5th Hybrid Power Systems Workshop

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Optimizing Cost Saving Potential of Solar Battery and Gensets Hybrid Systems for Island Grids using Advanced Hybrid Energy Allocation and Dispatch (AHEAD) Tool

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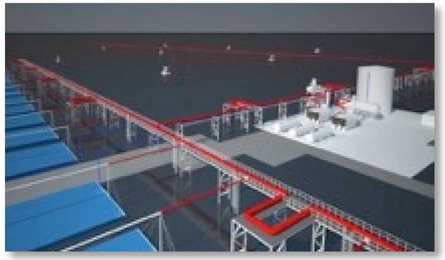
Agenda

- About Suntrace GmbH
- Motivation to develop AHEAD
- Features of AHEAD
- Case Study
- Results and Conclusions

Independent experts for renewable energy solutions

- Expertise: >7500 MW solar, > 135 projects, > 46 countries. Owner's engineer for Word's Biggest Hybrid Plant for a mine in Mali.
- Solutions for all steps of the project development chain from feasibility, project development, finance and investment to construction and operation

Technology & Engineering



- Techno-Economic Design Optimization
- Feasibility Analysis
- Hybrid Systems
- Site Specific Engineering
- Procurement
- Construction Supervision

Renewable Resource

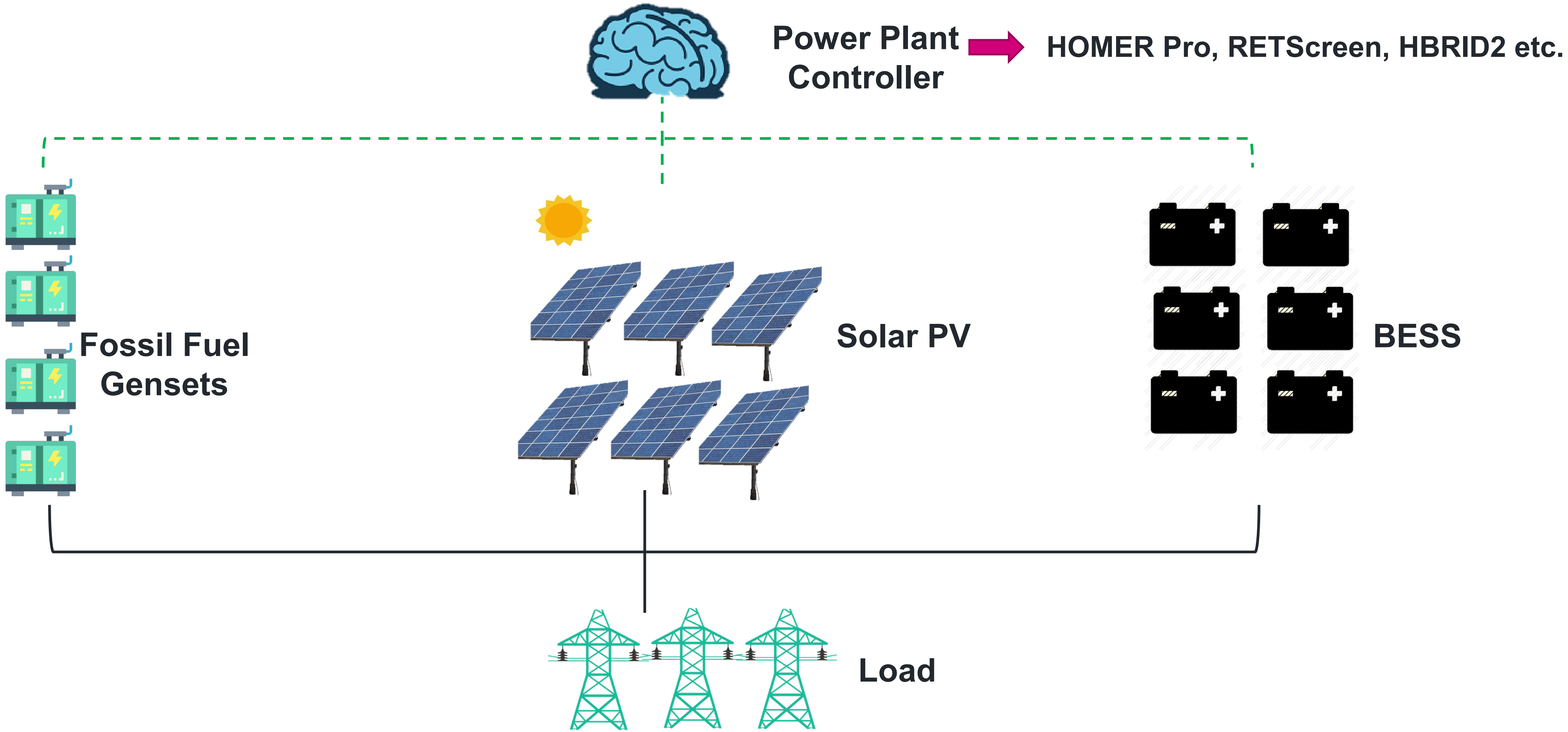
- Solar & Wind Resource Assessments
- Site Qualification with Measurements:
- Solar, Wind, geophysical conditions

Project Development & Finance

- Holistic view and technical and economic concepts
- Project development management / support
- Financial structuring and placement (equity and debt)

Suntrace Headquarters in Hamburg, Germany

Hybrid Controllers



Why a new tool?

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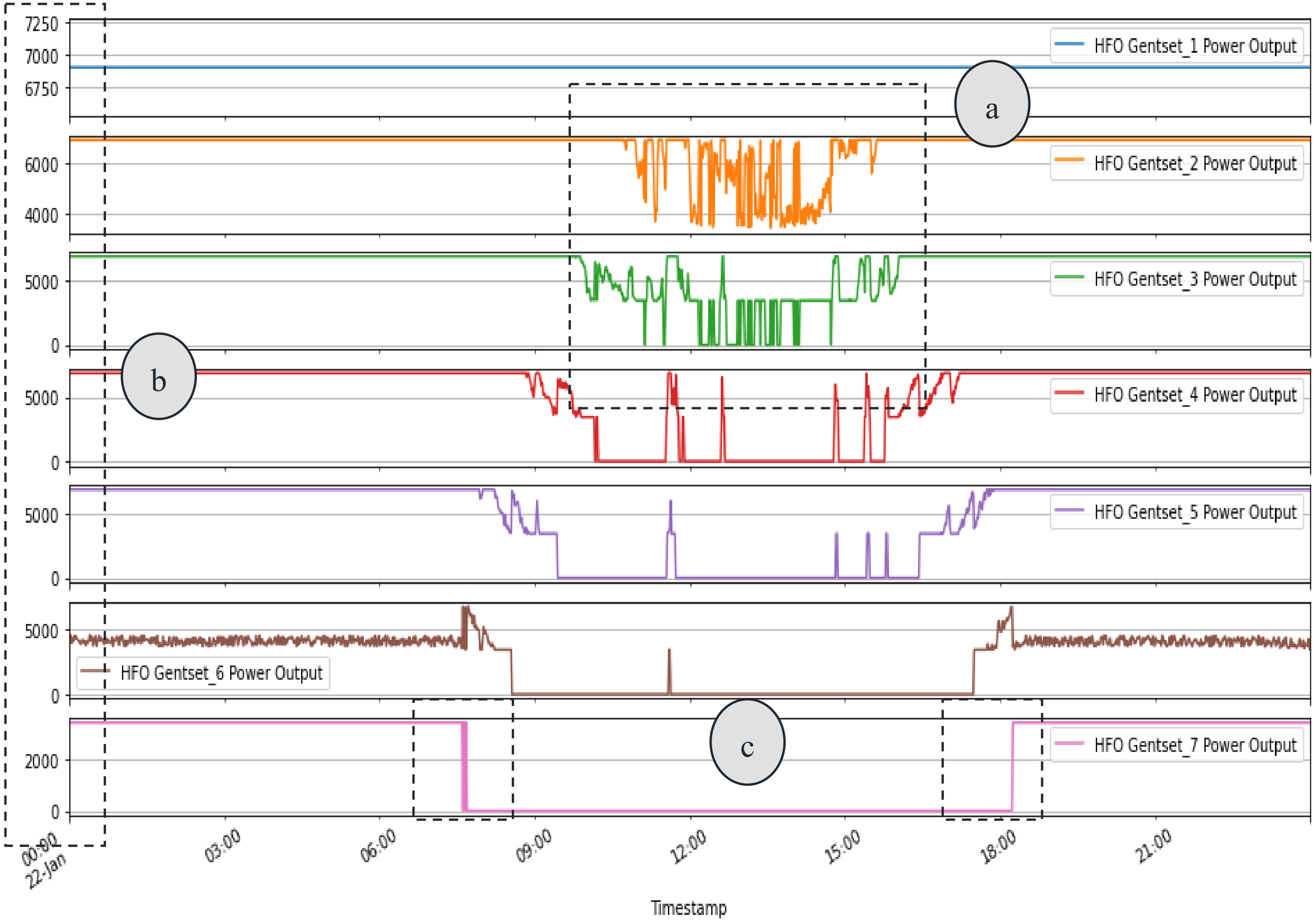
Features	Other Simulation Tools	AHEAD
• Solar PV Forecasting Control	✗	✓
• Battery operation to enable PV output forecasting	✗	✓
• Smart and equal load sharing among the running gensets	✗	✓
• Ramp up and ramp down control of gensets	✗	✓
• Visualization of real time system parameters and behavior	✗	✓
• **Open source, flexible and adaptable control strategies**	✗	✓

