Task 18: Off-grid and edge-of-grid power systems Subtask 2

Blueprint on how to conduct feasibility studies

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Leader and key contributors

Blueprint (report) scope of work

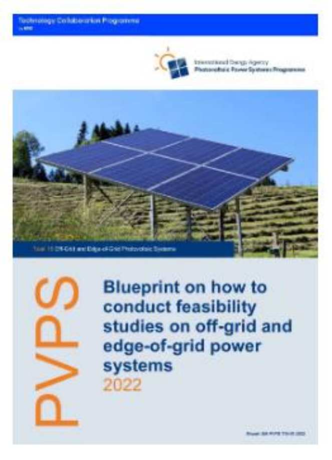
- Provide a blueprint to readers on how to conduct feasibility studies on off-grid and edge-of grid hybrid power systems

Leader of Subtask 2

- Ekistica – professional engineering technical advisory firm based in Alice Springs, Central Australia

Key contributors and reviewers of Subtask 2

- University of New South Wales (Australia)
- Yukon University (Canada)
- Rolls Royce Solutions (Australia)
- Other experts involved with Task 18



High-level structure of the blueprint

1. Literature review
   - Summary of existing literature
   - Repository created that stores relevant publicly available feasibility studies

2. Contents of the blueprint
   - Types of feasibility studies (what, when, how)
   - Stakeholders, ownership, governance, regulatory, social aspects
     - Anything not technical or financial related
   - Technical aspects
   - Financial aspects
   - Optimisation and sensitivity

3. Case Study
   - A real-world example of a feasibility study explored in detail

Contents of the Blueprint

The blueprint breaks a feasibility study down into the following four stages:

1. Determining the nature and extent of the feasibility study
2. Gathering information and data
3. Modelling and analysis
4. Assessment and recommendations

Each stage is then split into the following three key project areas that are used to discuss and guide each stage of a feasibility study:

1. Organisational
2. Financial
3. Technical

Contents of the Blueprint *continued*

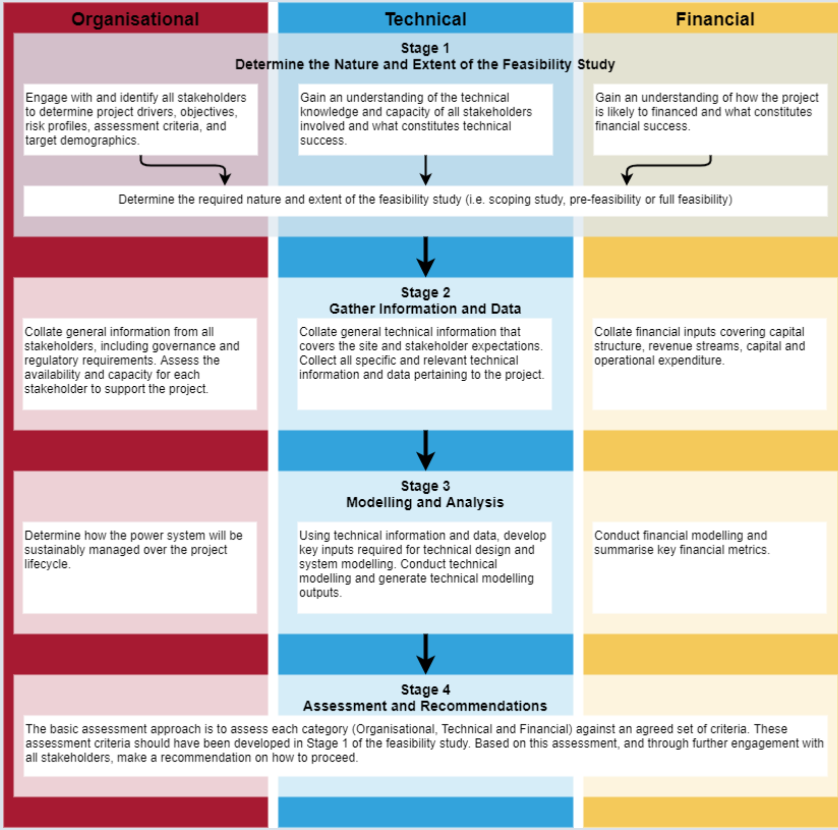


Figure 1. High-level framework for conducting a feasibility study on off-grid and edge-of-grid power systems

