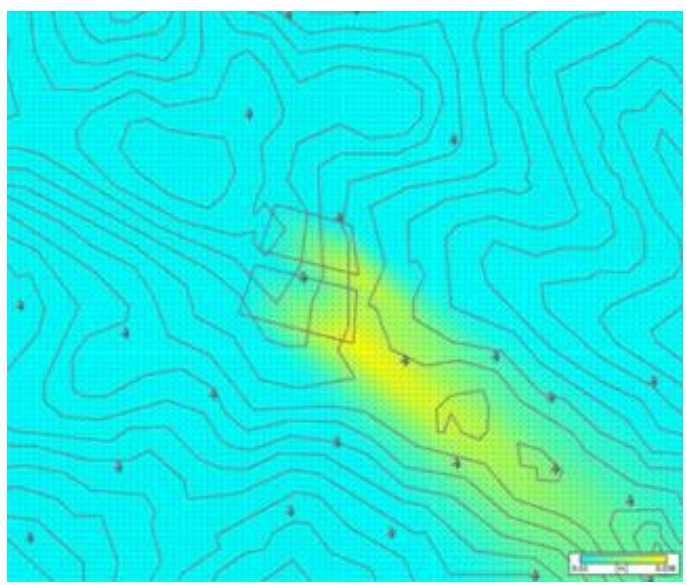
P: porosity of a roughness element

A_h: available horizontal area of element

z_0: aerodynamic roughness height

	Panel 1	Panel 2	Panel 3	Panel 4
h [m]	2.6	2.7	3.0	2.7
S/Ah [-]	0.236	0.242	0.268	0.164
P [-]	1	1	1	1
Zo [m]	0.258	0.273	0.321	0.185

Simulation of wind profile disturbance by the PV plant (*turbulence + wake effects in yellow below*)