Basic Drawbacks Software Tools

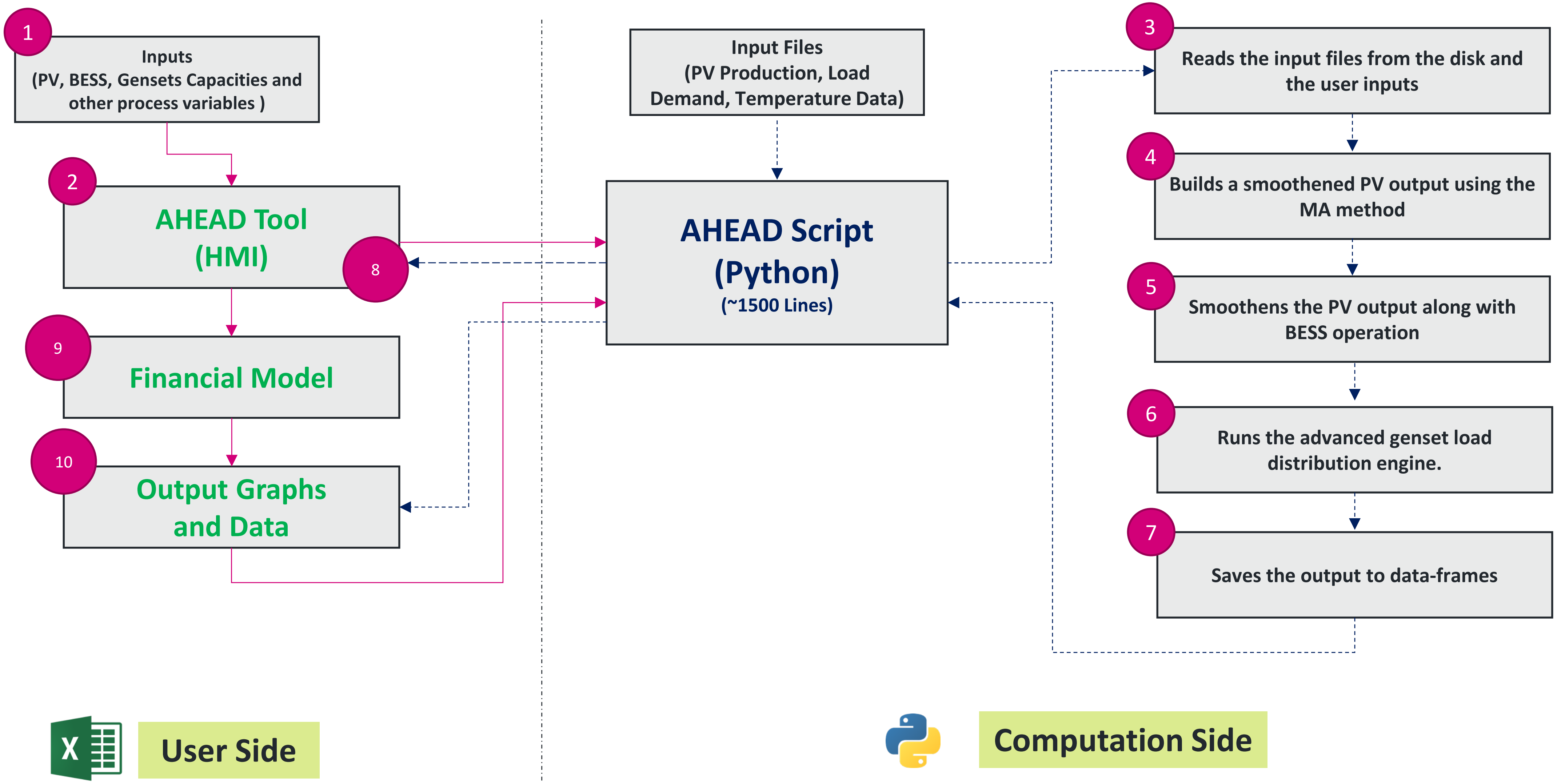
a) Fluctuations in the genset production due to no PV output smoothing.