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Contents of the Blueprint ***Stage 1***

Determine the nature and extent of the feasibility

- Gain an understanding of the project context
- Define the nature/extent of the feasibility that best suits this context

This involves identifying and engaging with all key project stakeholders to:

- Identify the target audience
- Identify the project aims and drivers and their relative priority
- Determine the commitment of and involvement from each stakeholder
- Assess stakeholder capacity
- Determine the agreed project assessment criteria

Contents of the Blueprint *Stage 1 continued*

Determine the nature and extent of the feasibility

	Preliminary Assessment	Pre-Feasibility	Full Feasibility
Bankability uncertainty	Up to 50%	15 - 25%	5 - 10%
Level of detail / effort required	Up to 20%	20 - 50%	50 - 90%
Project design	Indicative design only	Moderately detailed design	Highly detailed design
Stakeholder	Identify	Identify	Identify / engage
Project risks	Identify	Identify	Identify and manage
Technical modelling	No	Maybe	Yes
Financial modelling	No	Maybe	Yes
Site Investigations	Identify	Identify / Complete	Complete
Approvals	No	Identify	Plan
Site Management	No	Identify	Yes
Drawings	No	Key drawings only	Yes
Resource planning	No	Maybe	Maybe

Contents of the Blueprint *Stage 2*

Gather information and data

Focuses on gathering, sorting, and collating the available information and data, which are used in the assessment and modelling work carried out in Stage three: modelling and analysis.

An effective feasibility study requires a considerable amount of information and data to be gathered from a wide range of sources.

A key source of information and data will be the project stakeholders, and the gathering process will therefore directly follow on and at times overlap with the stakeholder engagement work of Stage one.

Contents of the Blueprint ***Stage 3***

Models a range of potential solutions, with the results analysed, summarised, and presented in a meaningful way to help inform decision making. The core outcomes are:

1. Organisational: Governance structure, understanding of the legal and regulatory framework, and understanding of local supply chains.
2. Technical: A system design, or range of suitable designs, target site(s), procurement, installation, and long-term operation.
3. Financial: A financial model that accurately reflects financial aspects of the project with a key focus on the optimisation of each of these outcomes.

The organisational, technical, and financial elements are highly interdependent. Changes to any one of these elements will likely impact other elements. Optimisation therefore will require an iterative feedback process between these three elements.

Contents of the Blueprint ***Stage 4***

Provide clear recommendations

on how to proceed

Case Study

- Background
  - Remote community in the Northern Territory, Australia
  - Relying on 100% diesel generation

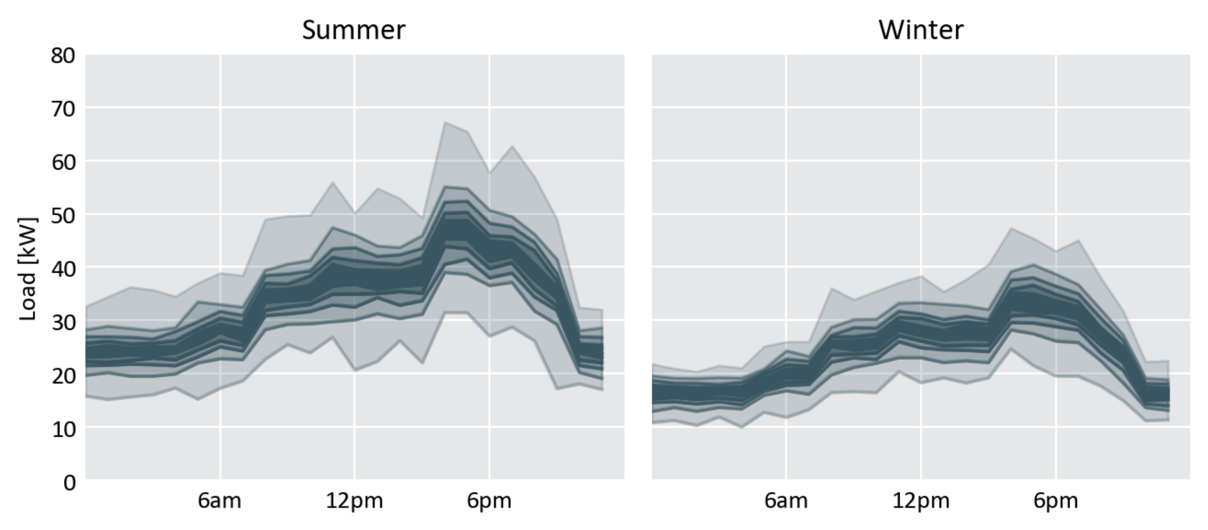
- Client goals
  - Maximise financial return, improve power system reliability, minimize operational cost volatility, improve environmental sustainability

