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Towards a new approach in evaluating the practical economic performance of off-grid storage-less Hybrid Energy System with integrated solar forecast

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► **To cite this version:**

Fuqiang Zhuang, Rodrigo Amaro E Silva, Thomas Carriere, Benoît Gschwind, Yves-Marie Saint-Drenan, et al.. Towards a new approach in evaluating the practical economic performance of off-grid storage-less Hybrid Energy System with integrated solar forecast. 8th World Conference on Photovoltaic Energy Conversion, Sep 2022, Milan, Italy. <10.4229/WCPEC-82022-5DV.2.90>. <hal-03842923>

HAL Id: hal-03842923

<https://hal.science/hal-03842923v1>

Submitted on 7 Nov 2022

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Towards a new approach in evaluating the practical economic performance of off-grid storage-less Hybrid Energy System with integrated solar forecast



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Context & Objective

- Off-grid energy system of mining sites are mostly based on fossil fuels. In the context of the energy transition, **Hybrid (PV-diesel) Energy System (HES)** with storage system is commonly used. Yet, using a storage system comes with additional investment cost, extra environmental impact and maintenance issues, etc.

Could a PV + diesel HES be operated without energy storage system, but using Power Management System (PMS) with solar forecast?

Case study & Approach

- A case study with rather stable 50MW demand and 70MW genset capacity in tropical area of West Africa is used.
- A python-based simulation platform using *oemof* is designed and implemented for the simulation.
- Probabilistic climatological and perfect forecast are used to define the full range of performance gain.
- HES operation is driven by P_{50} and spinning reserve is sized with the uncertainty range between $P_0 - P_{50}$.
- A cost-based metric that evaluate both system stability, economic and solar forecast performance is introduced.

Results & Discussions

- Integrating PV energy in HES can reduce the system cost before its saturation. At clear day (figure 1), the optimal penetration for perfect forecast is 175%, then the system cost increases due to the PV curtailment. At variable day (figure 2), more PV capacity can be integrated due to lower solar energy availability.
- The system cost in blue squares decreases significantly since gensets are stopped when PV energy is sufficient for all demand, the associated cost is hence avoided. This case is postponed at variable day since solar resource is lower.