b) No equal load distribution on the gensets

c) Ramp Up and Ramp Down of gensets

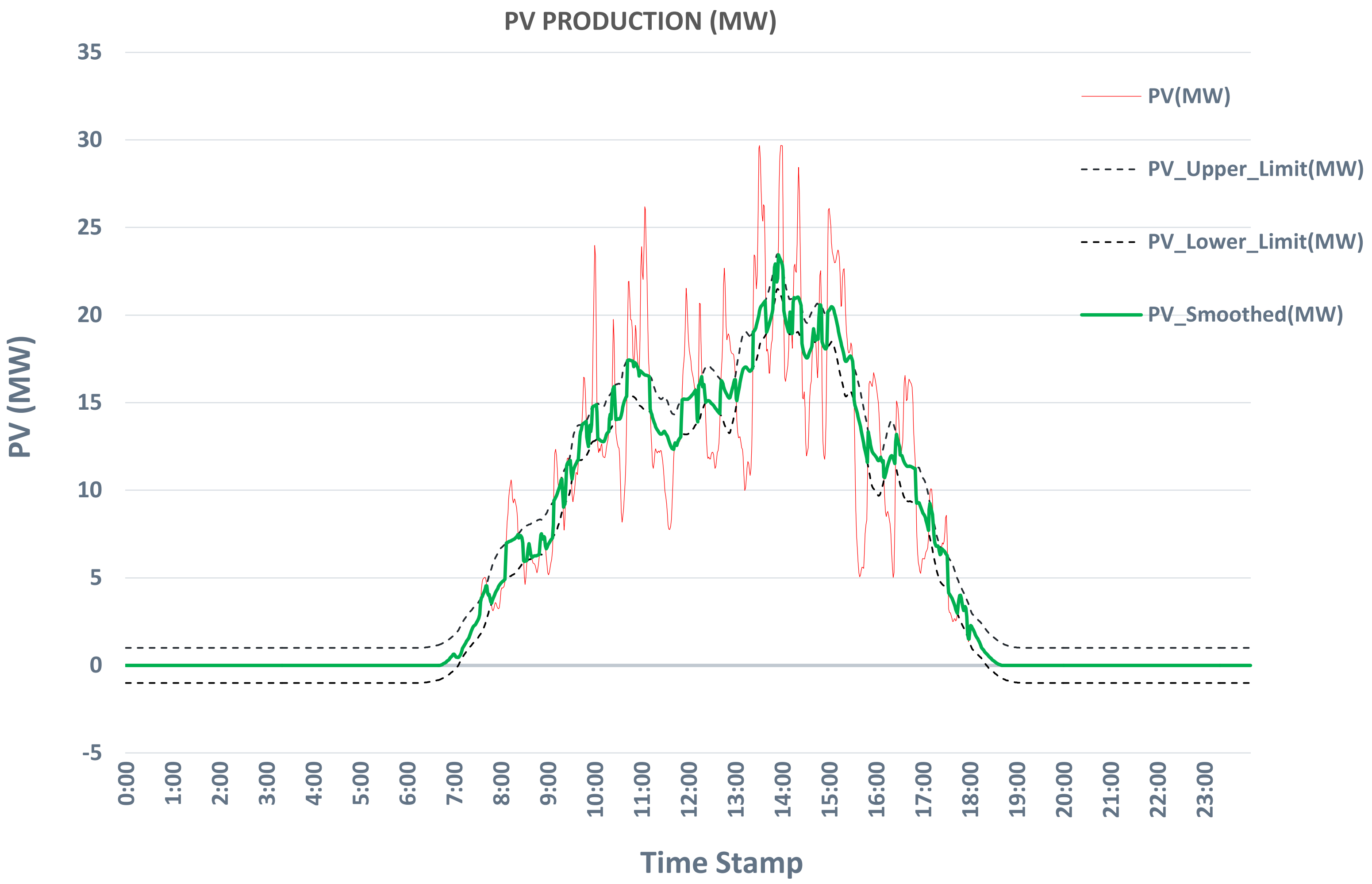


Basic Architecture of AHEAD



1. PV Smoothing Strategy

1. Takes the input of the forecasting window (w) from the user (30min)
2. Builds a rolling **moving average** of the window size (+w and –w PV signals)
3. Upper Limit (UL) and Lower Limit(LL) based on the genset ramp rate capabilities (±1MW)
4. Allows the PV signal to fluctuate only in this UL and LL.



2. BESS Operation to Assist PV Smoothing

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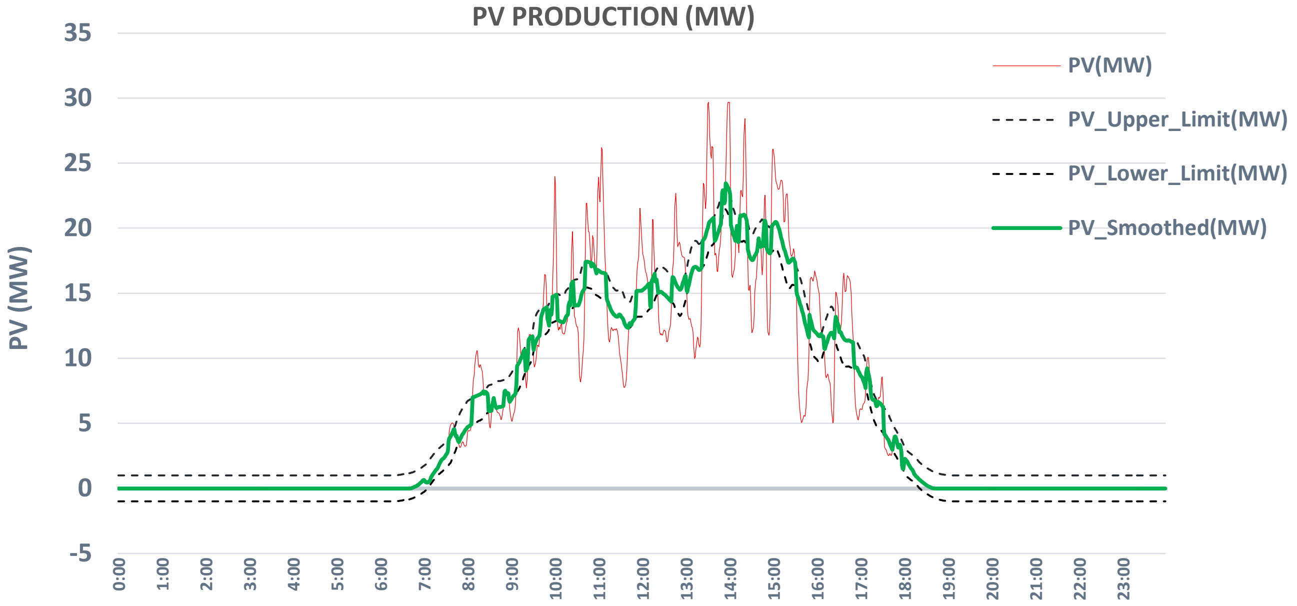
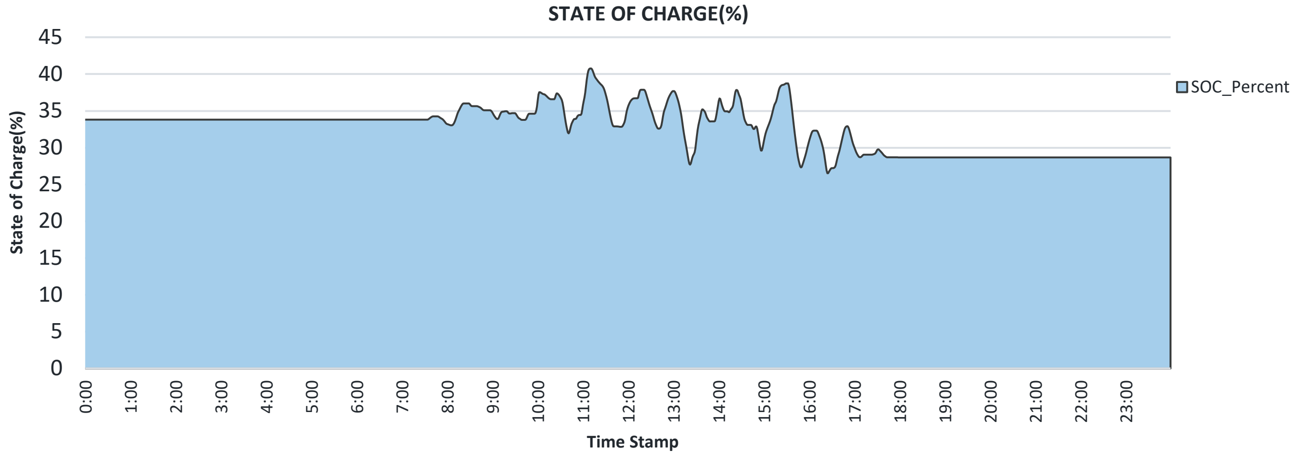
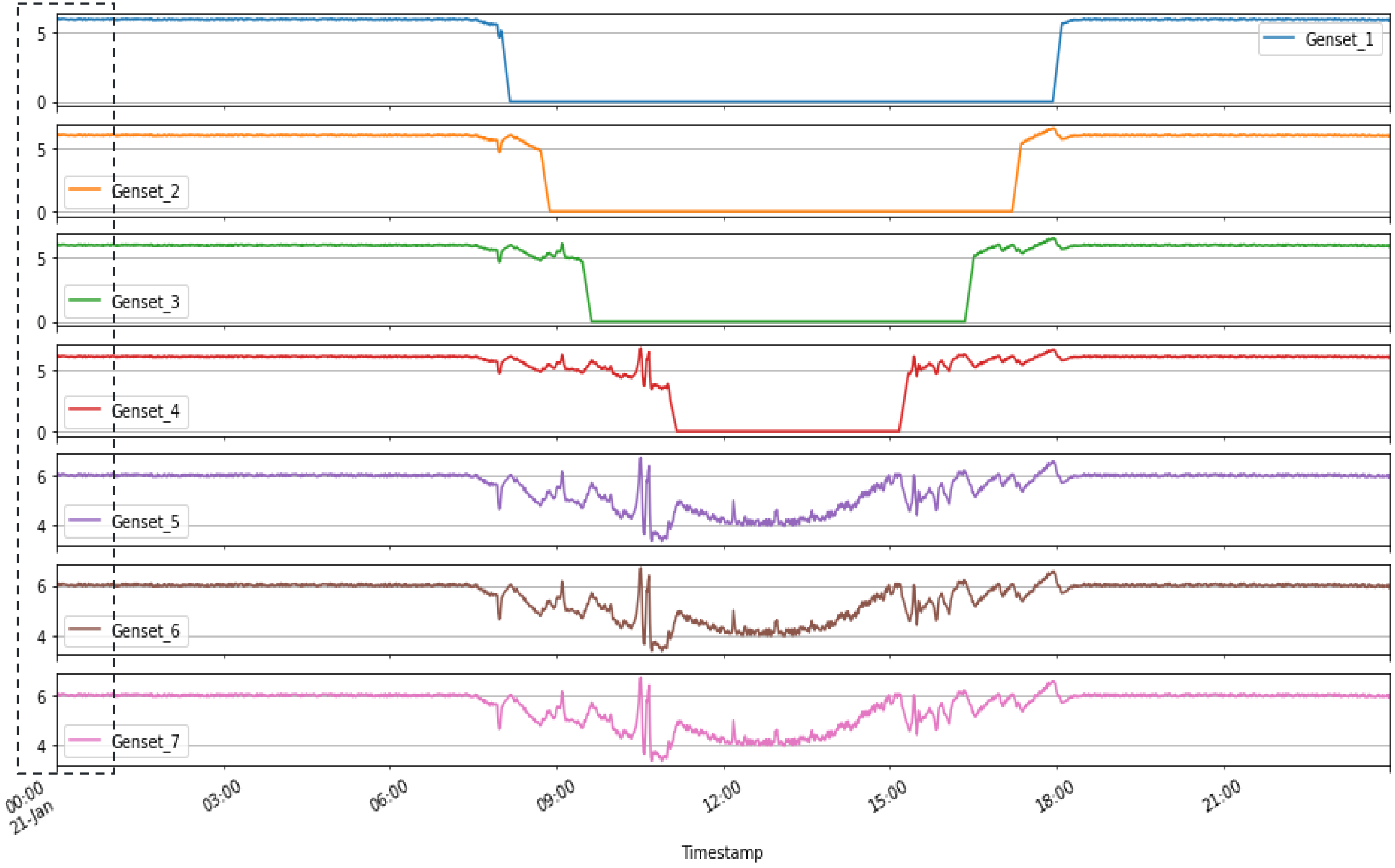
1. BESS Parameters (power, energy, min SoC, max SoC, Losses, Initial SoC) from user.
2. Battery charged when PV > UL and discharged when PV < LL.
3. The maximum charging and discharging power and energy discharged ≤ BESS power and energy, respectively.
4. The SoC does not go below the min. SoC and above the max. SoC.