- Power supply options
  - Business as usual (i.e. 100% diesel generation)
  - Grid-connection (i.e. located 10km from grid)
  - Standalone off-grid hybrid power station

TECHNICAL MODEL

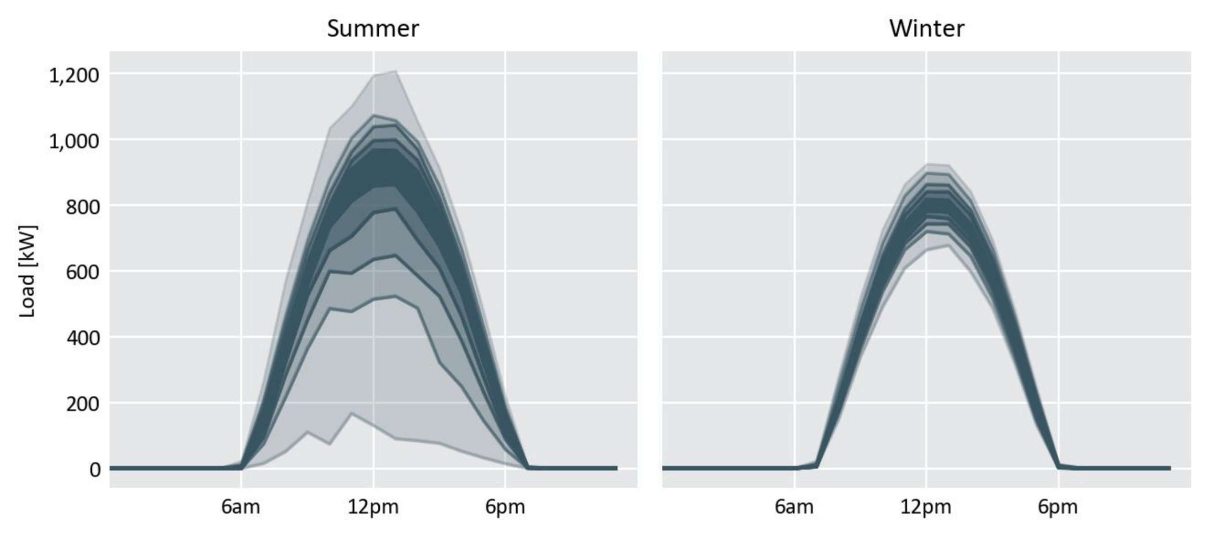
Case Study: Load Assessment

- Daily load profile in summer and winter – each shade of colour represents 20% of the data
- Typical daily energy consumption ranges from 600 – 800 kWh
- Average daily energy consumption of 672 kWh