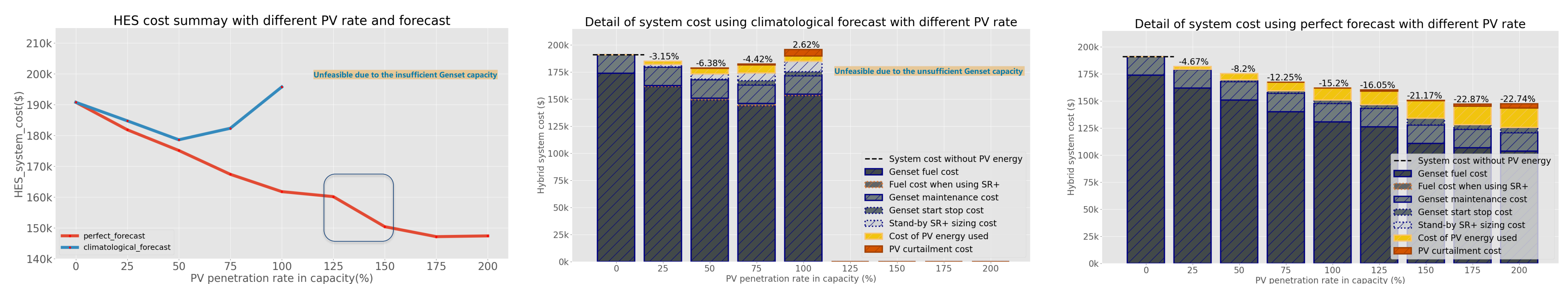


figure 1: Simulation results with different PV penetration rate at clear day

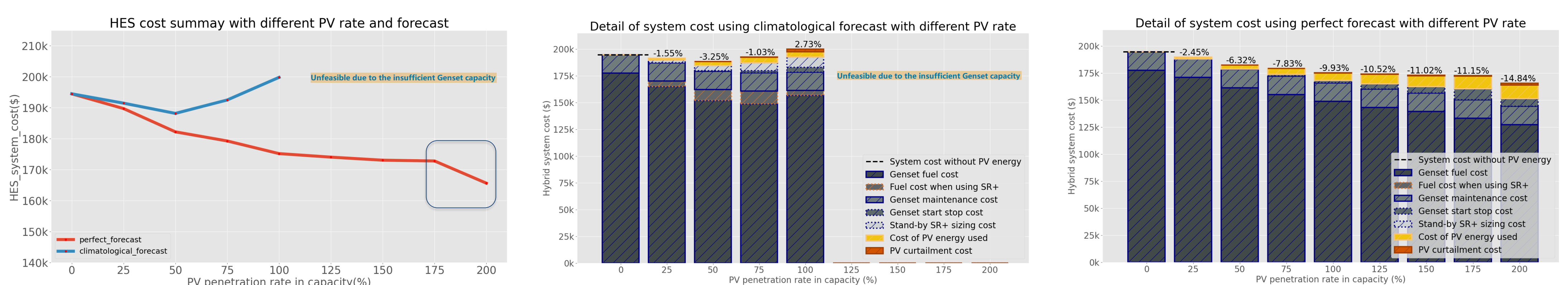


figure 2: Simulation results with different PV penetration rate at variable day

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- For high quality forecasts, long forecast horizon helps in reducing the system cost through genset dispatching. For basic model like persistence, forecast horizon should be relatively shorter to provide a good result. (figure 3)

- The maximum PV penetration rate is limited by the forecast uncertainty and available genset capacity, since more PV will imply more spinning reserve sizing and the system becomes unfeasible. Thus, less uncertain models allow for higher PV integration. (figure 4)