3. Equal Load Sharing over Gensets

- All gensets share equal load.
- Load drop is uniform among the gensets

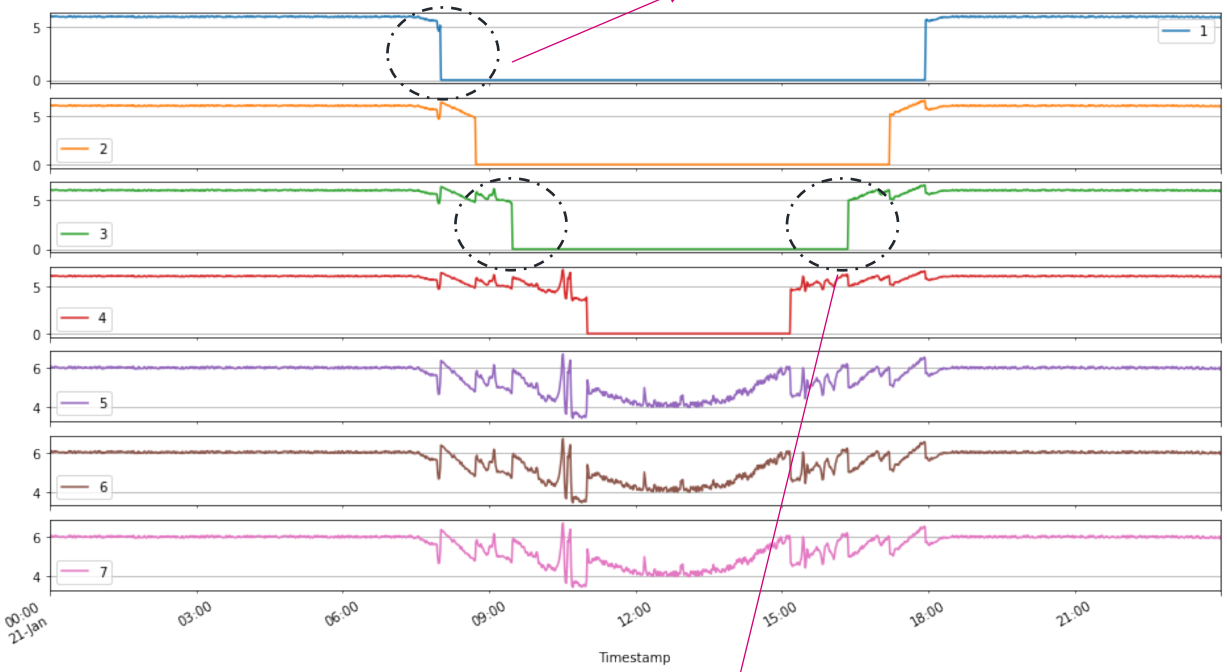


4. Ramp UP and Ramp DOWN Functionality

1. Gensets take some time to switch ON and OFF and cannot be abruptly switched ON and off.
2. Ramp UP and Ramp DOWN time of 10min considered for ideal operation