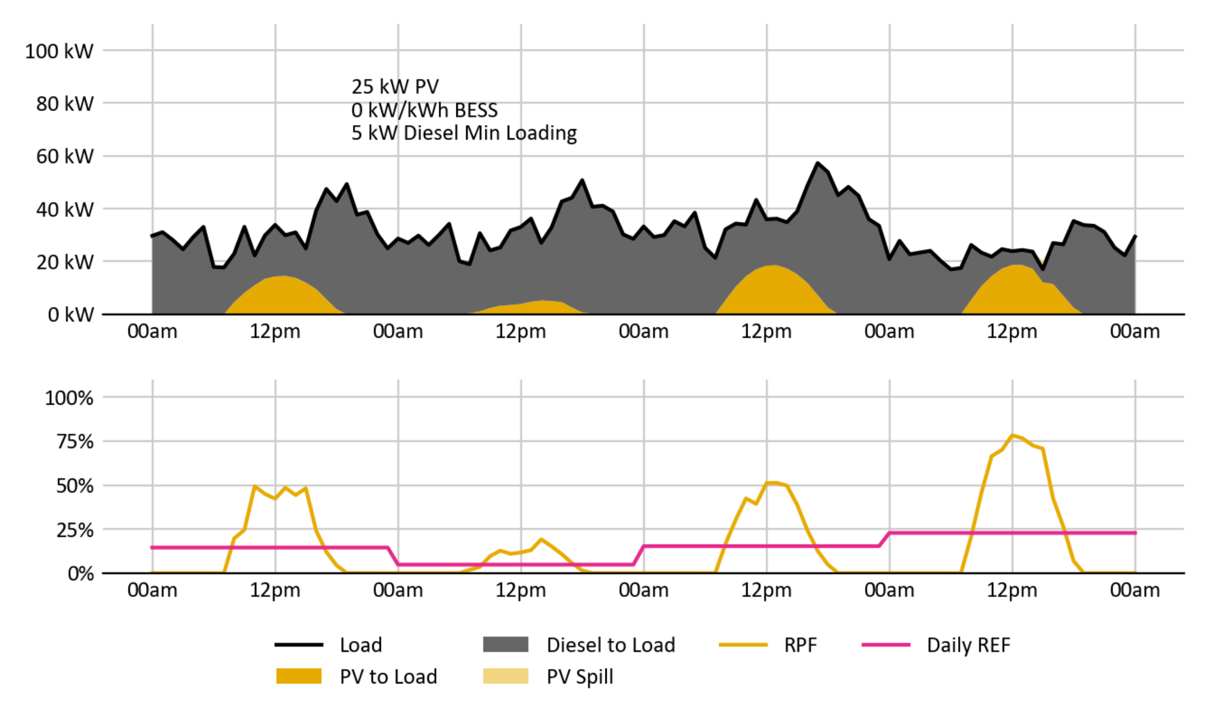
Case Study: Resource Assessment

- Daily solar resource profile in summer and winter – each shade of colour represents 20% of the data
- Summer falls within the wet season, which experiences more volatile weather