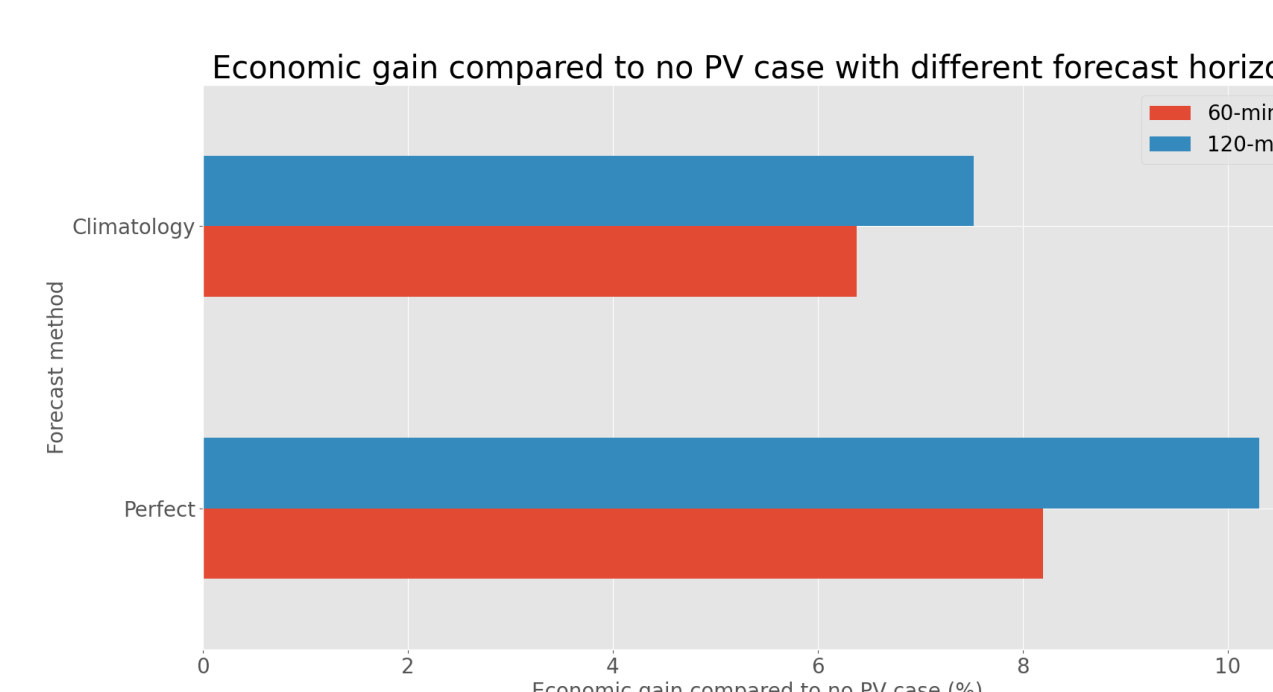


figure 3: Influence of forecast horizon in economic gain

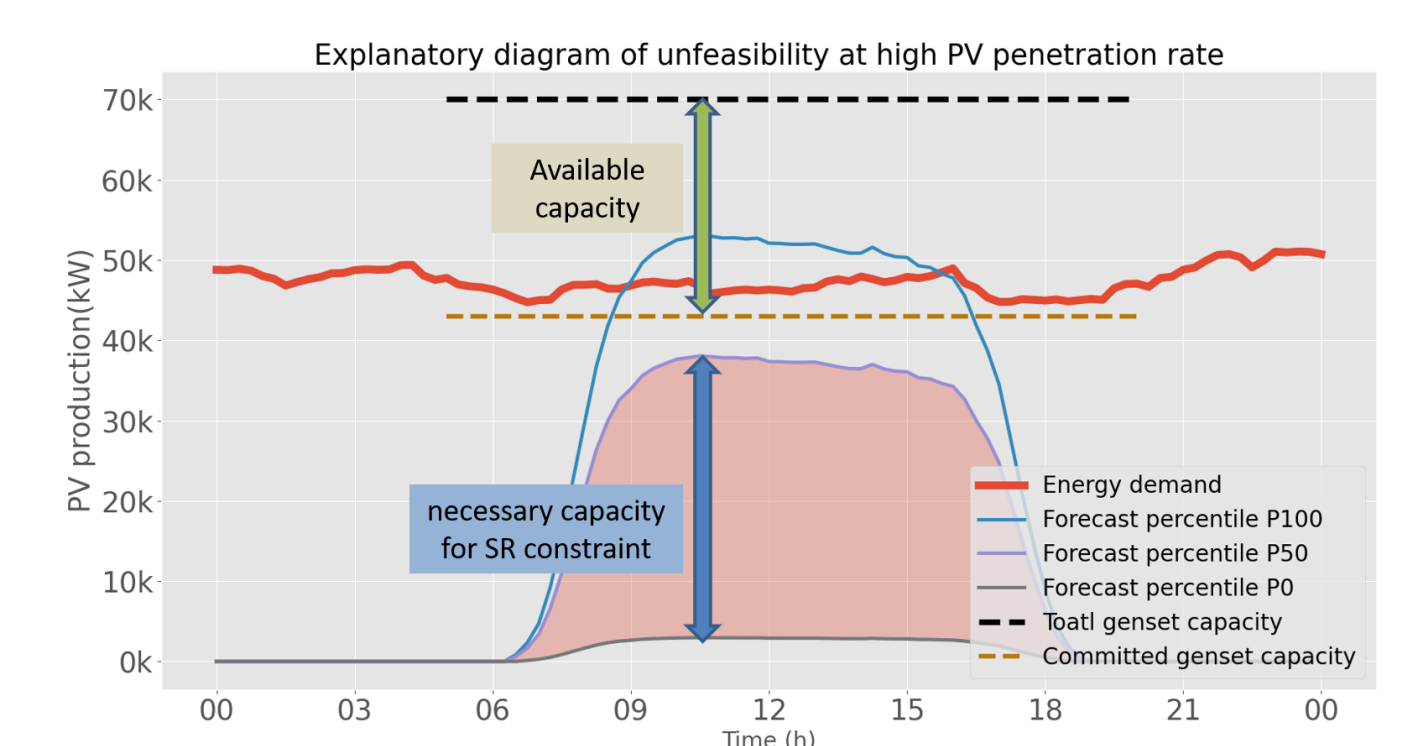


figure 4: Explanation diagram of system unfeasibility cases

Conclusions & Perspectives

- The concept of using PMS with solar forecast and without storage is shown to be feasible, the cooperation between the PMS and an automated dispatch or a strict manual operation of Gensets are the main enablers.
- The gain of using solar forecast depends on many elements, such as the weather condition, PV penetration rate, forecast model, and the Genset characteristic, etc. Results show a range up to 22.9% of decrease in costs with perfect forecast and 6.4% with climatological forecast. To be exploited with better forecast methods and lower uncertainty.
- Due to the storage-less design, inability to store PV surplus limits the ability to integrate large levels of PV capacity due to curtailment. Additionally, this concept should also be evaluated from a life-cycle perspective.

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