HOMER Pro

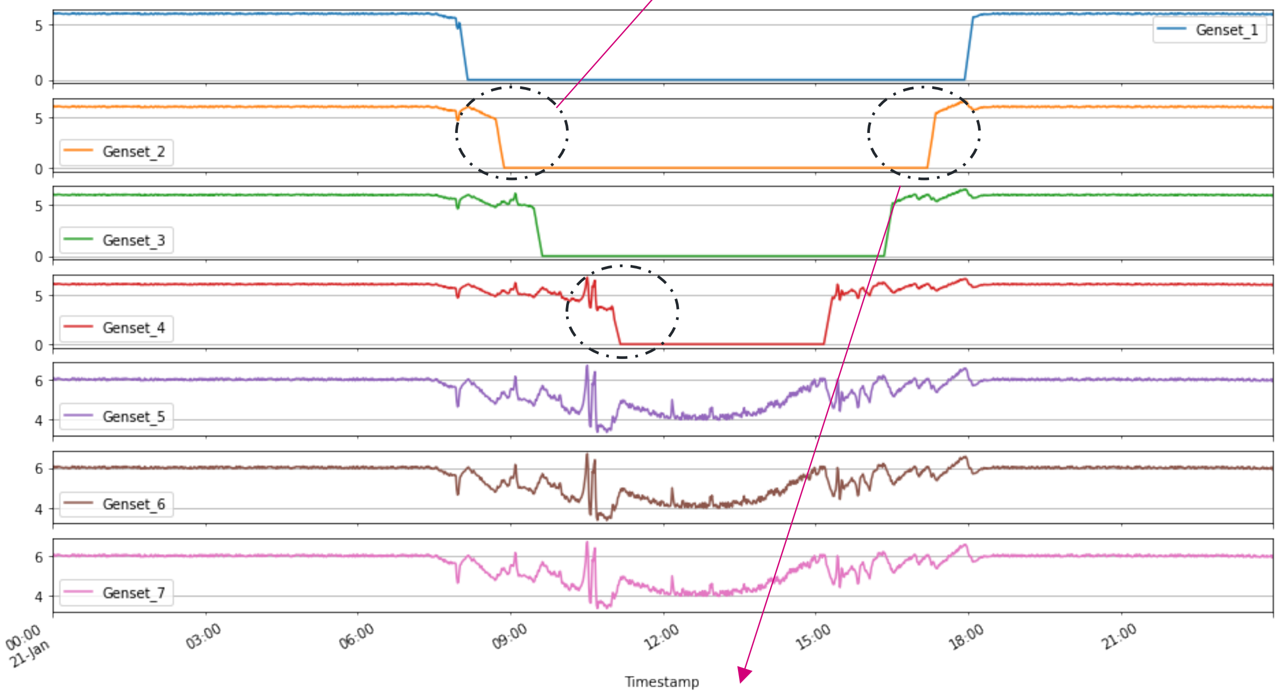
Gensets switch OFF directly. **NOT IDEAL**



Gensets switch ON directly. **NOT IDEAL**

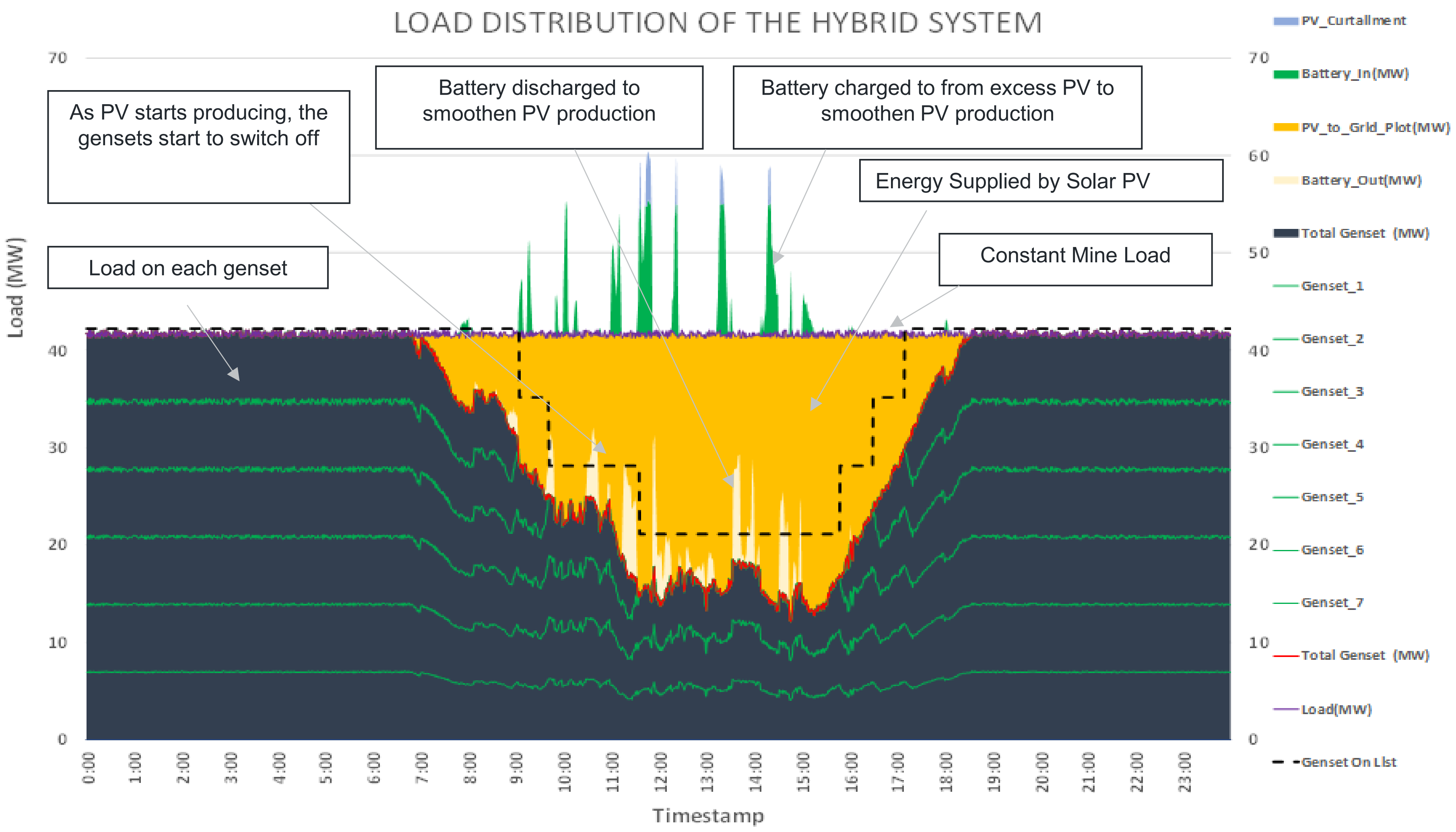
AHEAD

Gensets Fade OFF over a span of time (10min). **MORE REALISTIC**



Gensets Fade ON over a span of time (10min) **MORE REALISTIC**

5. System Overview Visualization



Verification of AHEAD

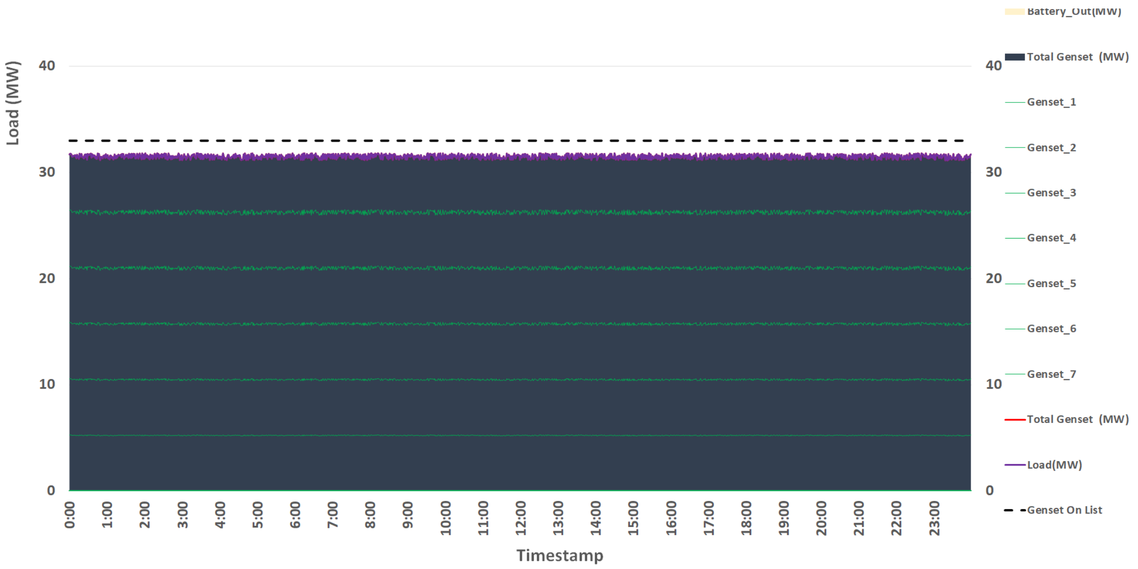
Two types of verifications done:

- **Visual Verification**: To check if all the designed feartures are working perfectly or not
- **Performance Data Verification**: Same configuration modelled in HOMER and results were compared.