conditions than winter, which falls in the dry season



Case Study: Solar / diesel

Scenario: **25 kW PV**, 5 kW minimum loading



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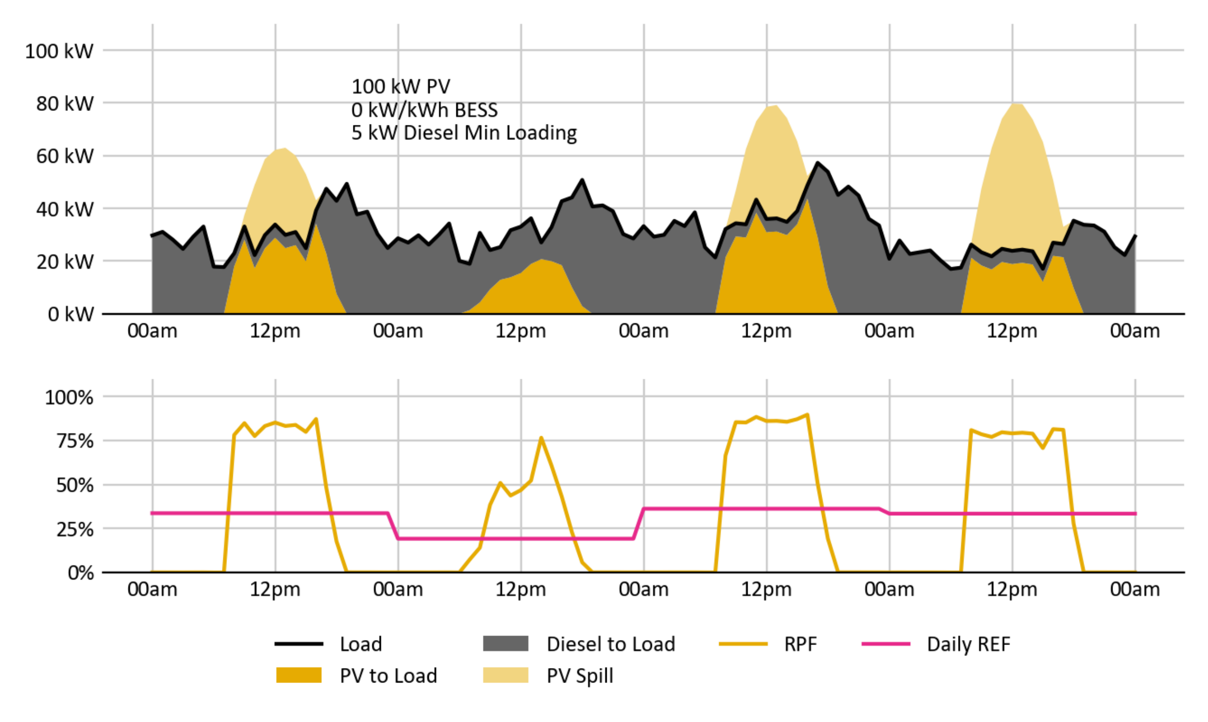
Case Study: Solar / diesel

