# Comparing Models and Actual Performance for PV/Diesel Minigrids in Northern Australia

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# Contextual Background

- SE4ALL – MGs identified as a High Impact Opportunity (HIO)
- MGs for energy Access up to 40% of new energy access 2010 to 2030
- “undervalued”, cost comparisons to SHS are misrepresentative and detrimental to quality > “Surplus” vs. “Subsistence” power

# Problem Statement

- Renewable Energy is no longer a new technology but still considered risky – Inherent due to high capital cost, and payback contingent on long term operation – Hybridisation also has different risks involved
- Deployment has been slower then predicted, few examples of large scale programmatic development
- Hybrid modelling literature is prolific, there’s a shortage of operational experience that can be used to verify the models and guide decision making.
- Poor performance could result in a backlash and localised market spoilage such as what has been observed in SHS where quality was poor.
- What can be done to better understand and manage risk in these projects?

# Broader Research

The aim of the research project is to:

1. Investigate the operational experience and risk proposition of Photovoltaic/Diesel Mini-grid systems in the Asia Pacific region

2. Recommend ways to mitigate risk and better manage uncertainty in both the ongoing operations of existing programs and expected future project development.

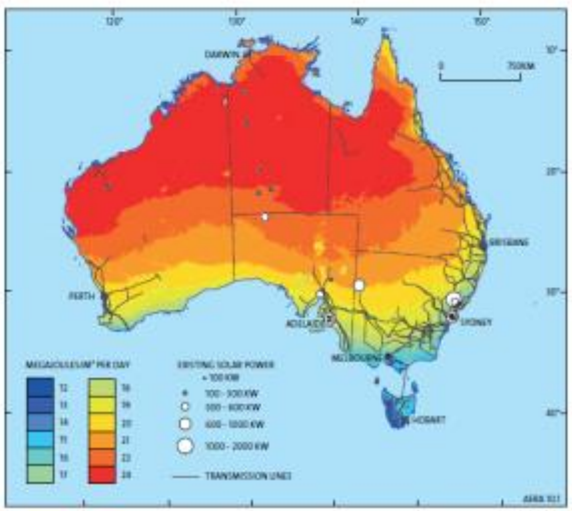
Broad Research Question

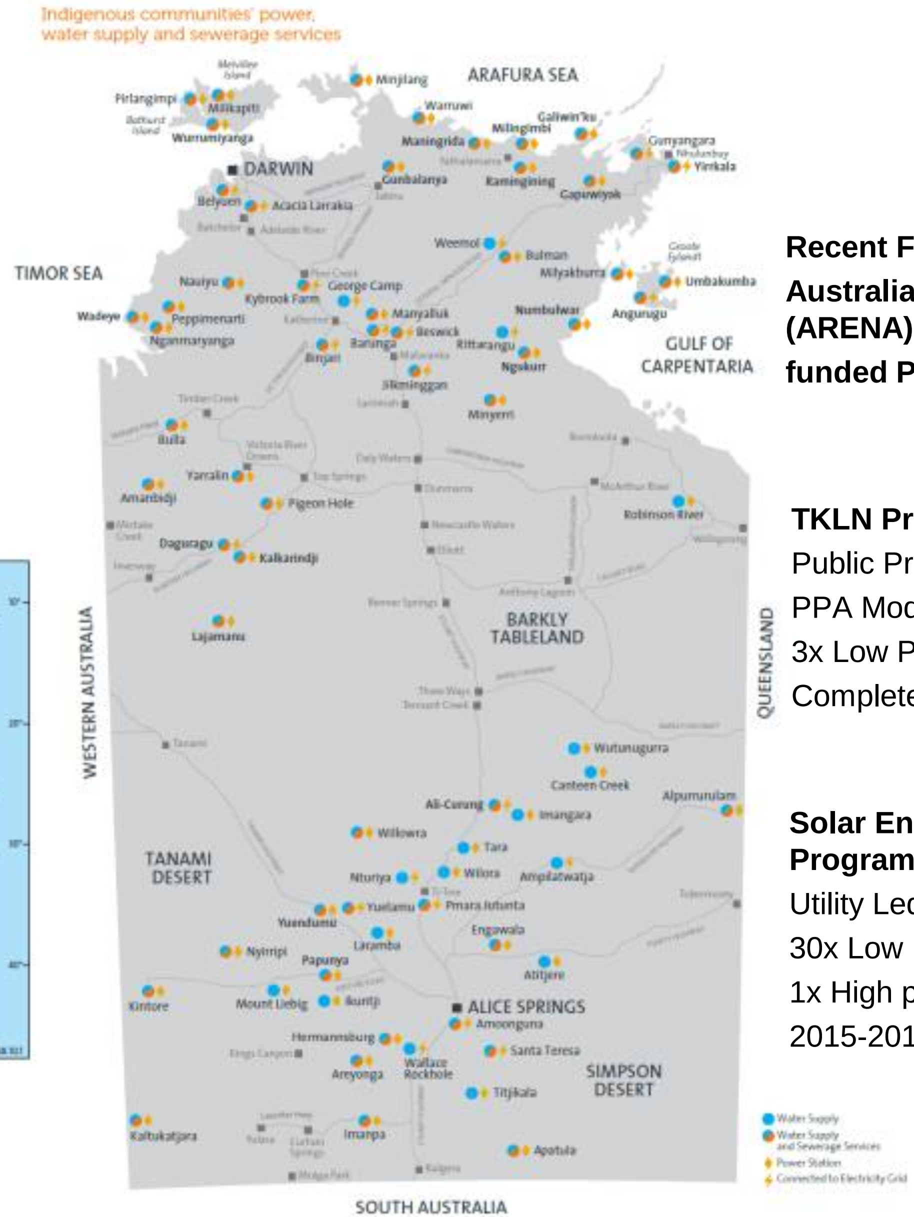
“How can we better model and manage the risks involved in PV mini-grid deployment in the Asia-Pacific?”

# Northern Territory, Australia

- Australia's 3rd largest State by land area, yet least populous.
- Power and Water Corporation acts as the State utility provider.
- Under their Not-for-Profit subsidiary, Indigenous Energy Services Pty Ltd (IES), they provide services to over 38,000 people living outside of population centres.
- IES own, operate and maintain 52 isolated electrical mini- grids (combined generation capacity of 76MW).
- Fuel mix historically 88% Diesel (2009)