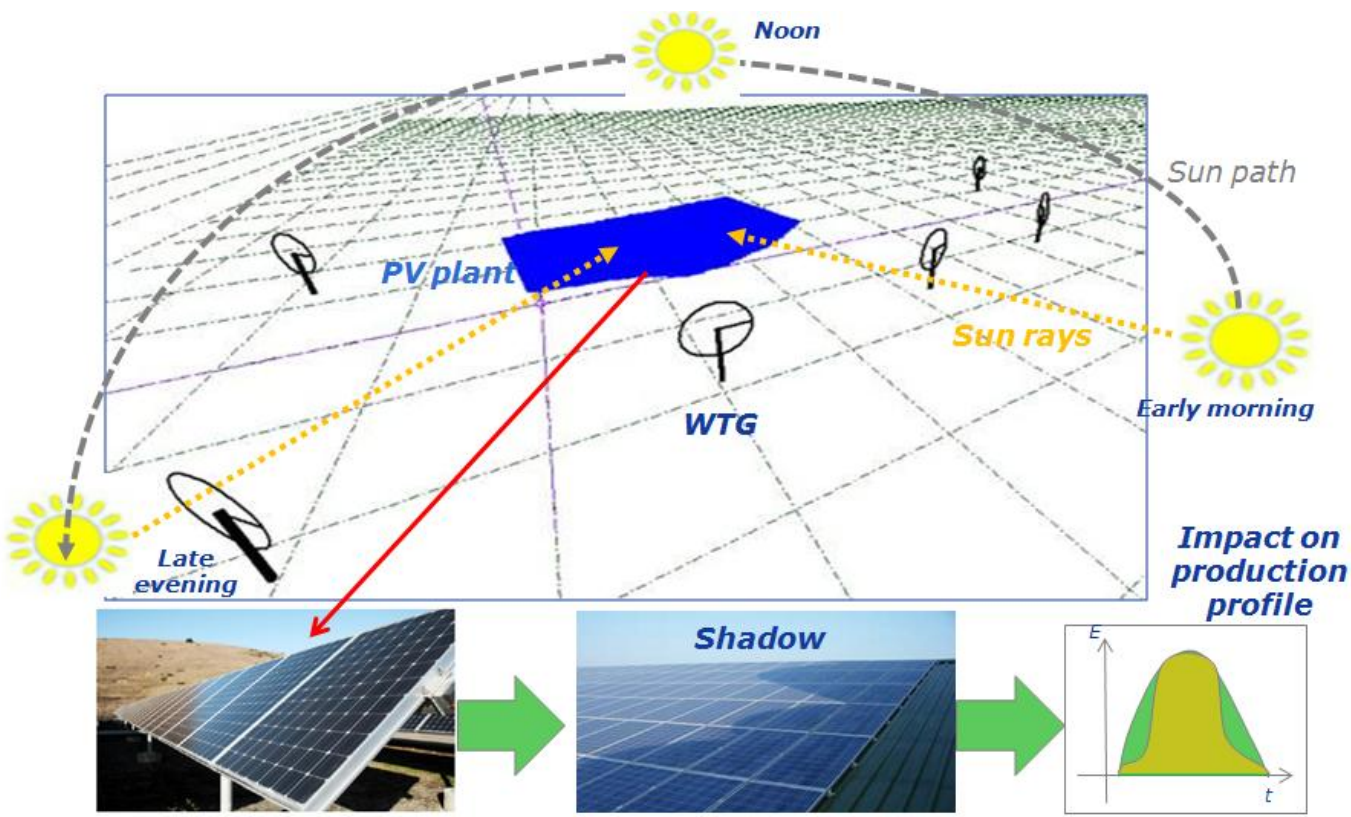


Hybrid Wind-PV Plant

Mutual interactions

The elements to consider to integrate a PV plant on a wind site are:

- The slopes of the available areas
- The far horizon (analyzed with an internal methodology)
- The shading impact generated by the wind turbine generators.

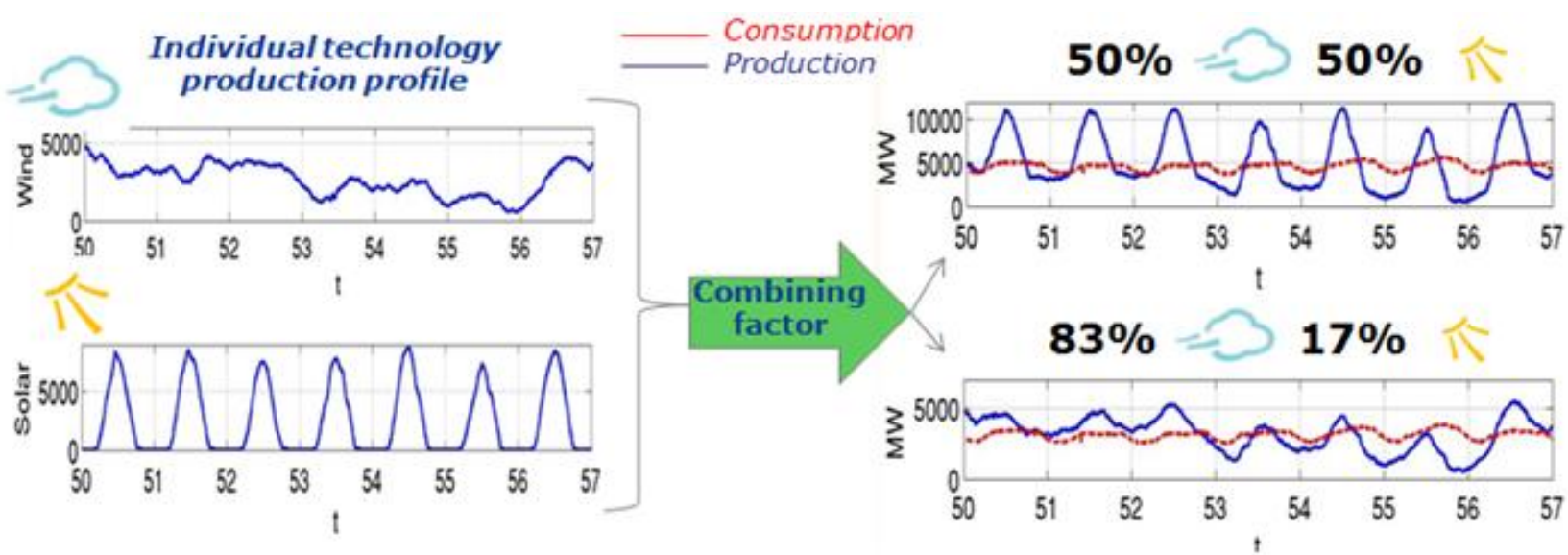


Hybrid Wind-PV Plant

Mutual interactions

Analysis of the possible stabilization of REN production by mixing sources of energy production :

- Wind during winter (lower radiation)
- Wind during night (no radiation)
- Wind during rainy/overcast day (lower radiation)
- Anticyclone sunny day (no wind)
- …



Hybrid Wind-PV Plant

Example on a real case

The aim is to compare the initial Capex gain with the revenue losses (for the operating period) due to the energy production losses.

