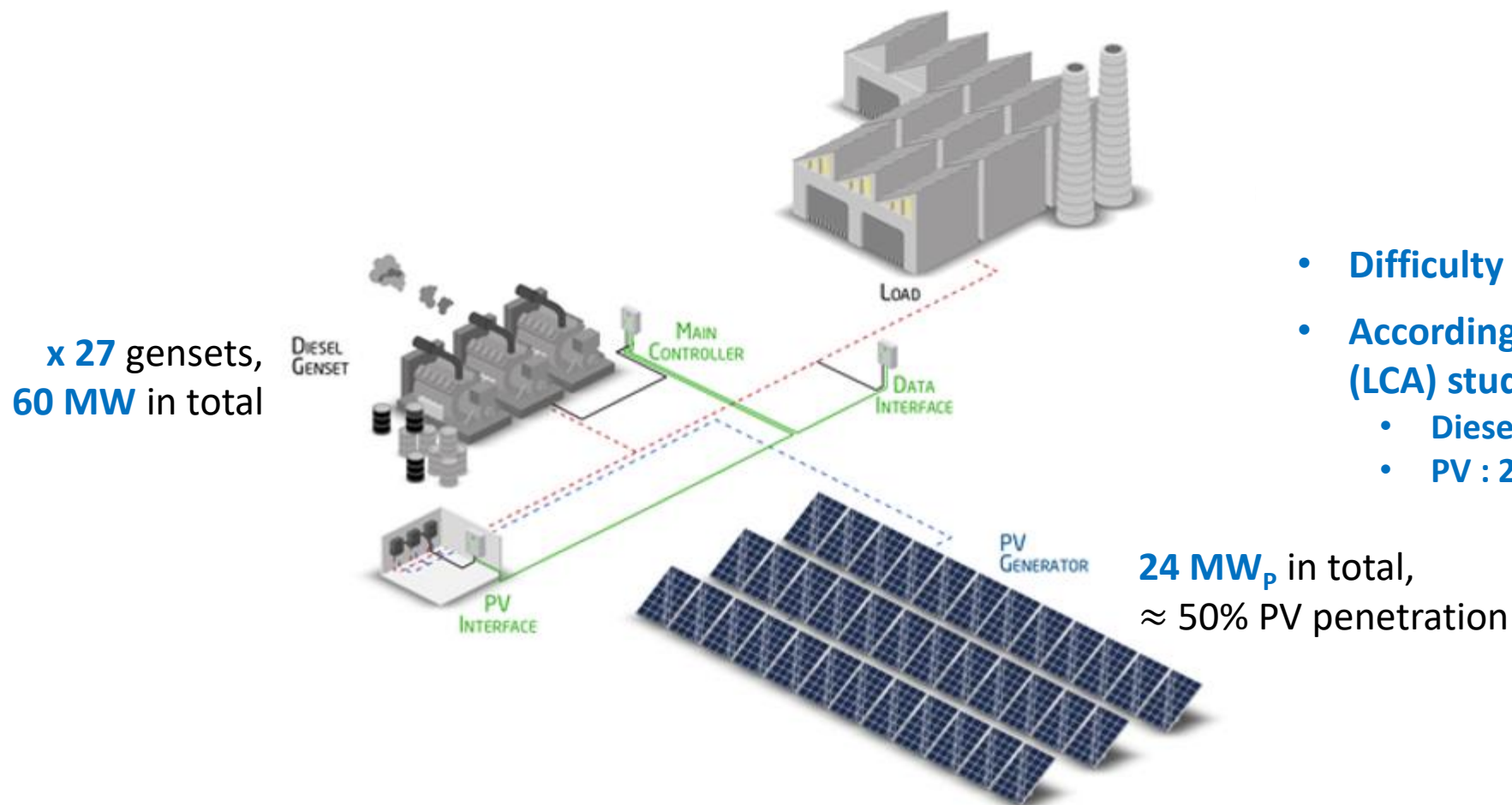


# **«Considering solar forecast in *off-grid storage-less hybrid (PV + Diesel) energy system simulation by using Oemof*»**