Image Source: PWC, Wikimedia Commons




**Recent Federal Government**

**Australian Renewable Energy Agency (ARENA)**

**funded Projects:**

**TKLN Projects**

Public Private Partnership

PPA Model

3x Low Penetration PV Integrations

Completed 2013

**Solar Energy Transformation Program (SETuP)**

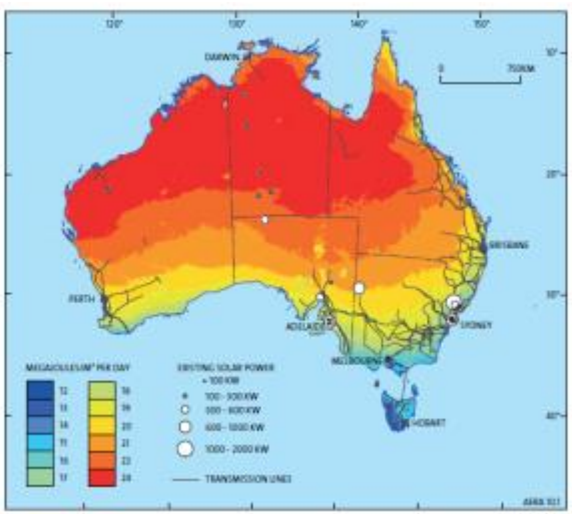
Utility Led

30x Low Penetration PV Integrations

1x High penetration PV Integrations

2015-2017

**Source: PWC Annual Report (2014)/Solar-Diesel Handbook (2013)**




**TKLN Projects**

Public Private Partnership

PPA Model

3x Low Penetration PV Integrations

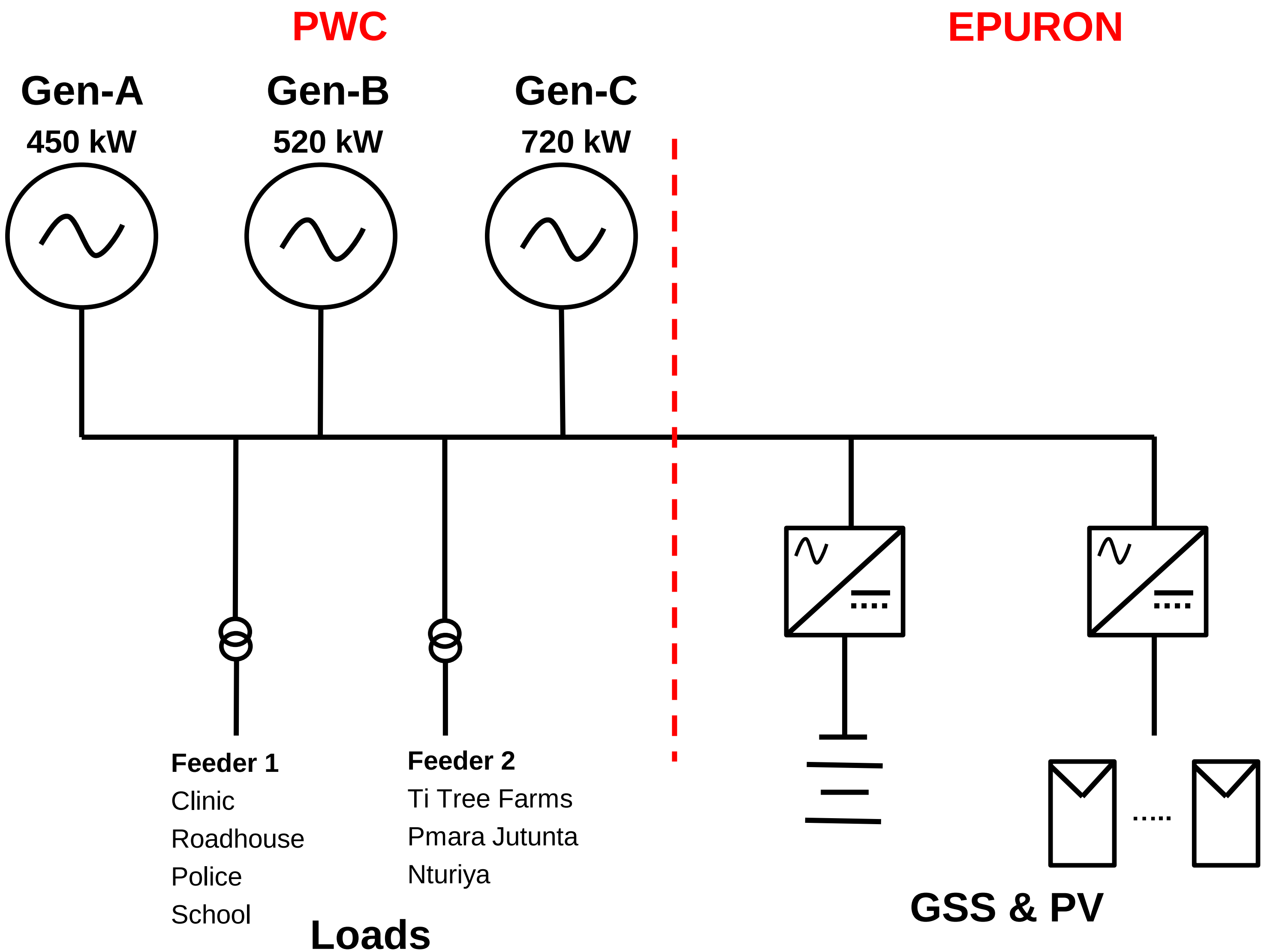
Completed 2013

**Source: PWC Annual Report (2014)/Solar-Diesel Handbook (2013)**

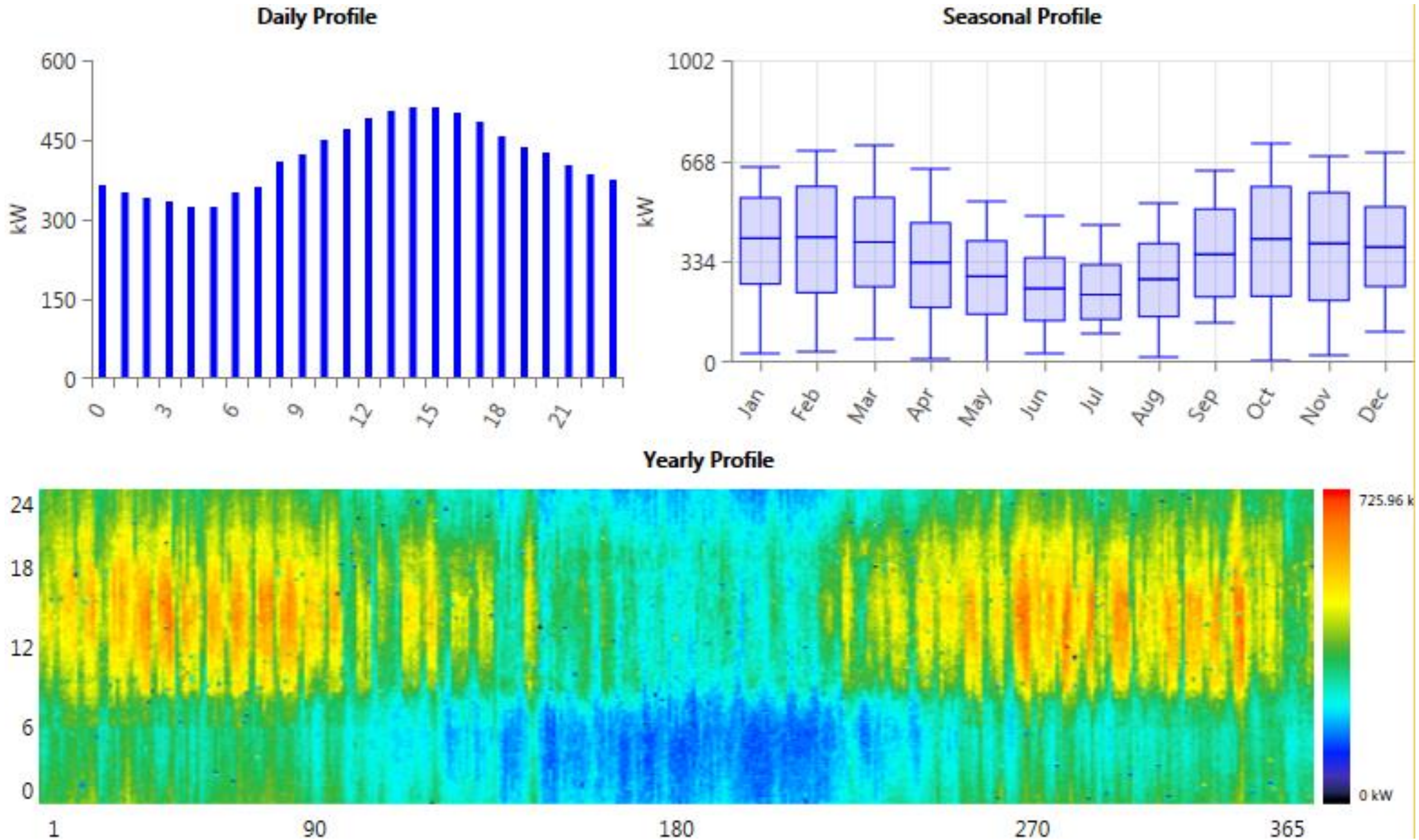
# TKLN Projects

- Tender awarded to Epuron to install, own and operate fixed tilt PV arrays and short term storage for 'smoothing' of output using lead acid batteries.
- RE plant capacity exceeds 1MWp
  - Kalkarindgi: 402kWp,
  - Ti Tree: 324kWp
  - Lake Nash: 266kWp PV + 45kWp WTG
- Coincided with PWC's replacement of existing diesel power station at Lake Nash which had reached end of life, along with communications upgrades for remote monitoring at all sites.