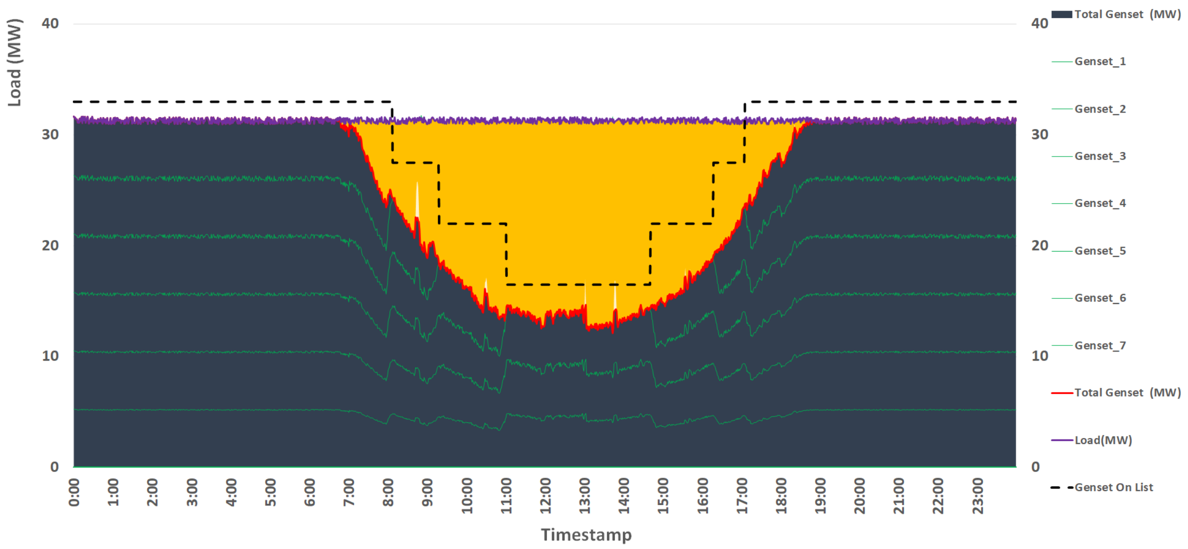
Configuration	Size	Unit
Average Daily Mine Load	32	MW
Solar system size	20	MW_{ac}
Solar system size	25	MW_p
Battery Power Capacity	12.5	MW
Battery Energy Capacity	9.6	MWh
No. HFO Gensets	7	-
Genset Nameplate Power	5.5	MW

Visual Verification

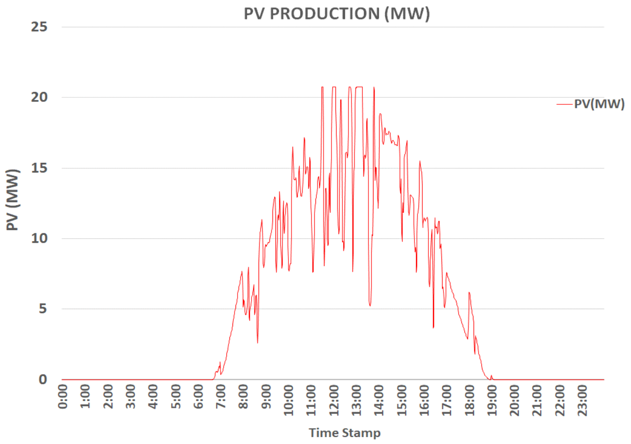
a) Reference Case (w/o Solar PV and Battery)



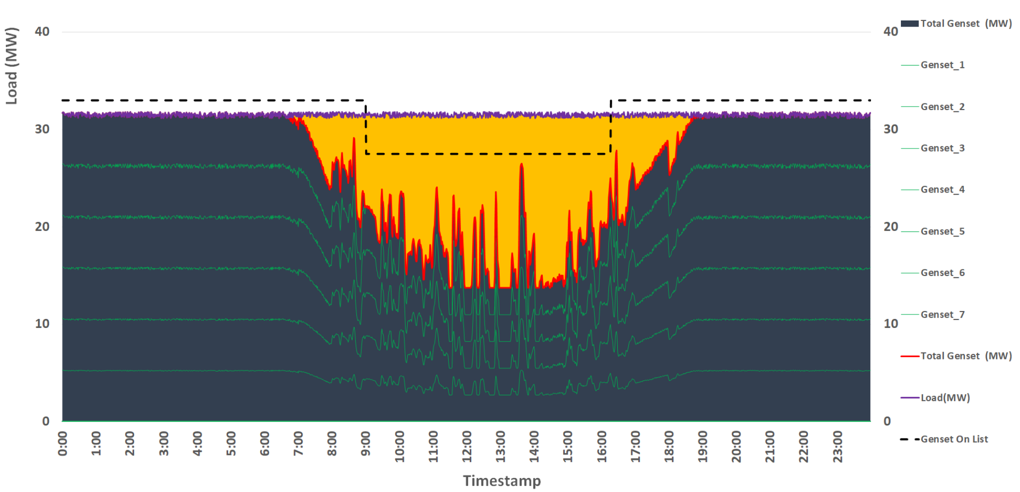
b) Hybrid Case – Clear Sky Day



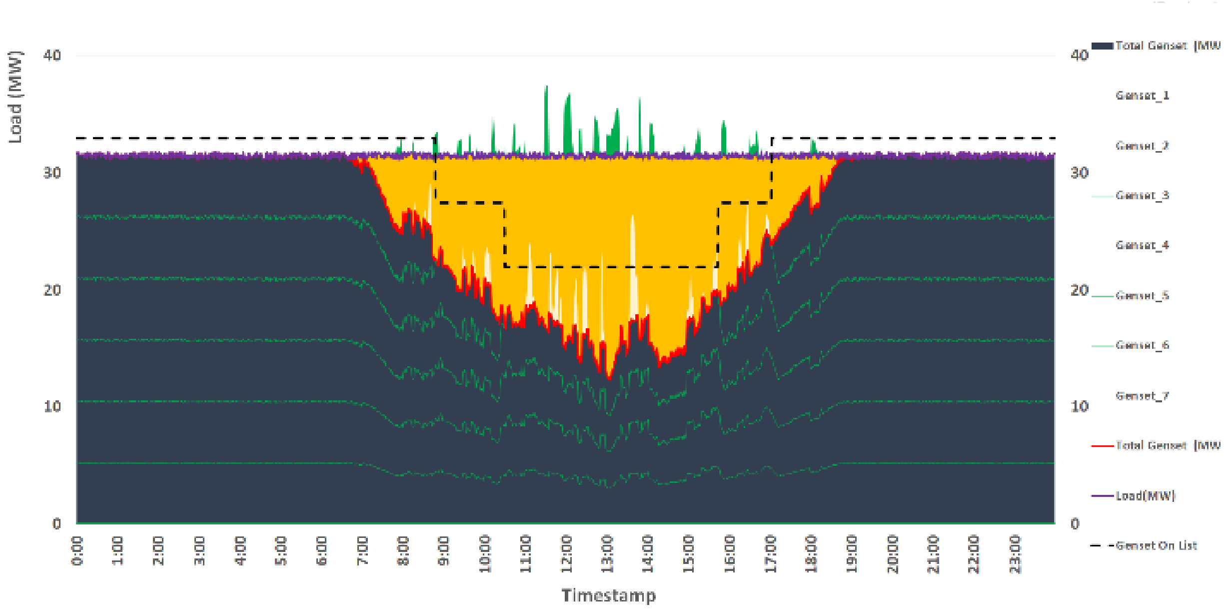
Visual Verification



c) Hybrid Case – Cloudy Day w/o Battery



c) Hybrid Case – Cloudy Day w. Battery



- All the PV fluctutaions of PV are absoved by battery
- One extra genset can be switched OFF saving extra fuel.