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SPIE Industrie

# General introduction

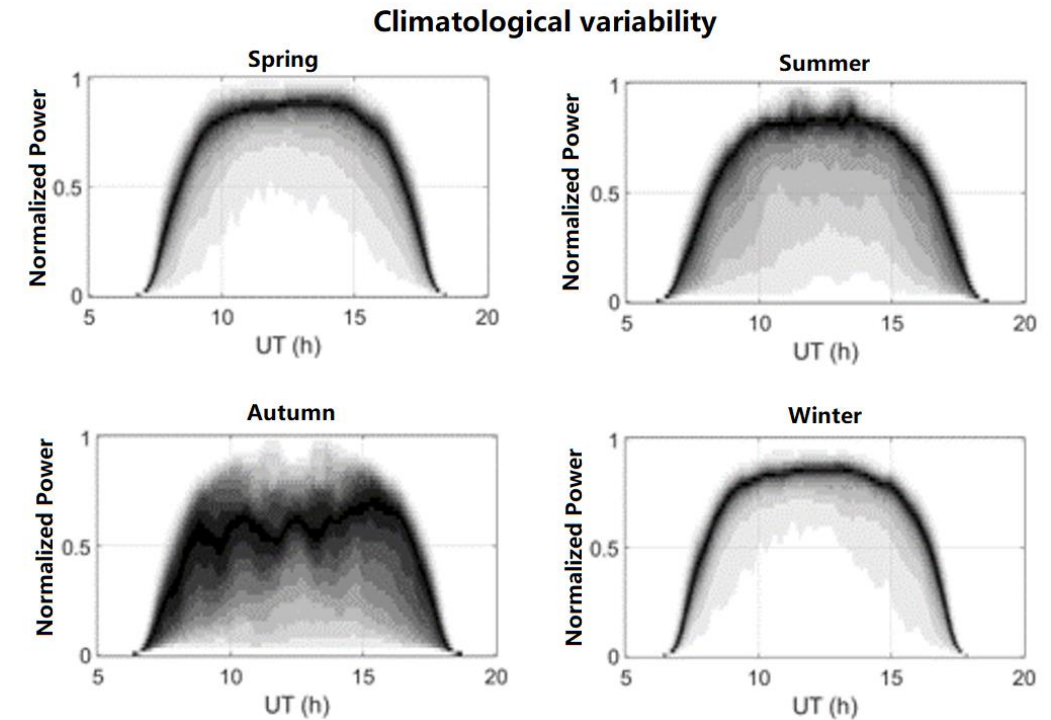
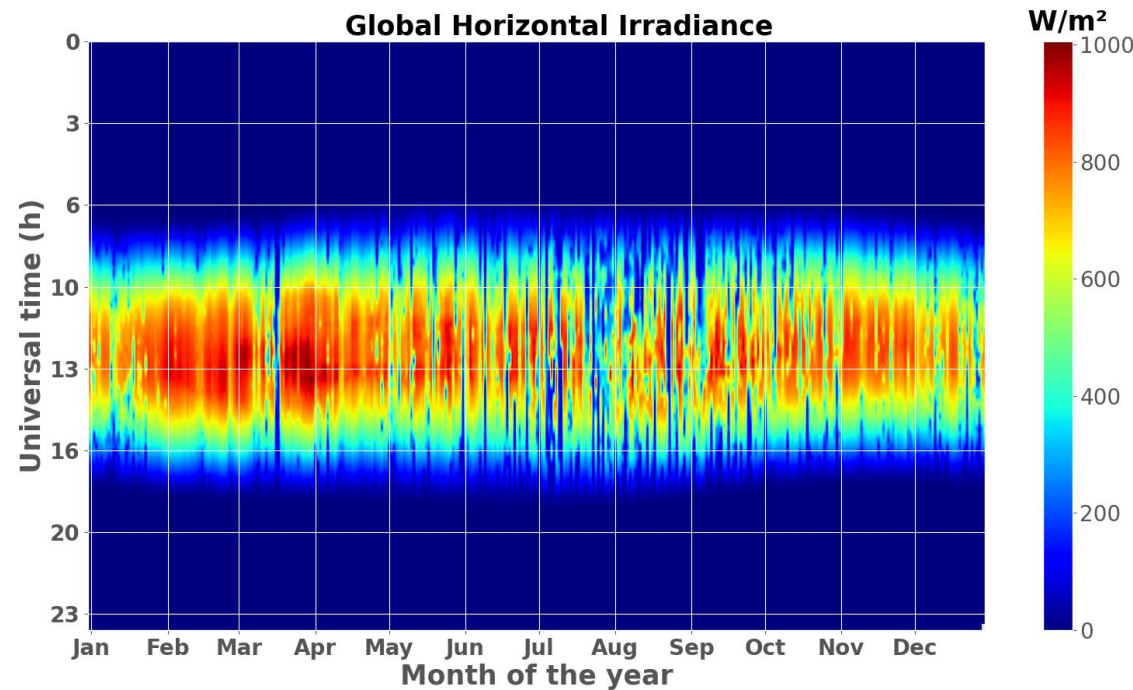


- Difficulty in fuel supply
- According to Life Cycle Assessment (LCA) study [1], [2]
  - Diesel : 700 - 800 gCO<sub>2</sub>eq/kWh
  - PV : 20 – 40 gCO<sub>2</sub>eq/kWh

For our case study, 9% PV energy share compared to demand, we reduce at least 71 t CO<sub>2</sub> emission **per day** !  
Which is equal to the average daily CO<sub>2</sub>eq emission of 3700 EU citizens !

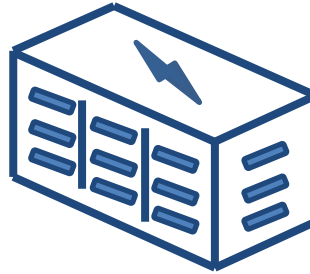
# Major challenges

- The potential failure of different components of energy production system.
- The variability of the energy demand.
- The variability of solar resource due to seasonal, diurnal and meteorological condition changes.

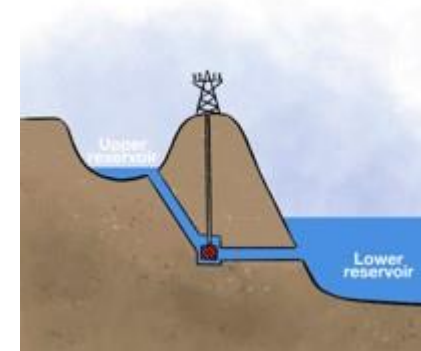


# Solutions for mitigating variability

- **#1 : Installing an energy storage system,**
  - Battery energy storage system,
  - Pumped-storage hydroelectricity station,
  - Flywheel energy storage system,
  - Compressed air energy storage system,
  - ...