# Block Diagram - Ti Tree

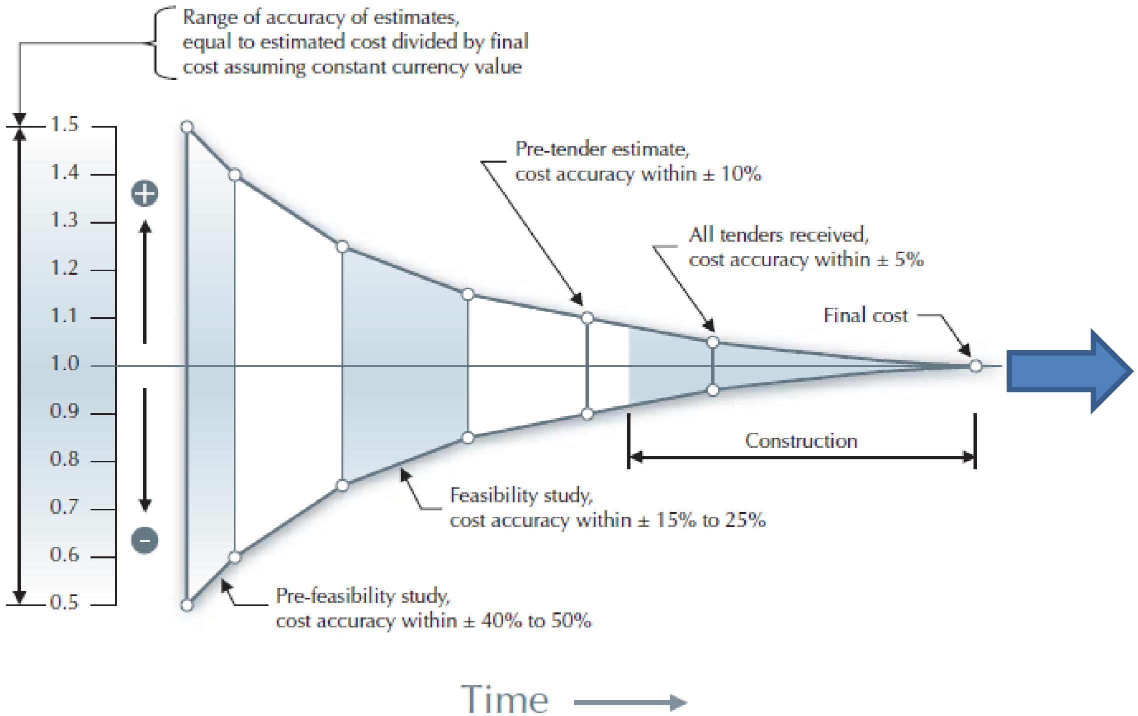


# Data Analysis – CY13 Ti Tree



## Uncertainty in Project Development

## Uncertainty in Operating Performance




Does the Asset perform as expected?

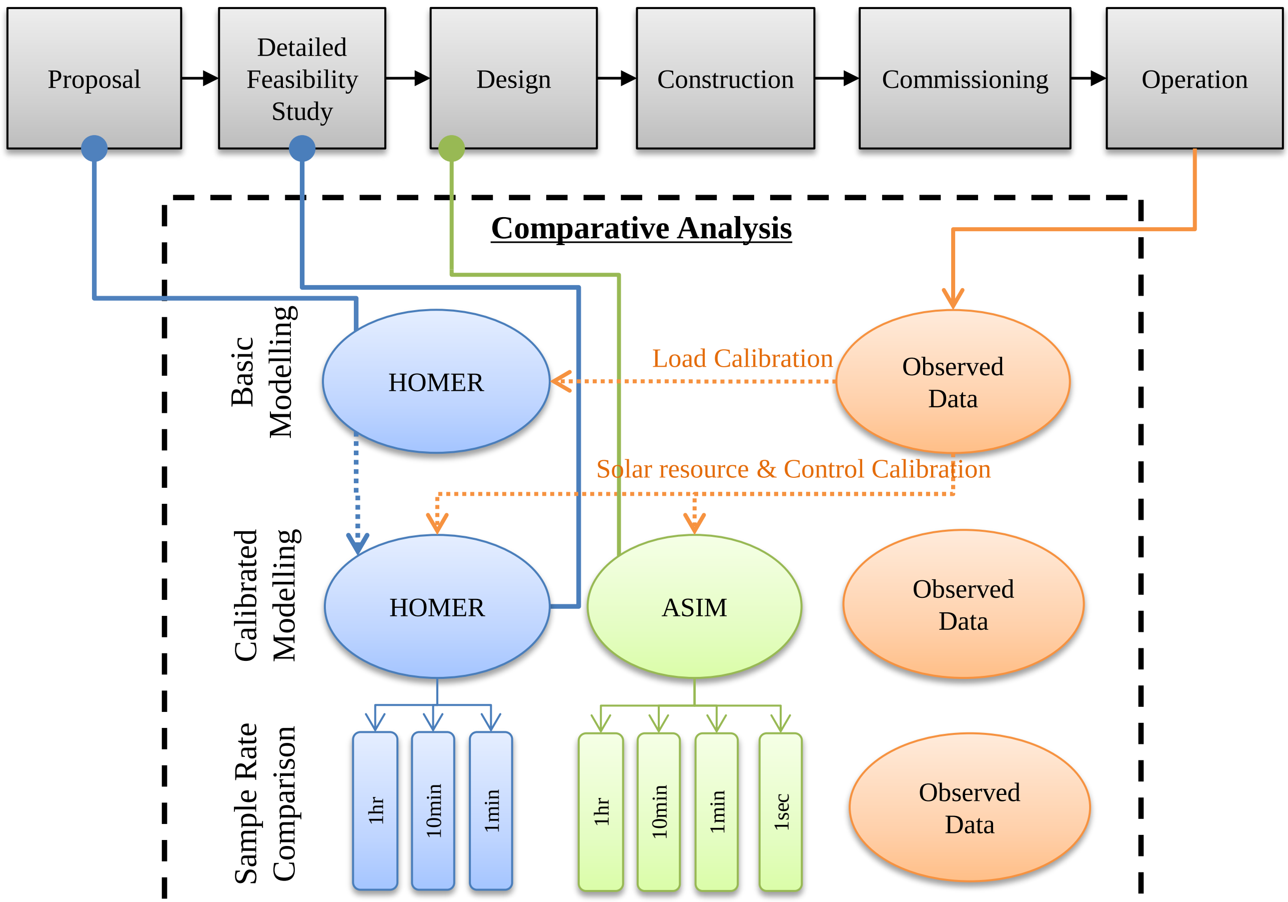
How do we measure & report performance?

What variables can (should) we forecast?

How do we avoid/
..reduce/
..transfer/
..retain
the risks involved?