Scenario: **100 kW PV**, 5 kW minimum loading



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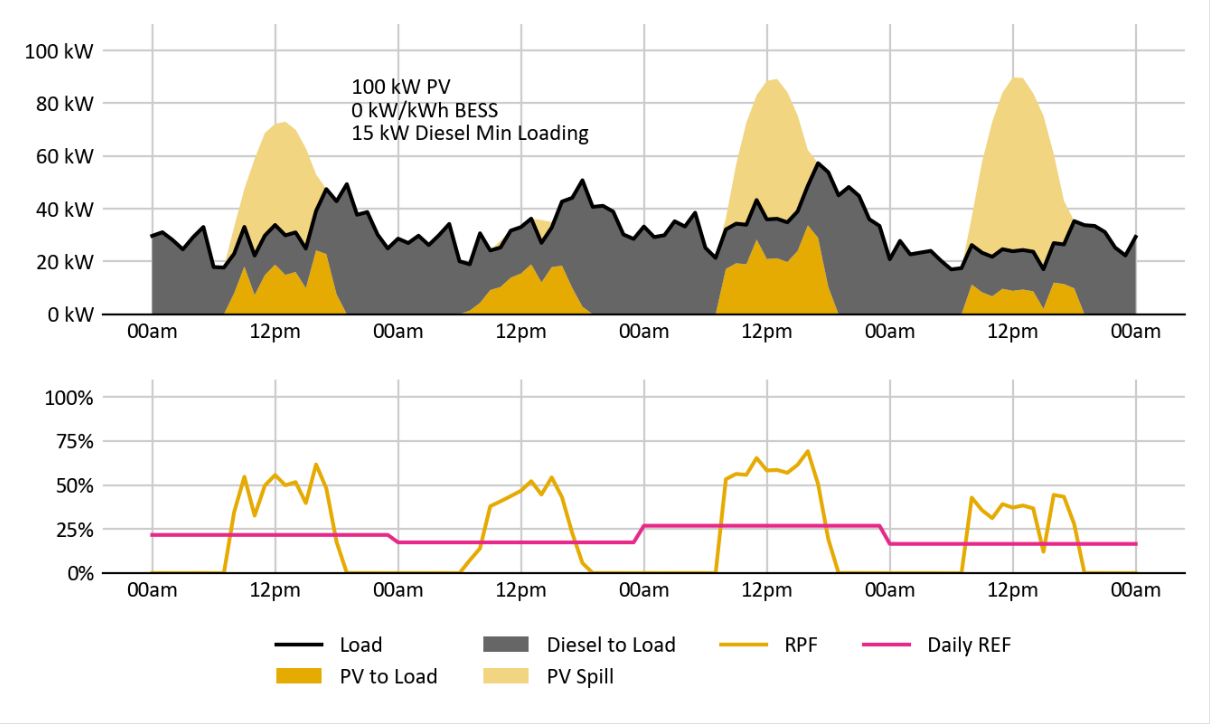
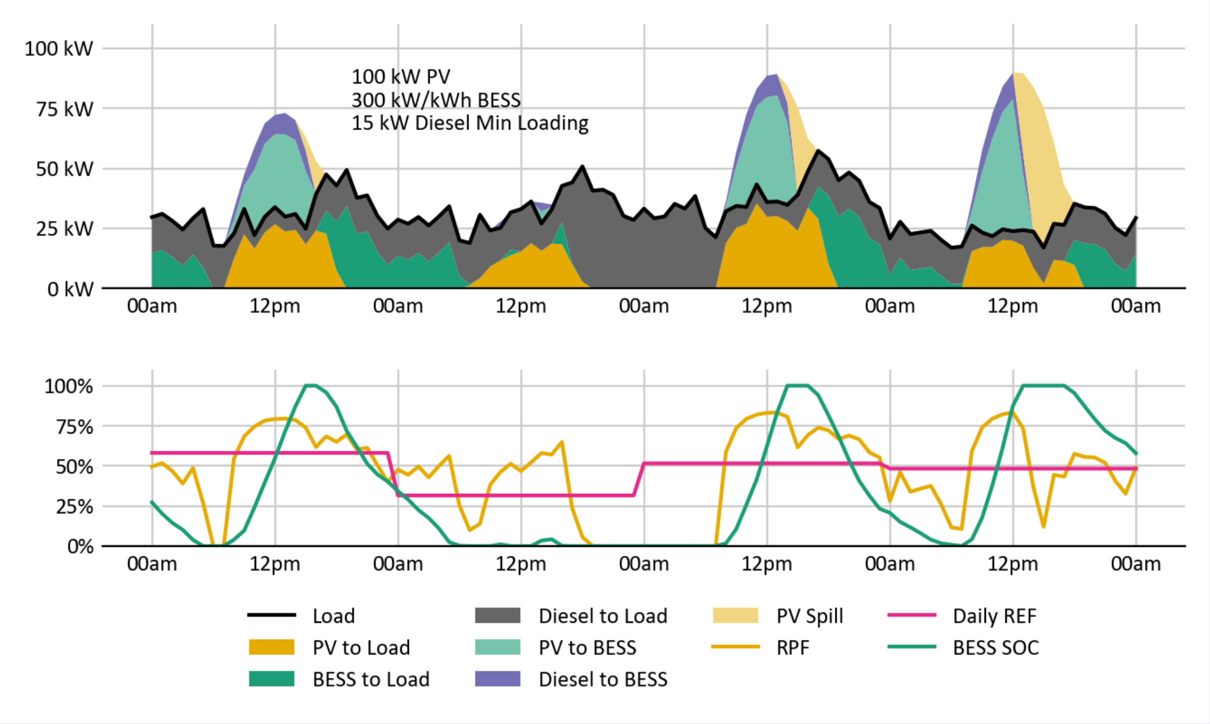
Case Study: Solar / diesel