Battery



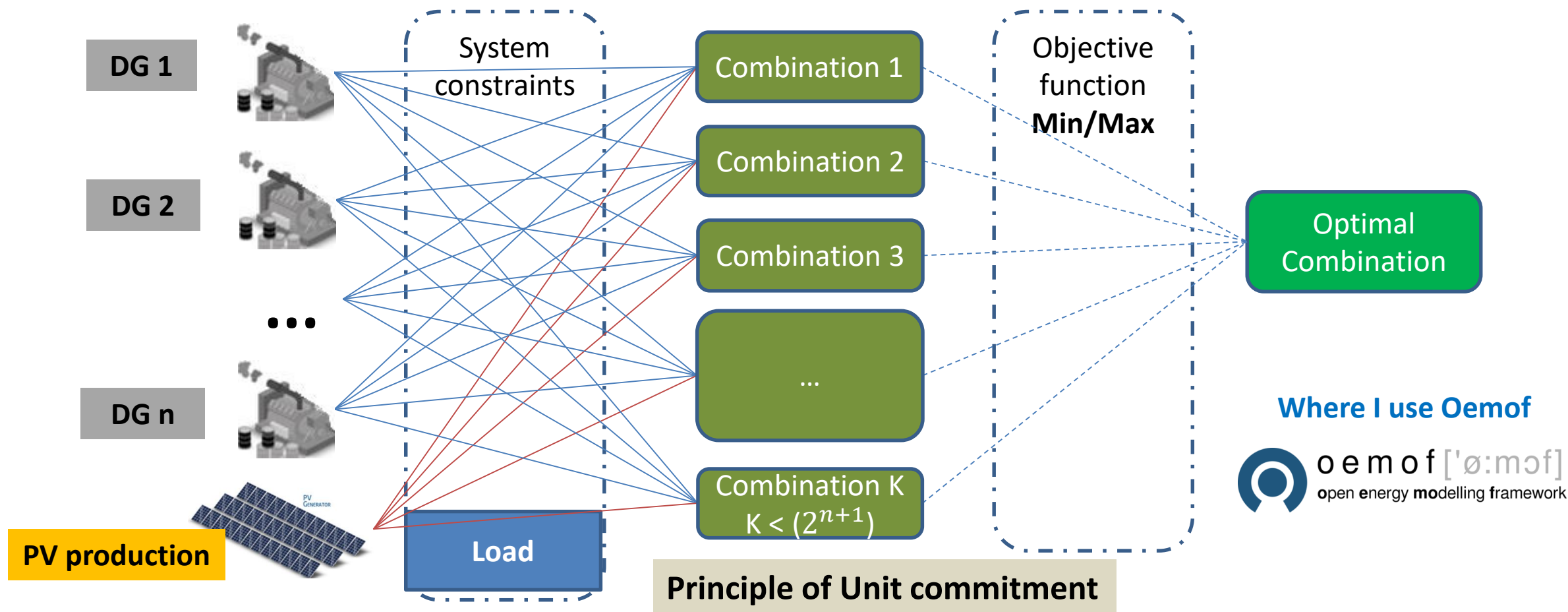
Hydroelectricity

## Drawbacks

- High investment cost,
- Raw materials needs,
- Environmental impact,
- Geographical condition requirement, (e.g. difference in height)
- ...

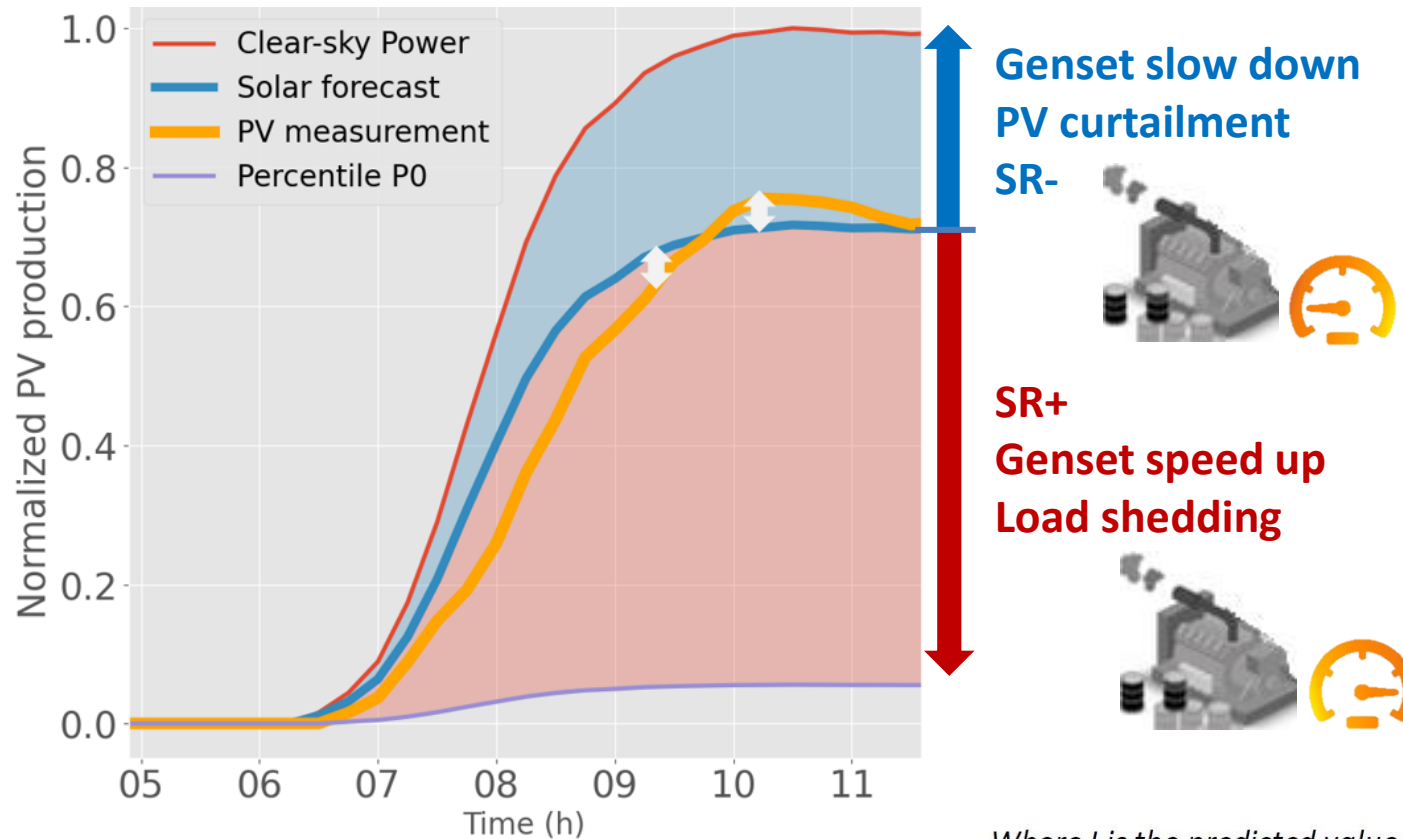
# Solutions for mitigating variability

- #2 : Dedicated designed Power Management System (PMS) with smart generators dispatching and spinning reserve sizing by using solar forecasting.