Source: RETSCREEN

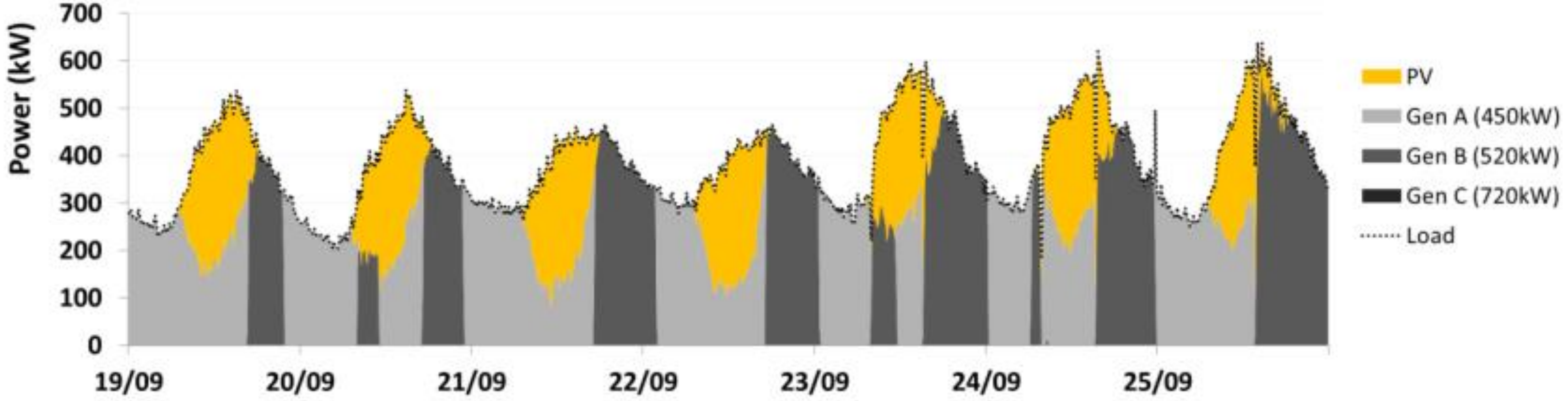
## RET Integration Project Steps



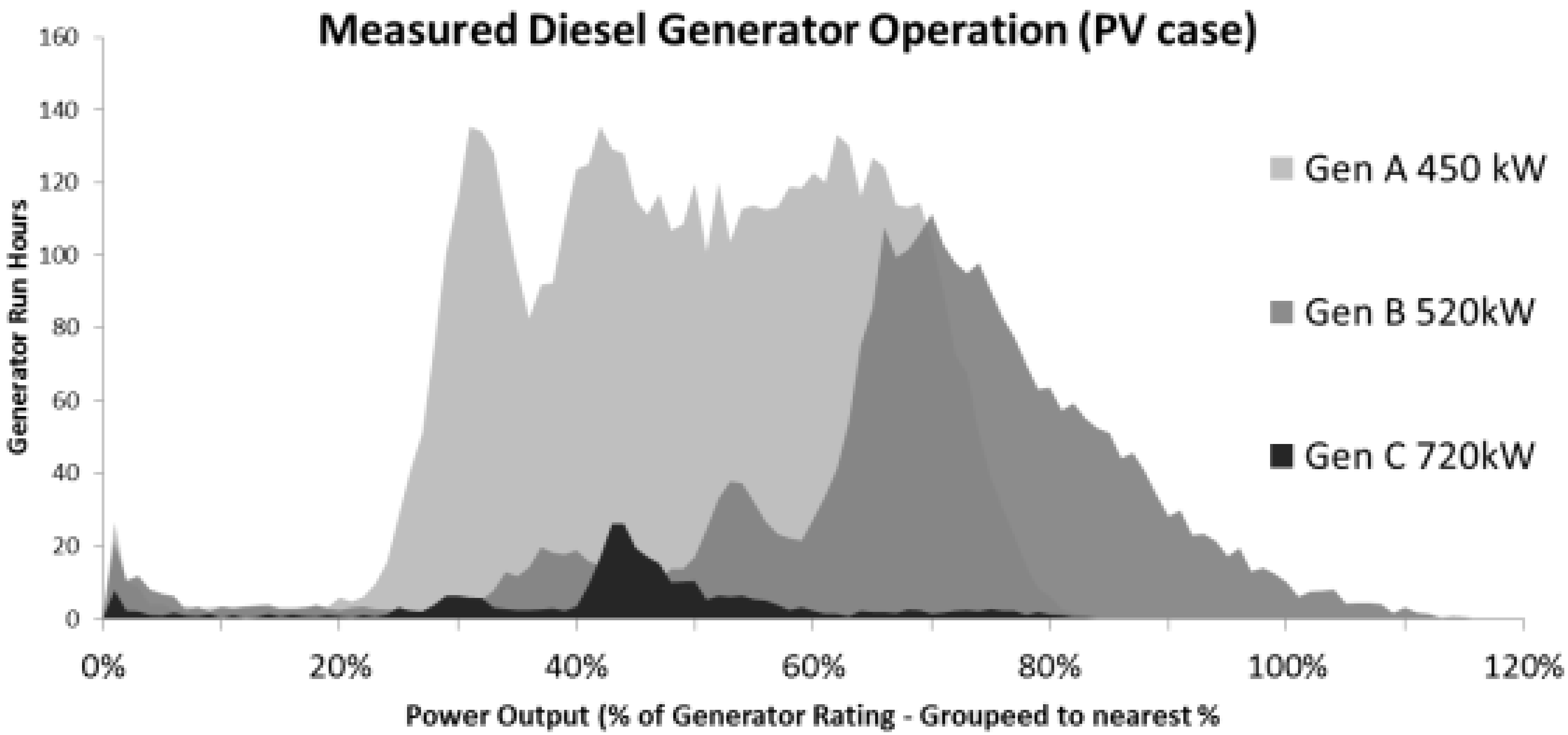

**Metrics of Comparison**:
- RE % (Annual kWh and Peak kW)
- Generator Run hours
- Generator Starts
- Generator Operating Ranges
- ~Fuel Reduction (L) compared to Diesel Only Case
- ~NPC ($) and ~LCOE ($)

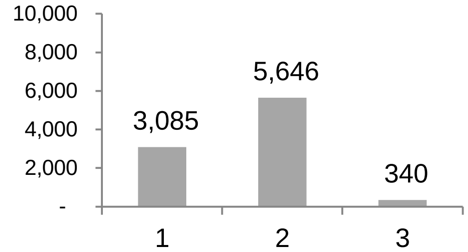
# Data Analysis – CY13 Ti Tree

7 Days Observed Operation



# Data Analysis – CY13 Ti Tree – Operating Ranges



<table>
<tr><th>Metric</th><th>Observed</th><th>Homer ‘Basic’</th><th>Homer ‘Calibrated’</th></tr>
<tr><td>Maximum Instantaneous PV Power Penetration (%)</td><td>77%</td><td></td><td></td></tr>
<tr><td>Annual RE Energy (%)</td><td>18%</td><td></td><td></td></tr>
<tr><td>Generator Run hours</td><td>
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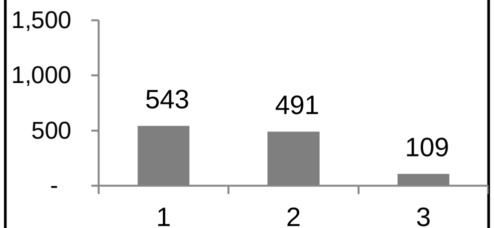
<tr><td>Generator Starts</td><td>
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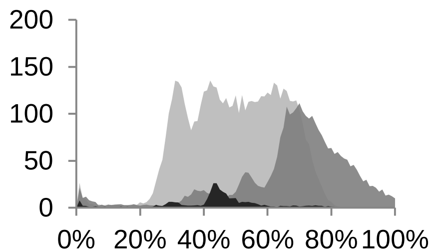
<tr><td>Generator Operating Ranges</td><td>
</td><td></td><td></td></tr>
<tr><td>Fuel Reduction</td><td>13%</td><td></td><td></td></tr>
<tr><td>LCOE $</td><td>N/A</td><td></td><td></td></tr>
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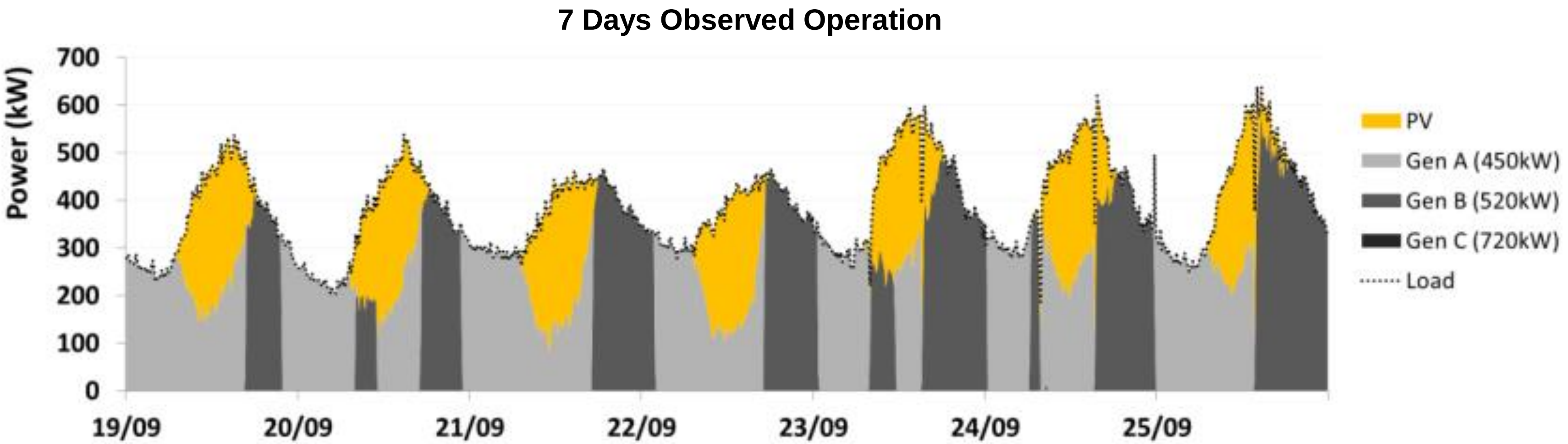
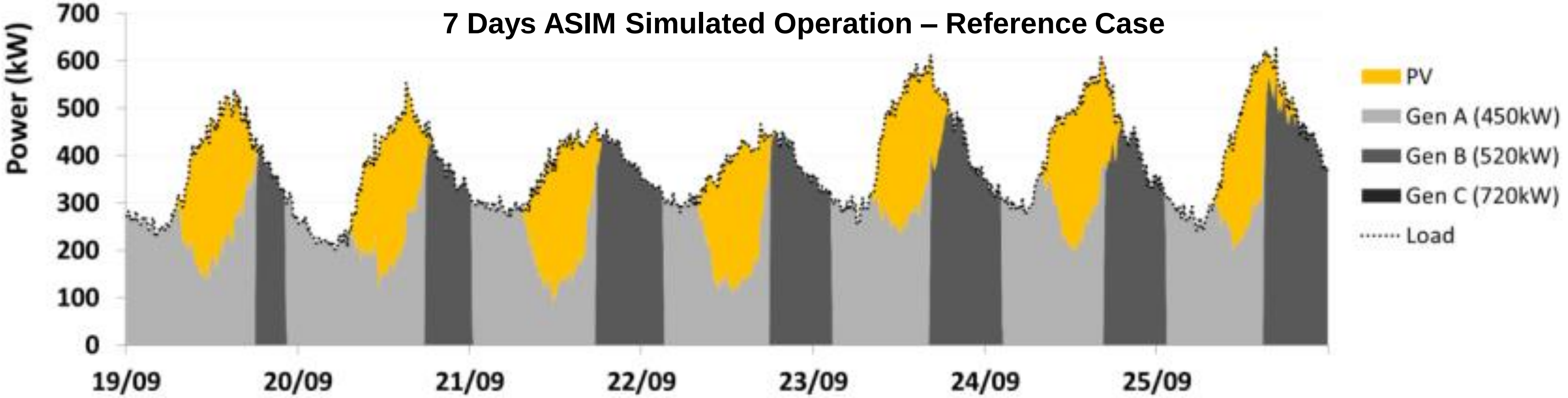
# …but how to derive fuel reduction?