Performance Data Verification

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- Same system was modelled in HOMER
- The resutls were found not to deviate from the HOMER

Parameter	Variation of Results from AHEAD Tool compared to HOMER Pro
Total Energy Consumption	< 0.1%
Total Solar Energy	< 0.1%
Genset Production	-0.1%
HFO Fuel Consumption	0.4%
Total Genset Running Hours	1.2%
Average Genset Efficiency	1.0%
Genset Average Loading	-5.2%
Renewable Energy Share	1.1%
LCOE	-1.9%

Case Study

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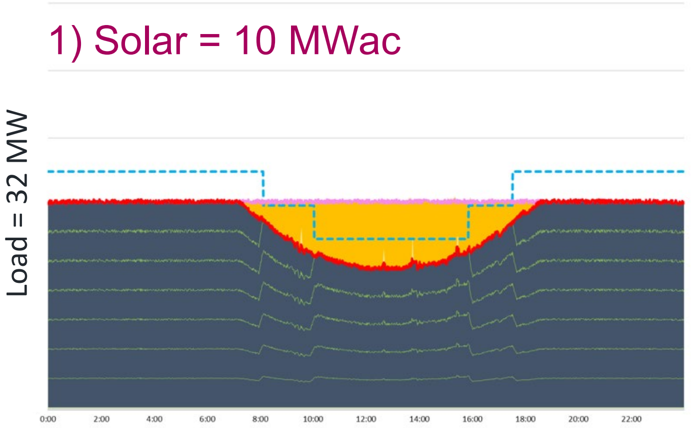
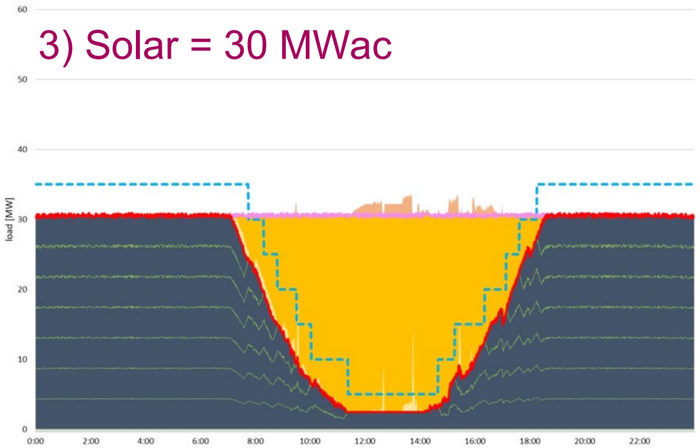
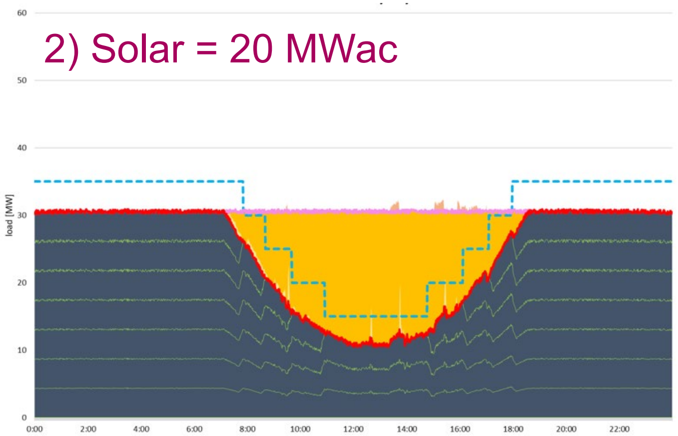
Objectives

- Assess the electricity cost reduction potential of off-grid mining operations for
  - HFO fuelled power generation combined with solar PV and battery storage
  - High renewable energy share scenarios
  - Expected future price development







<u>Main Assumptions</u>

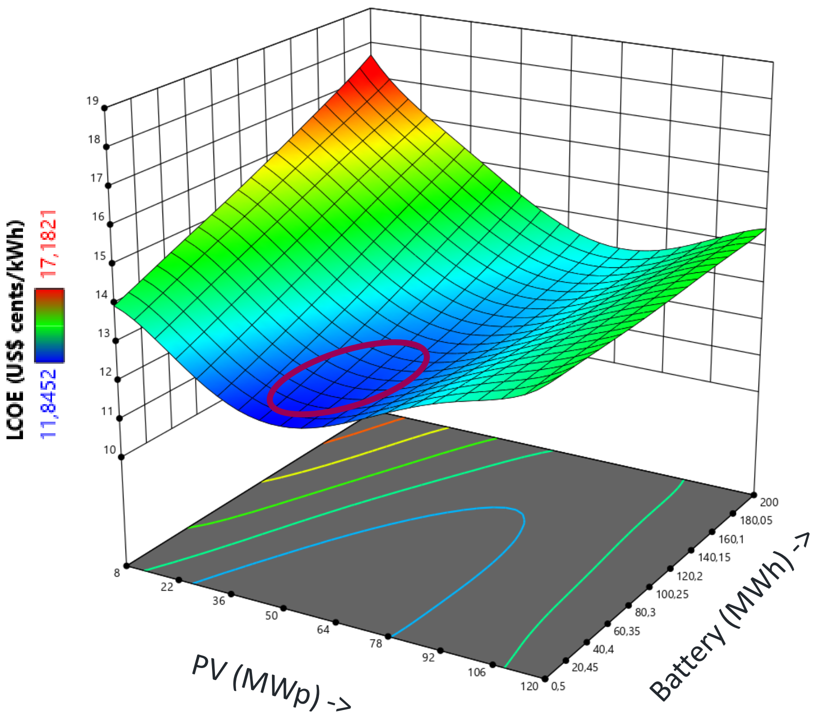
- Load demand 32 MW, 7 HFO gensets of 5.5 MW each
- Life of mine 10 years, mine availability 93%
- HFO fuel price 0.64 US$ / l
- OPEX cost escalation 2.5% / interest 5%
- On balance project implementation
- Location: West Africa
- Annual Solar irradiation 2155 kWh/m^2 (GHI, P50)
- 2095 kWh/kWp/year for a single axis tracker system
- Key Performance Indicator: LCOE, RE-share
- Solar 720 US$ / kWp + Owner Cost (+ electrical heating)
- Battery 440 US$ / kWh (1C, rated), cost curve considered