# Solutions for mitigating variability

- Using **probabilistic solar forecasting** for generators dispatching and spinning reserve sizing.



**Diesel generator  
reserved capacity**

The nominal power

Actual power  
output

SR

$$RMSE = \sqrt{\frac{1}{N} \sum_{i=1}^N (I_i - \hat{I}_i)^2}$$

Where  $I$  is the predicted value of irradiance and  $\hat{I}$  is the measured reference value.

# Cost calculation model

- What would be the best practical metrics to assess HES performance ?



- Genset cost**

☒ CAPEX – Capital Expenditure (investment cost)

☑ OPEX – Operational Expenditure

- Operation and Maintenance cost, Marginal (fuel) cost

- PV system cost**

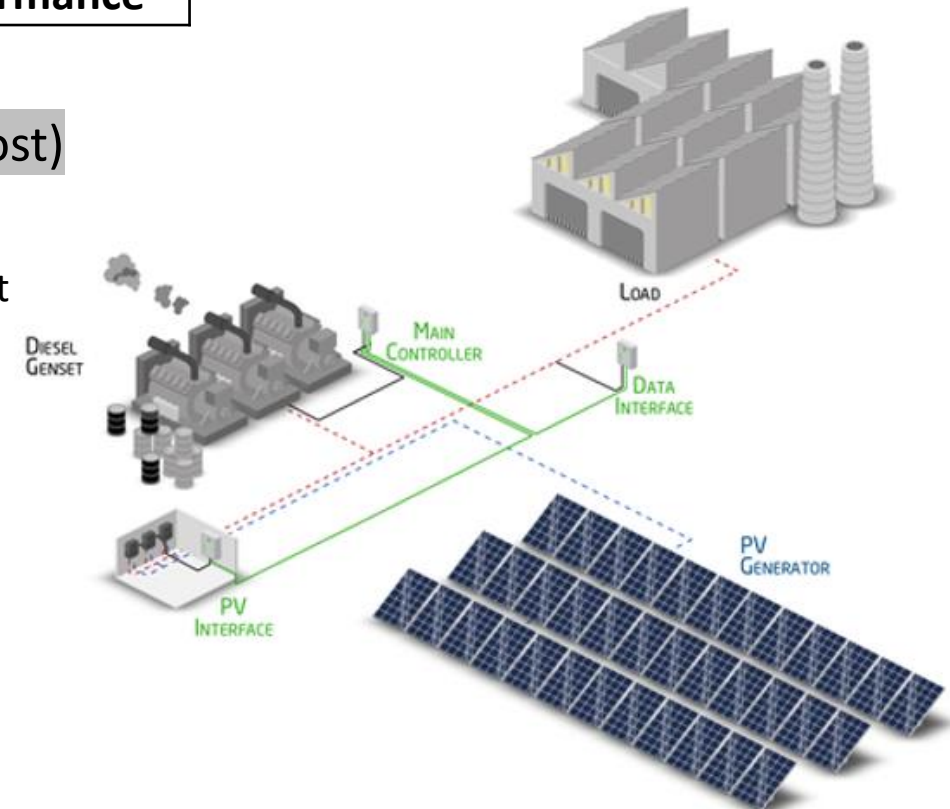
☑ Levelized cost of PV energy (*LCOE*)