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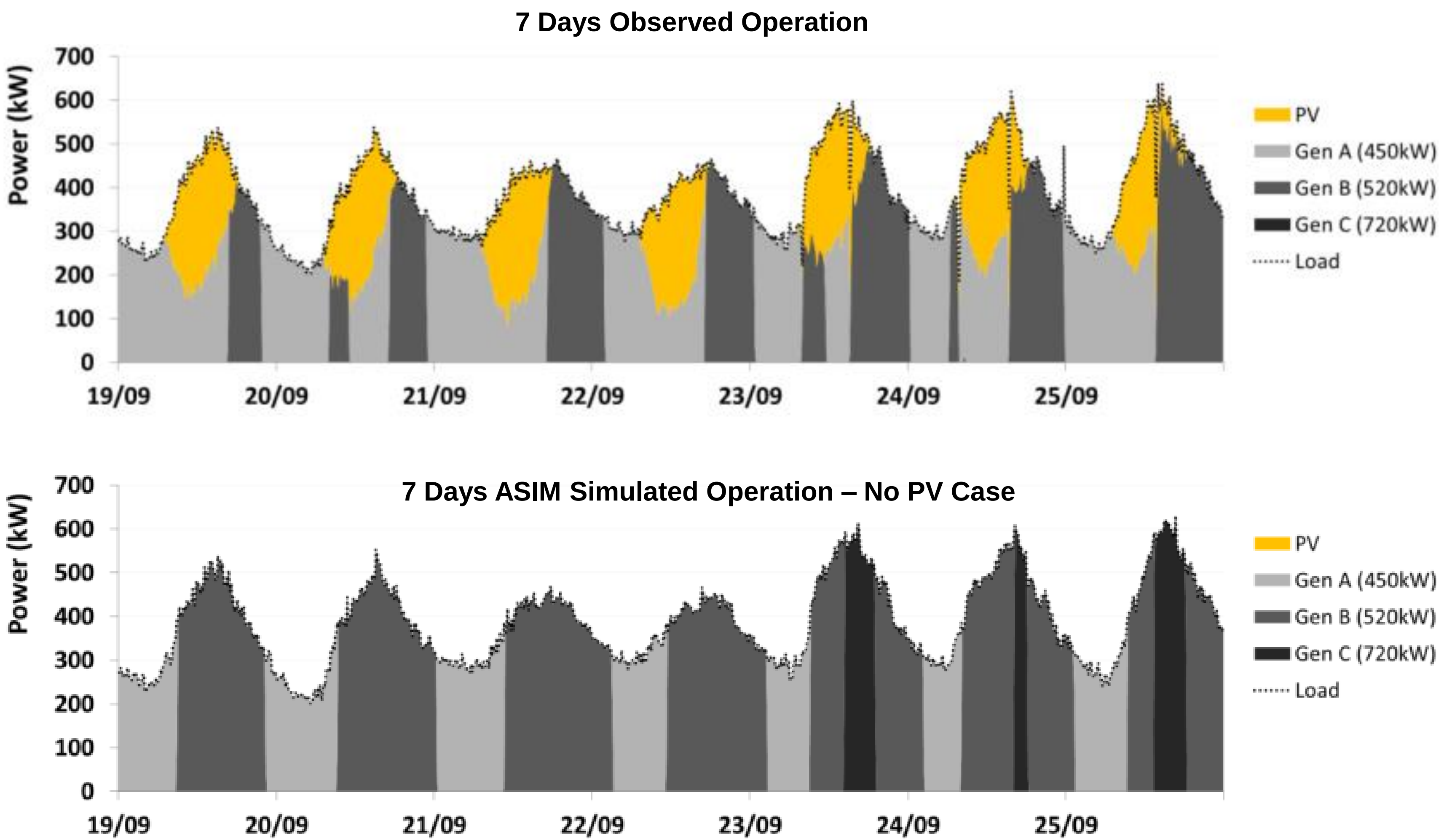
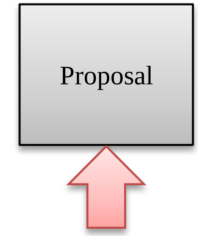
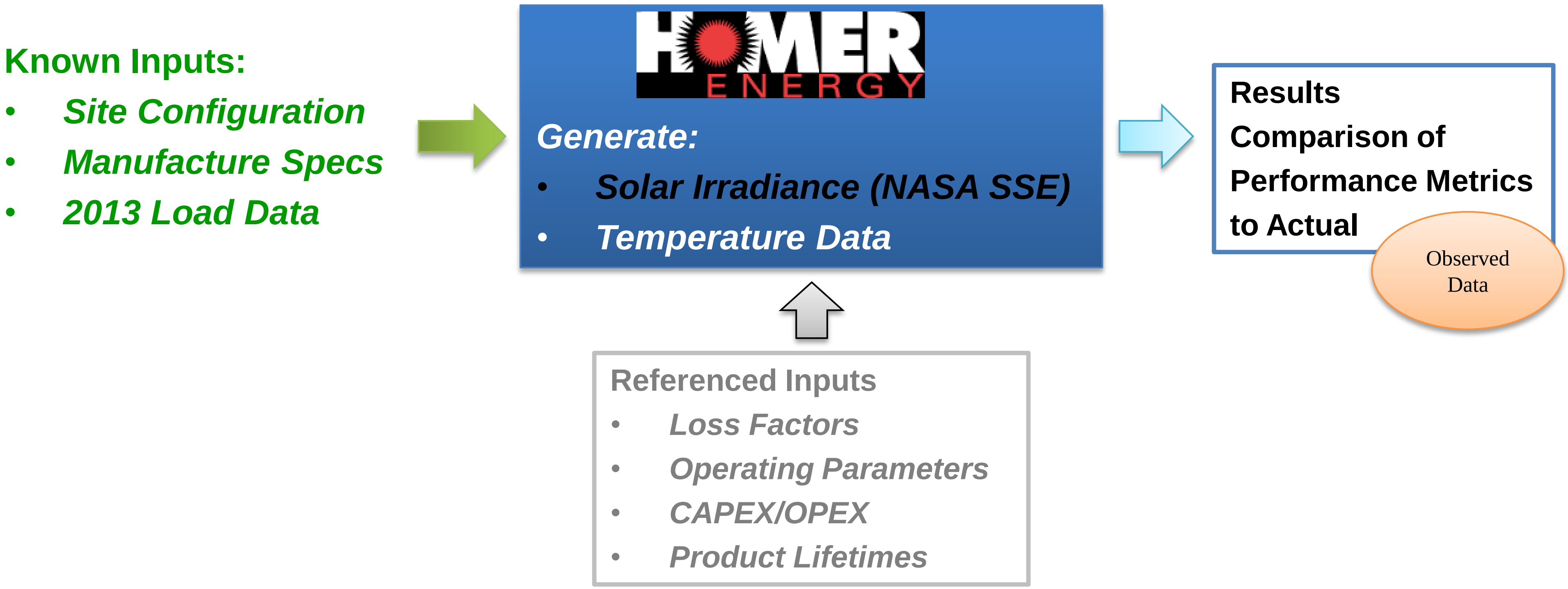