Items profiting from a synergy with the wind farm:

- Access road
- Land leases
- Electrical equipments (transformers, HV lines…)
- Grid interconnections.

The revenue loss takes into consideration:

- The mutual interactions
- The annual degradation of modules
- The Feed in tariff
- The discount rates.

Wind farm:

- Capacity: **90MW** (45 WTG of 2MW each)
- Losses due to the PV plant: **1.5%**

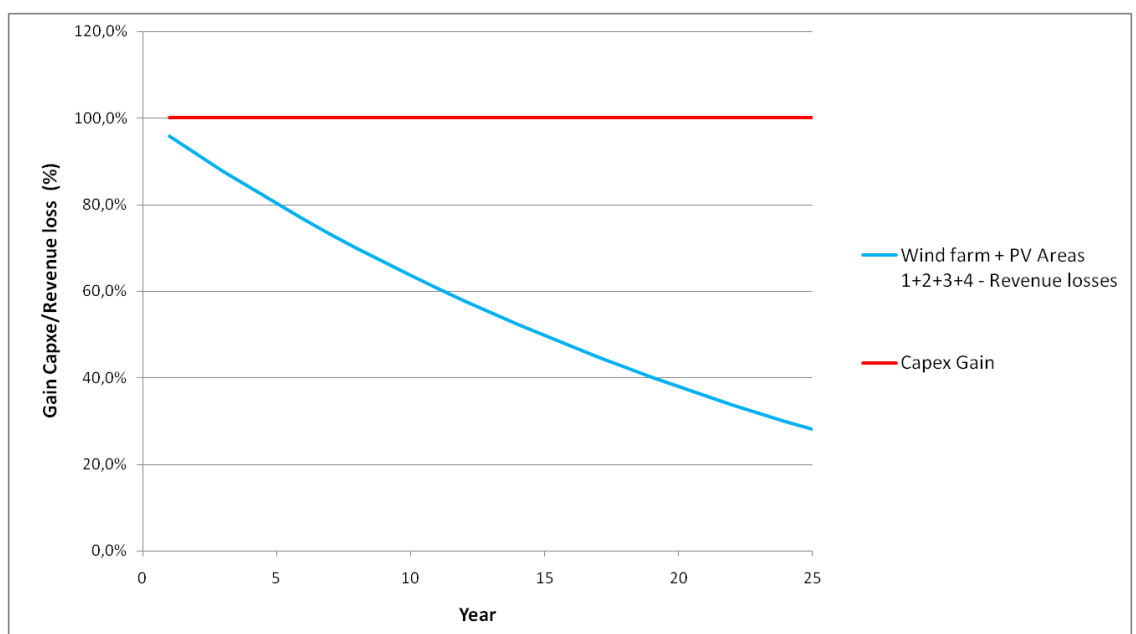
=> revenue loss of 1.5%

PV plants:

- Capacity: **55MWp**
- Losses due to the WTG: **1.6%**

=> revenue loss of 1.7%

Initial Capex gain (in comparison with independent PV plant): **~5% of PV plant**



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Conclusion and next steps

The wind-photovoltaic hybrid plant presents some advantages but also some limits:

Avantages	Drawbacks
Use of installed electrical equipments and civil engineering works (accesses, roads…)	Energy production losses => Revenue decrease
Gain of installation costs	
Stabilization of the produced energy	
Technical and economical analysis (during the operating period) permit to validate or not the possibility to combine both technologies	

The first results are encouraging but in order to optimize this kind of hybrid plant, some points remain open:

- Consideration of operating and maintenance activities

- Analysis of the inverter behavior when we have alternating shadow/light generated by the blades

- Insurance constraints (ice blocks from blades for example).

Thank you for your attention

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