- Conventional cost at 0.04\$/kWh

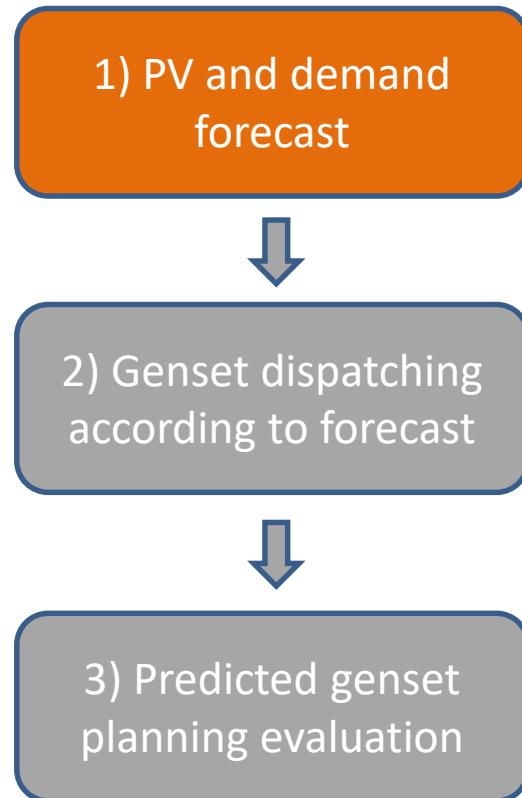
- System imbalance penalty cost**

☑ Cost of energy excess -> PV curtailment

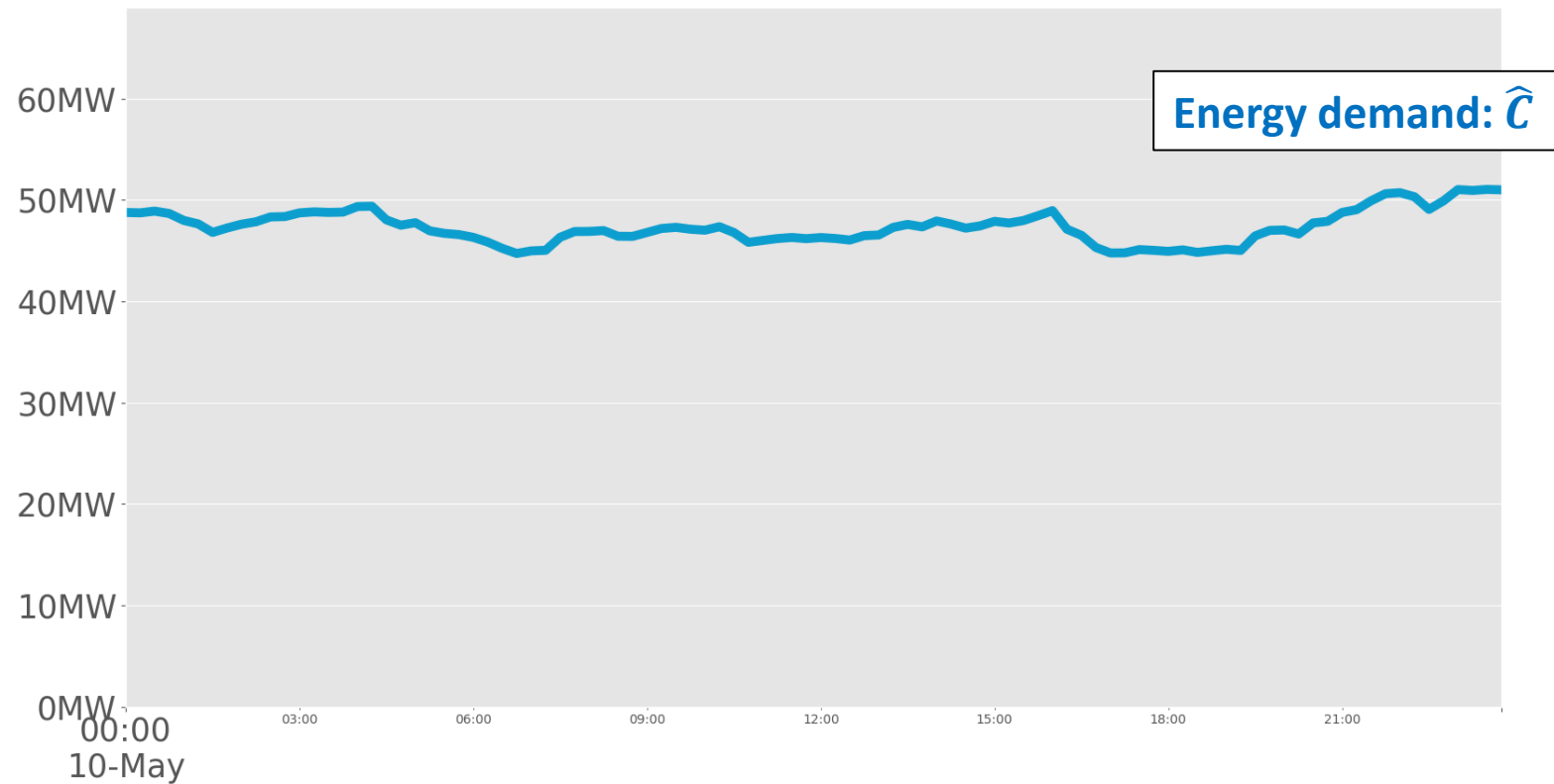
☑ Cost of energy shortage -> Load shedding



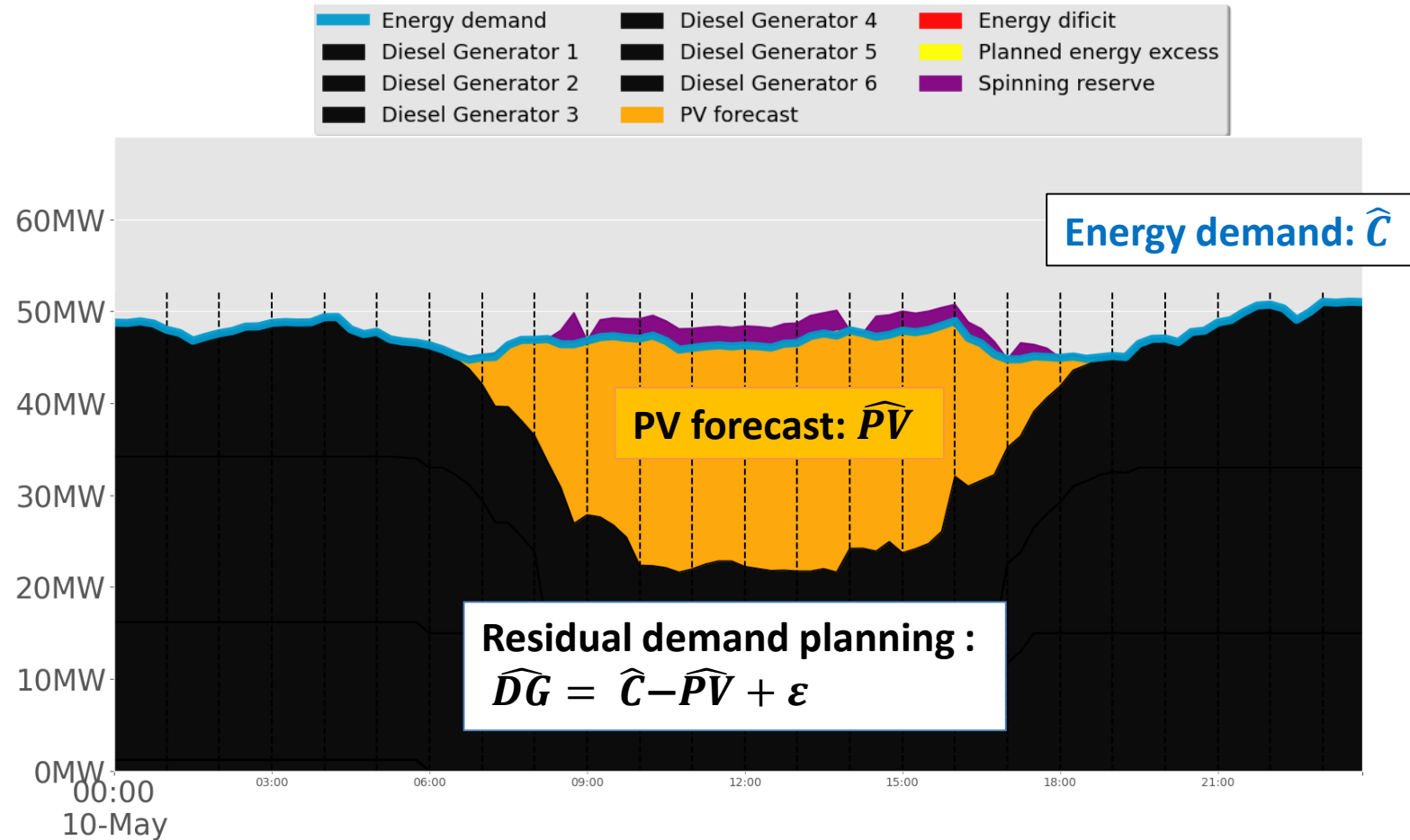
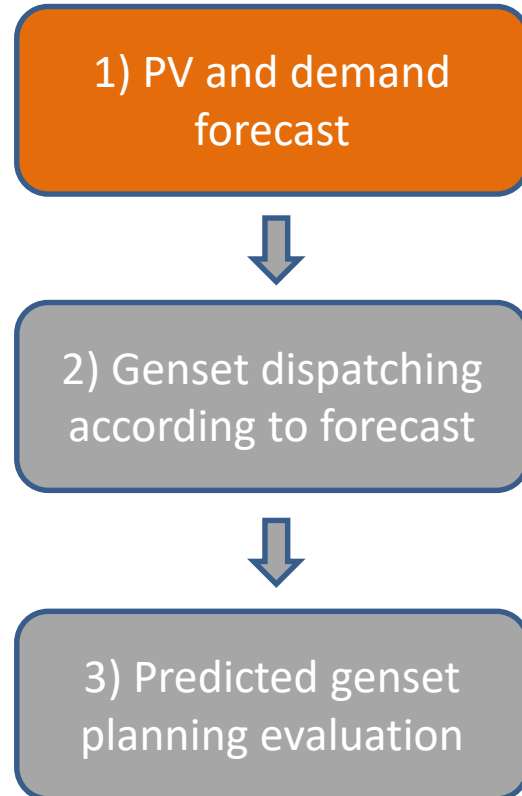
# HES simulation framework