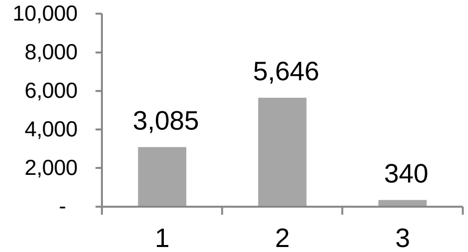
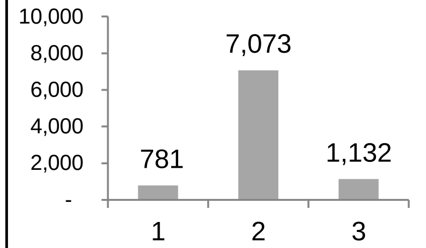
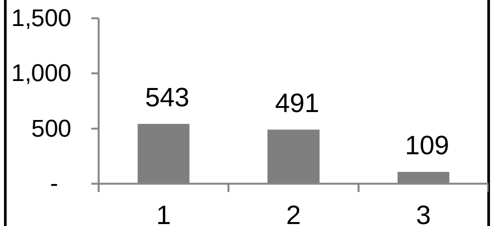
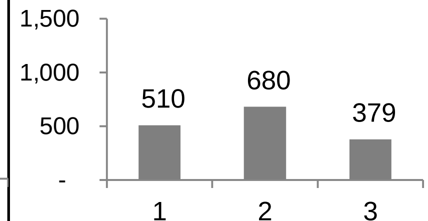
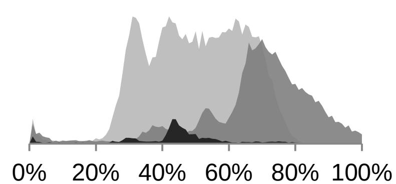
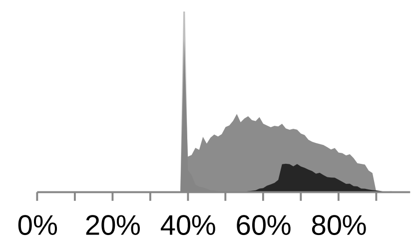
# Homer Modelling – Part 1: Basic Homer Model Comparison



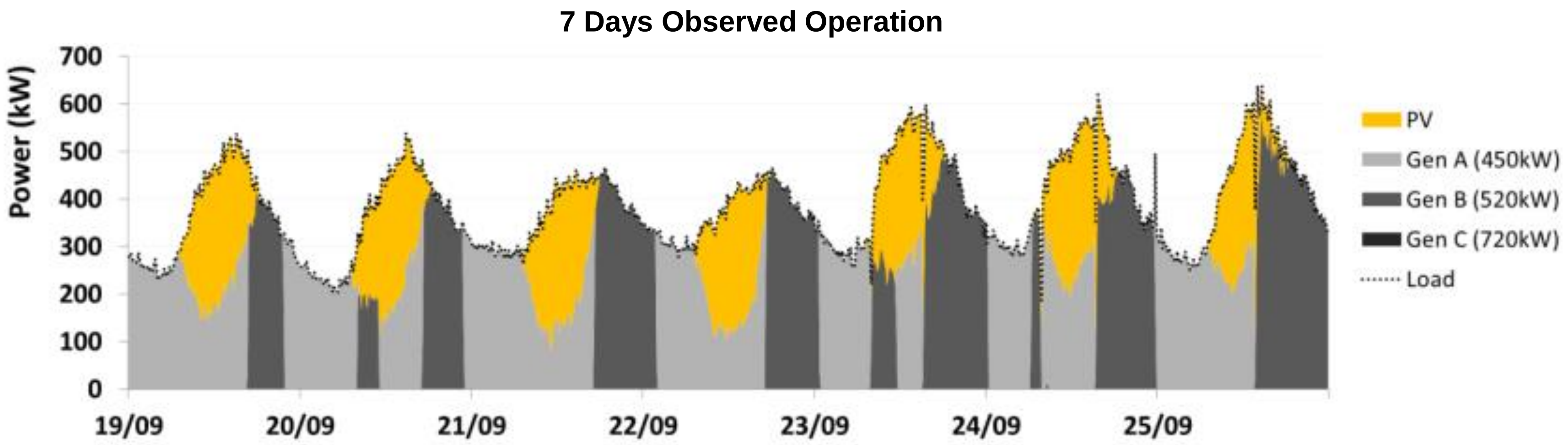

**Comparison 1: Basic Model**

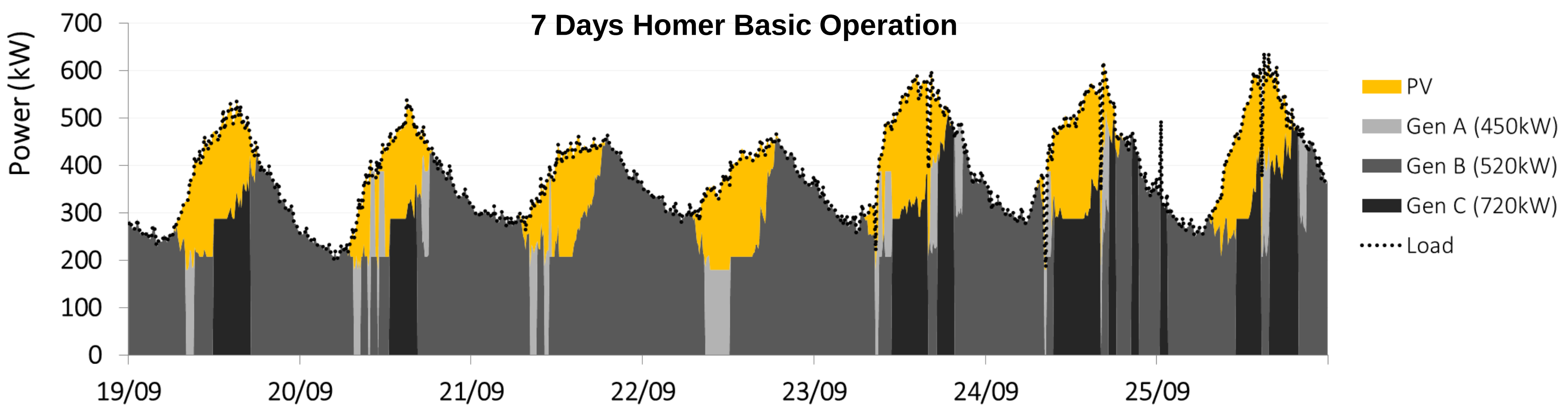
What's expected to be known without detailed analysis of site..



| Metric | Observed | Homer 'Basic' | Homer 'Calibrated' |
|---|---|---|---|
| **Maximum Instantaneous PV Power Penetration (%)** | 77% | 54% | |
| **Annual RE Energy (%)** | 18% | 15% | |
| **Generator Run hours** |  |  | |
| **Generator Starts** |  |  | |
| **Generator Operating Ranges** |  |  | |
| **Fuel Reduction** | 13% | 11% | |
| **LCOE ($/kWh)** | N/A | $0.29 | |