Case Study

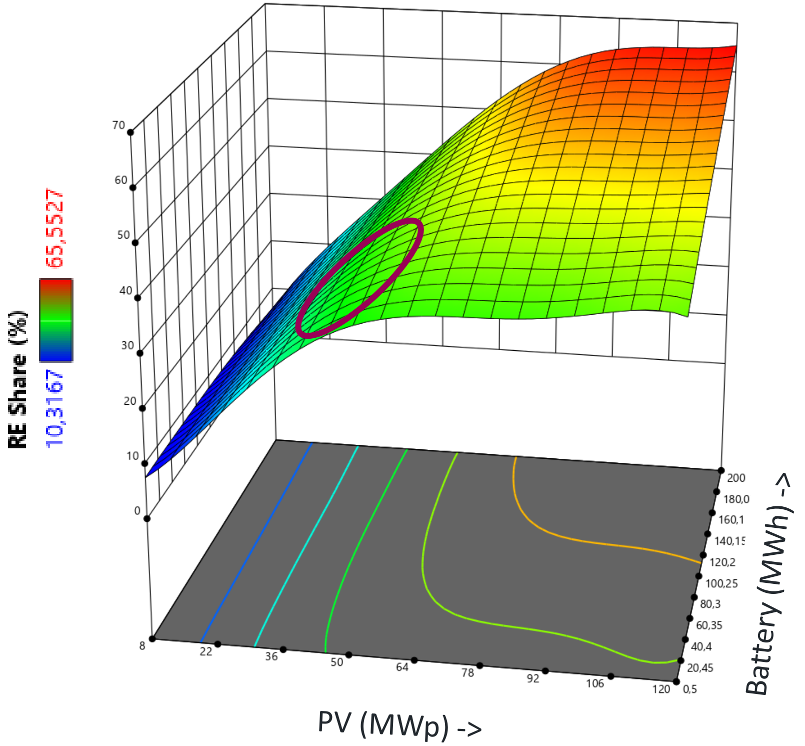
Results

- Optimal solar and battery capacity range
  - Solar 35-65 MWp
  - Solar / Load = 1-1.7
  - Battery 20-60 MWh / 30 MW
  - Battery full load = 0.7-2 hrs
- Main cost reduction drivers
  1. Solar power directly substitutes HFO in the system
  2. Increased solar capacity allows for utilizing more cheap solar power also during cloudy days
  3. Excess energy used to charge the battery during clear sky days for load shifting towards evening hours

LCOE < 12 $ cents / kWh



RE-Share 30% – 40%



Case Study - Solar-Battery Cost Variation

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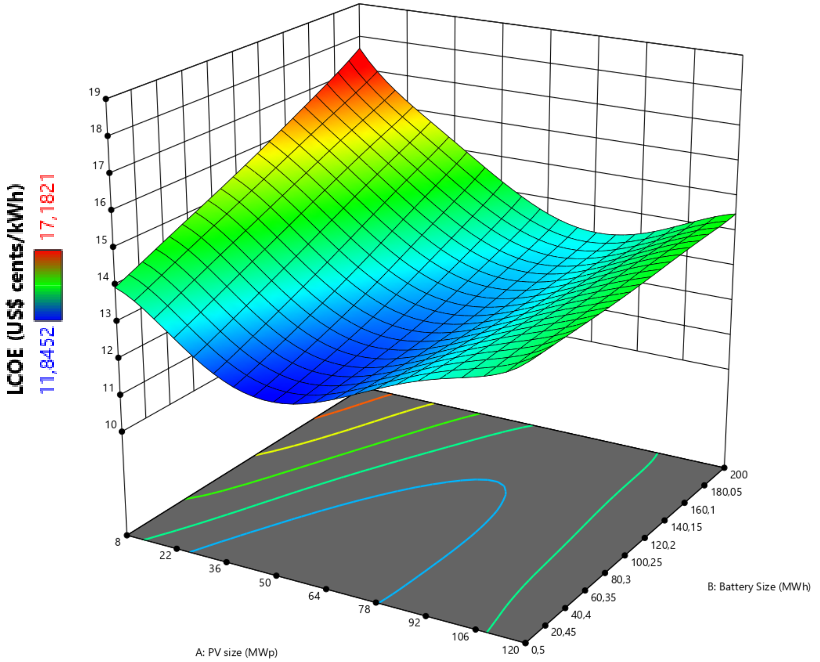
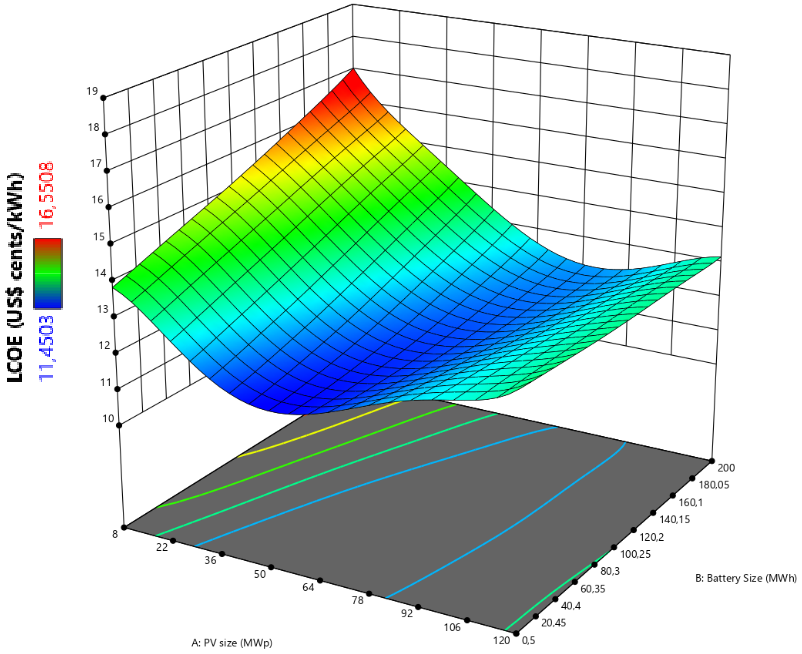
Base Case



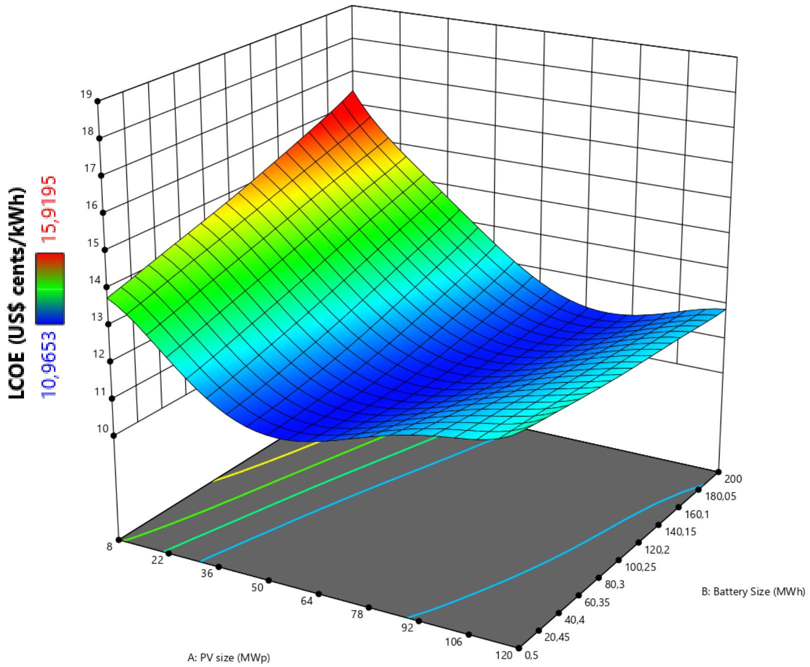
-15% Cost

LCOE < 11.5 $ cents / kWh
RE-Share > 40%



-30% Cost

LCOE < 11 $ cents / kWh
RE-Share > 50%



Optimal Range Moves Towards Larger Solar and Battery Plant Capacity and higher RE-Shares

Conclusions

- Modular tool developed with more realistic dispatch of the gensets
- Solar forecasting and battery enabled solar PV smoothing is be integrated.
- Battery storage can reduce the need of operating reserve from the gensets and enables reliable system operation for high solar power penetration
- Solar power forecasting is vital for efficient generator dispatch planning to maximize fuel savings
- Large Solar-Battery Plant capacities leading to significant renewable energy shares of 30% to 40% are economically viable at today’s cost
- Near to mid-term future price expectations allow reaching even higher shares and further increase fuel savings
- Combination with other renewable energy resources such as wind should be considered when analysing a specific project location
- The optimal solution for each project needs to be assessed on a case-by-case basis

What can we do for you?

Let‘s keep in touch

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