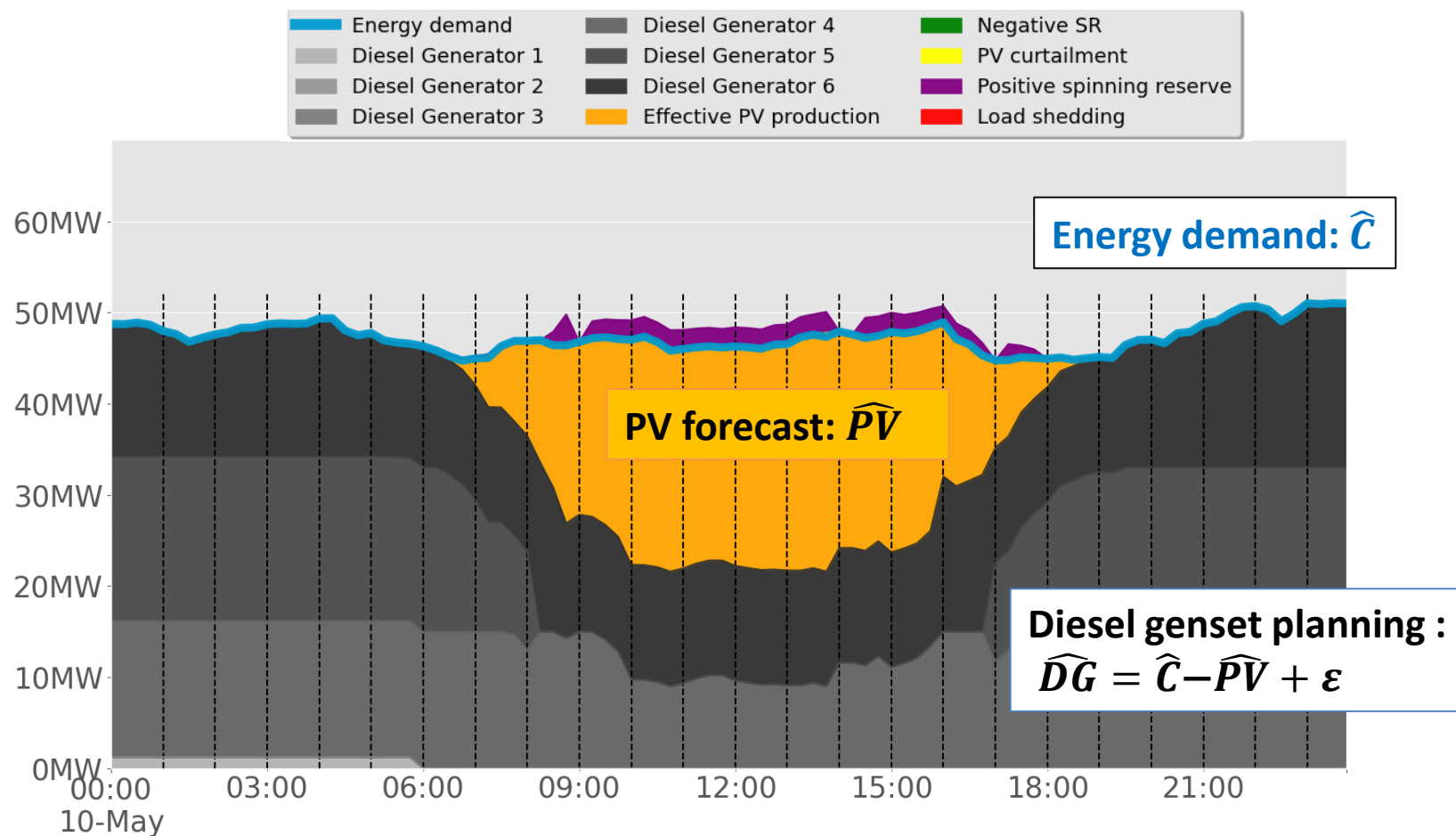
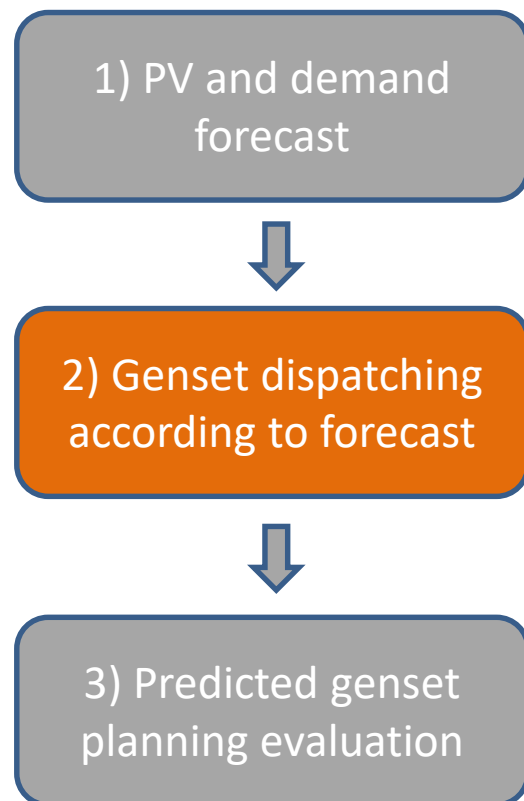
## 1) PV and residual load forecasting