# Data Analysis – Comparison



# Homer Modelling – Part 2: Calibrated Homer Model Comparison

Detailed Feasibility Study

## Comparison 2: Calibrated Model

What's expected to be known from detailed operational/development data…

**Known Inputs:**

- *Site Configuration*
- *Manufacture Specs*
- *2013 Load Data*

*+ Solar Radiation*

*+Temperature Data*

HOMER ENERGY

*Observe Operating Measures*

*Iterate with Sensitivities*

*Present Best Case*

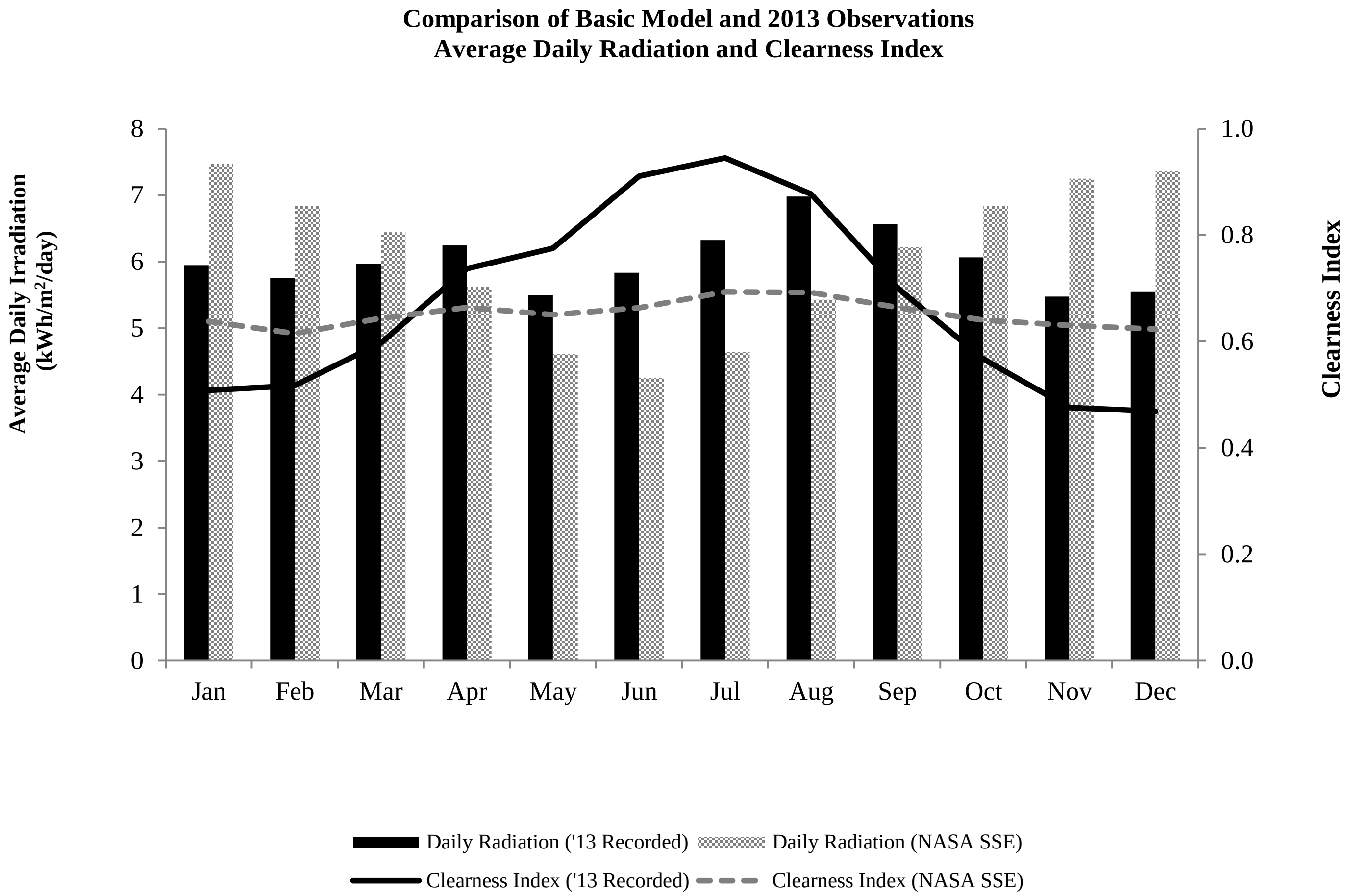
**Results Comparison of Performance Metrics to Actual**

Observed Data

**Referenced Inputs**

- *CAPEX/OPEX*
- *Product Lifetimes*

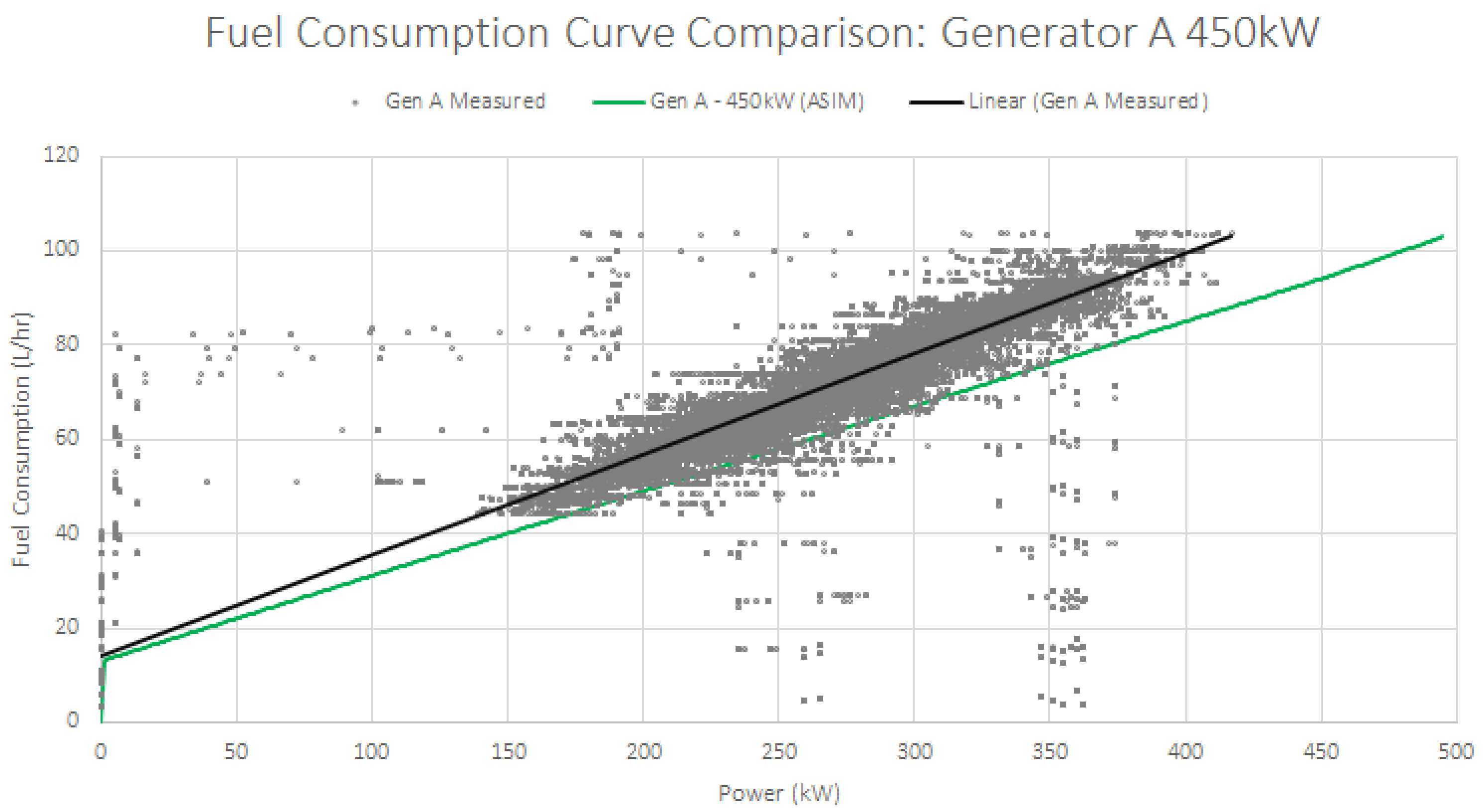
# Homer Modelling – Part 2: Calibrated Homer Model Comparison