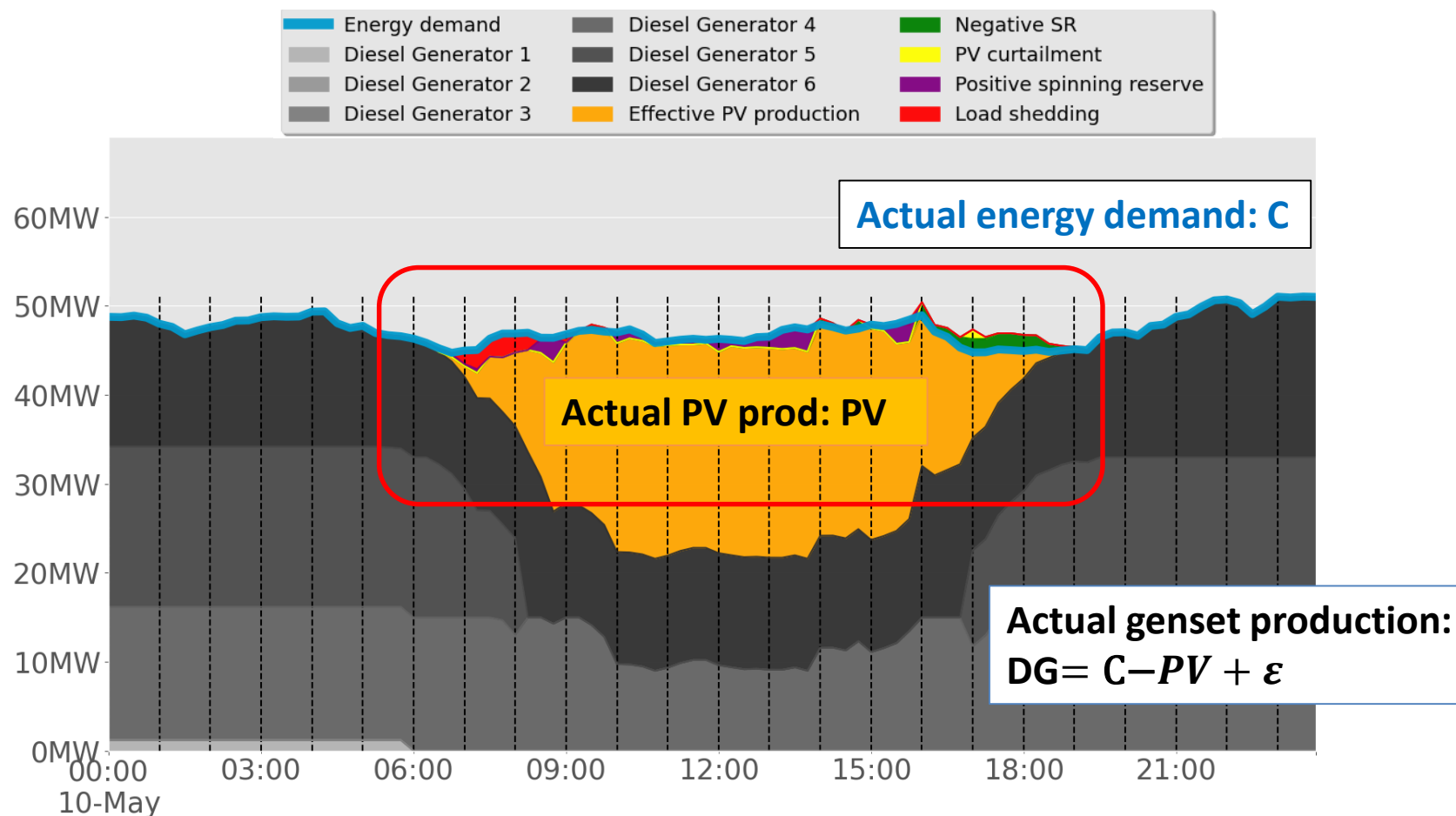
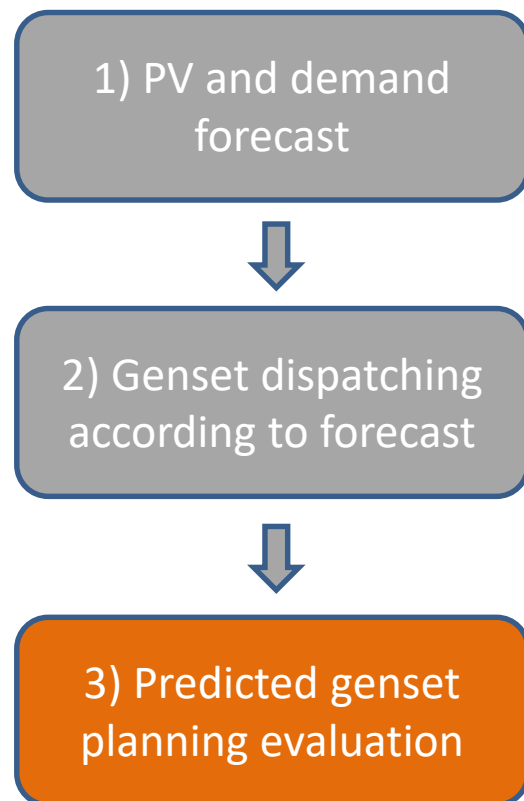
# HES simulation framework



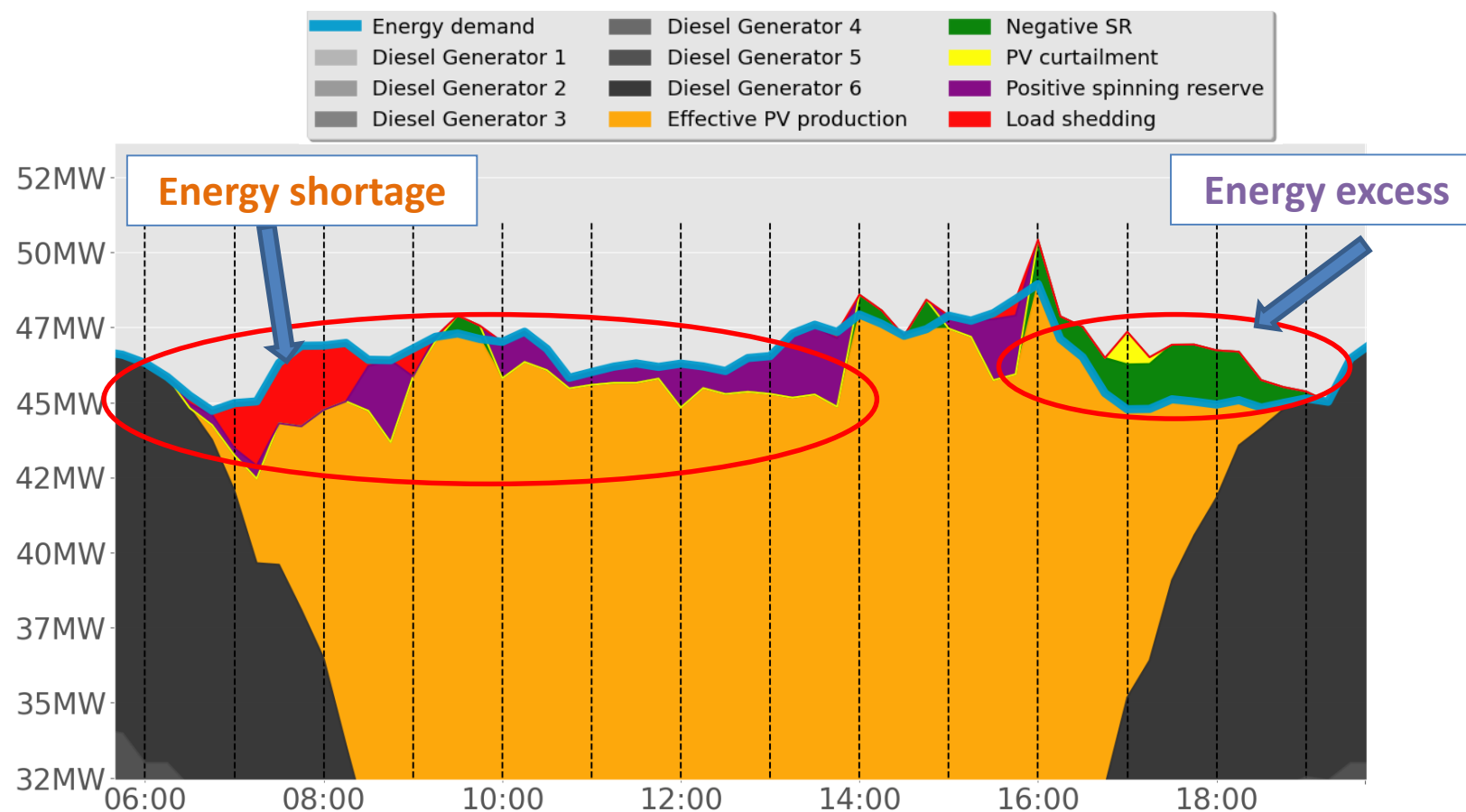
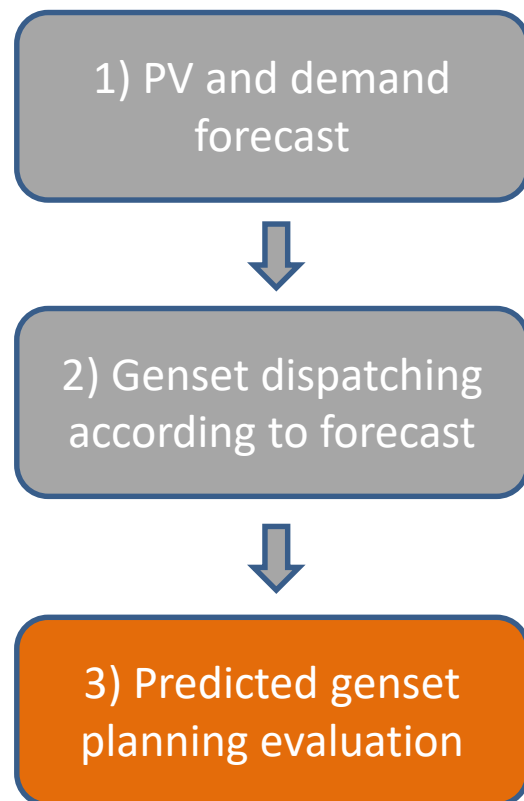
# HES simulation framework



# HES simulation framework



# HES simulation framework



# Thank you for your attention

## Any questions ?

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