*Annual Average ('13 Recorded):* ***6.01 kWh/m²/day***

*Annual Average (NASA SSE):* ***6.08 kWh/m²/day***

# Homer Modelling – Part 2: Calibrated Homer Model Comparison



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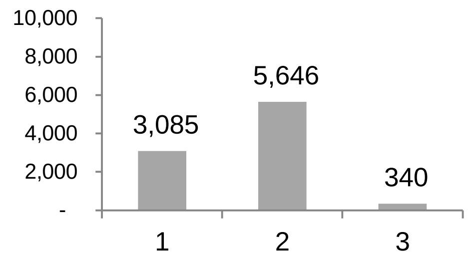
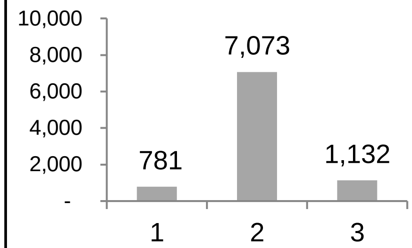
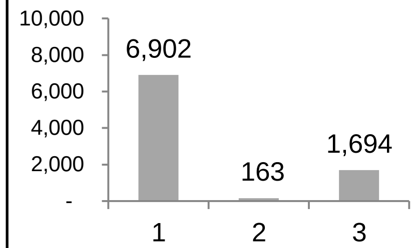
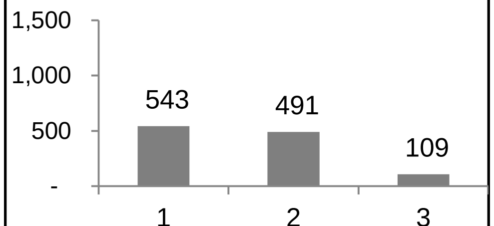
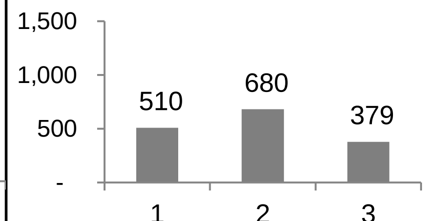
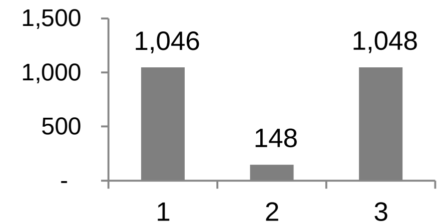
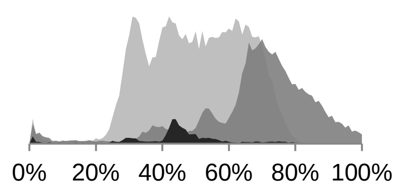
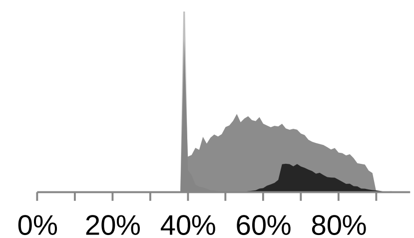
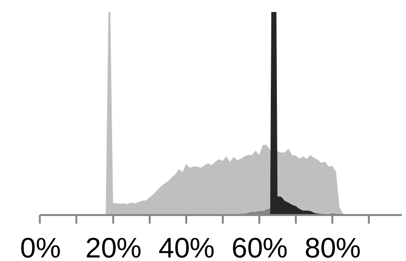
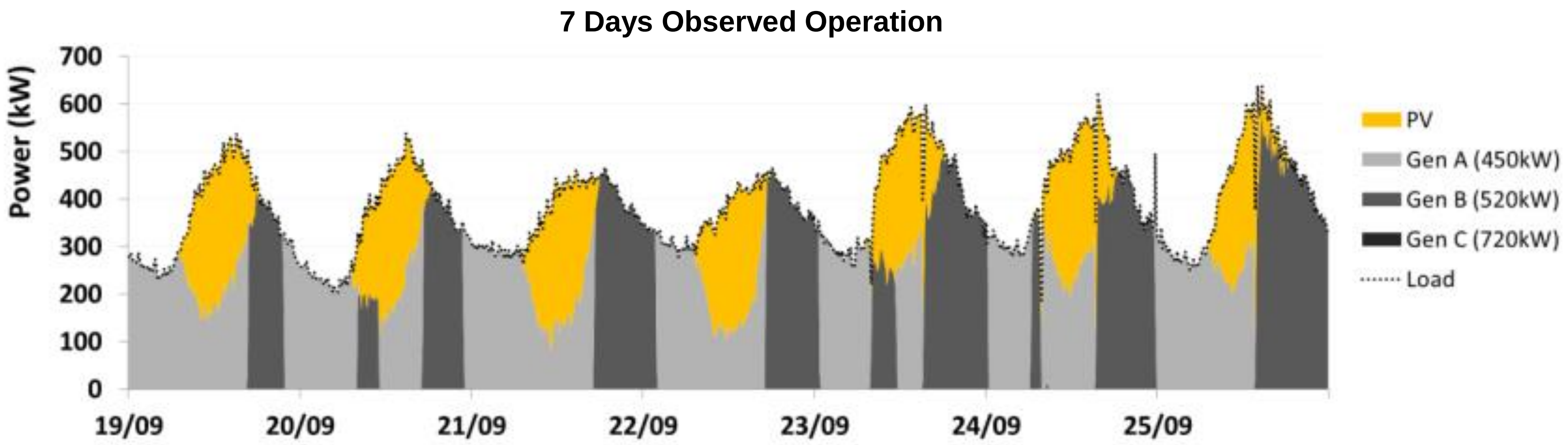
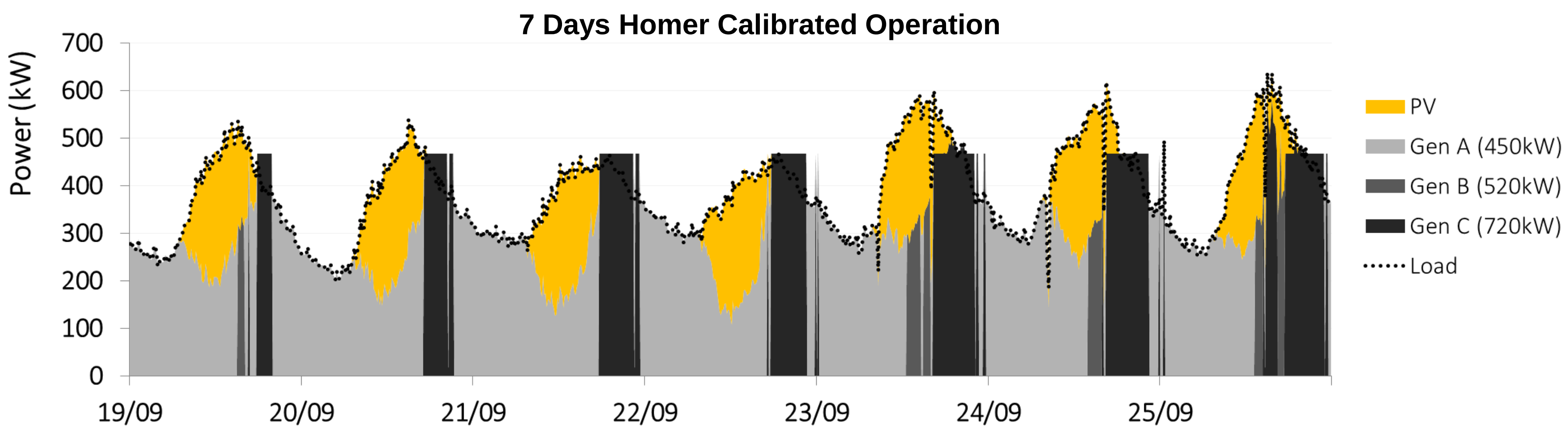
| **Generator Run hours** |  |  |  |
| **Generator Starts** |  |  |  |
| **Generator Operating Ranges** |  |  |  |
| **Fuel Reduction** | 13% | 11% | 14% |
| **LCOE ($/kWh)** | N/A | $0.29 | $0.33 |

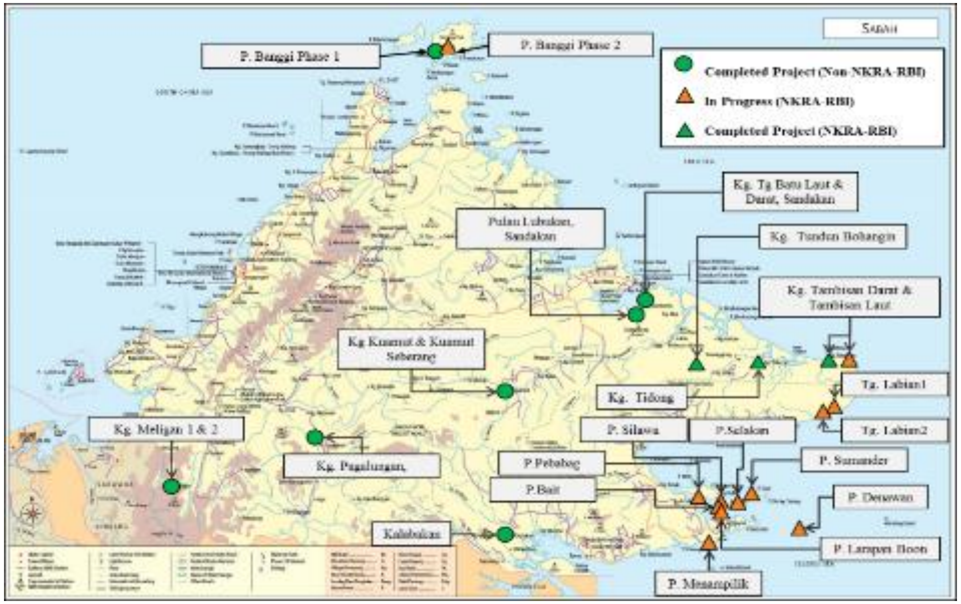
# Visual Comparison with Calibrated Model



# Further Work

- Finishing Comparative Analysis for Northern Territory
    - Second Site (Kalkarindji)
    - Demonstrating how HOMER and ASIM can be used together
- Deployment models + how to best manage risk between stakeholder.
- Analysing data and deployment models from Malaysian Borneo




# Conclusions

- Homer is an incredibly robust tool for decision makers.
- As with all models it will only be as good as the inputs for the person using it and limitations with less conspicuous performance metrics need to be understood.
- With PV integration we focus on the renewable energy element (so does funding!), however wholistic system impacts and alternative optimisation methods are equally important for success.
- Models such as Homer and ASIM are useful not just in project development, but in Asset Management.
- The NT Context provides an appealing case for retro fitted PV/Diesel applications in a developed context.
- TKLN Projects specifically are a highly innovative undertaking from both a technical and organizational perspective.
- While fuel savings were modest (13%), instantaneous PV penetrations can be as high as 77%. This highlights the design challenge of even a low PV integration.