Scenario: 100 kW PV, **15 kW minimum loading**



Case Study: Solar / grid-following BESS / diesel

Scenario: 100 kW PV, **300 kW/kWh BESS**, 15 kW minimum loading



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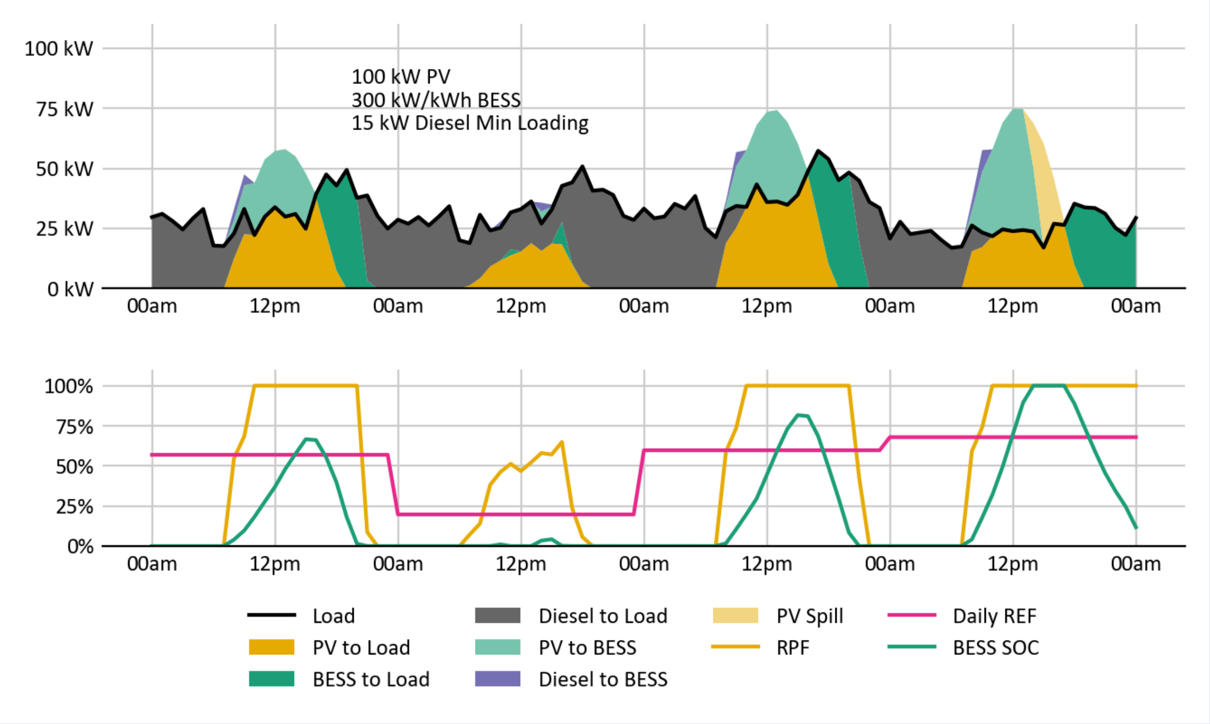
Case Study: Solar / grid-forming BESS / diesel

Scenario: 100 kW PV, 300 kW/kWh BESS, 15 kW minimum loading



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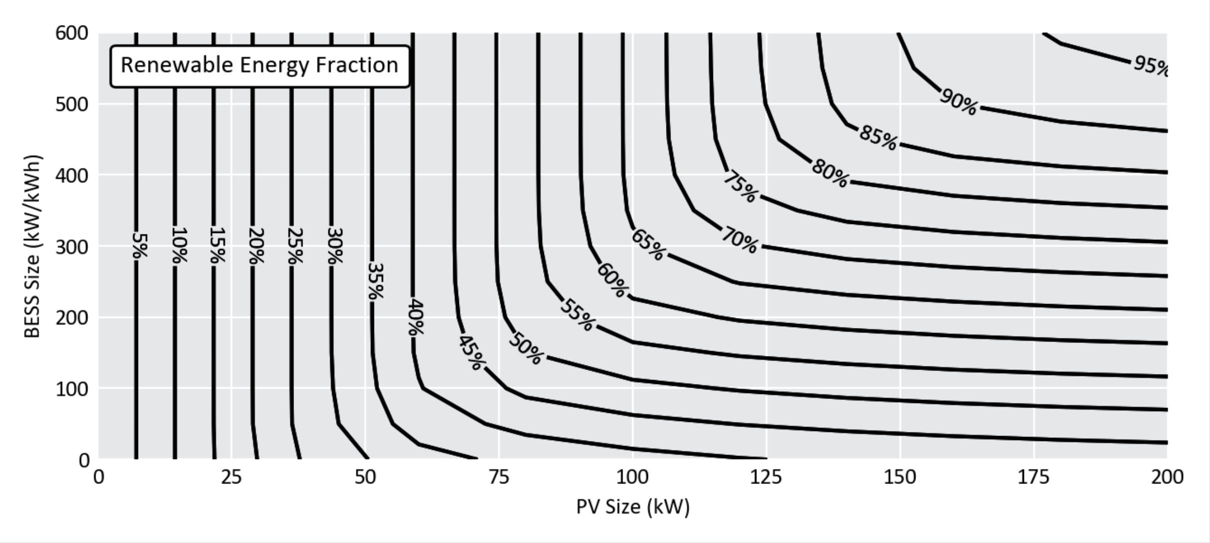
Case Study: Optimisation

Renewable energy fraction as a function of solar PV and BESS size



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FINANCIAL MODEL

Case Study: Financial inputs

Input	Value
Operational Life (years)	25 years
Debt to Value Ratio	100%
Cost of Debt (%)	5%
Cost of Equity (%)	6%
WACC (%)	3.5%
Loan Tenure (years)	7 years
CPI (%)	2.5%
Tax Rate (%)	30%

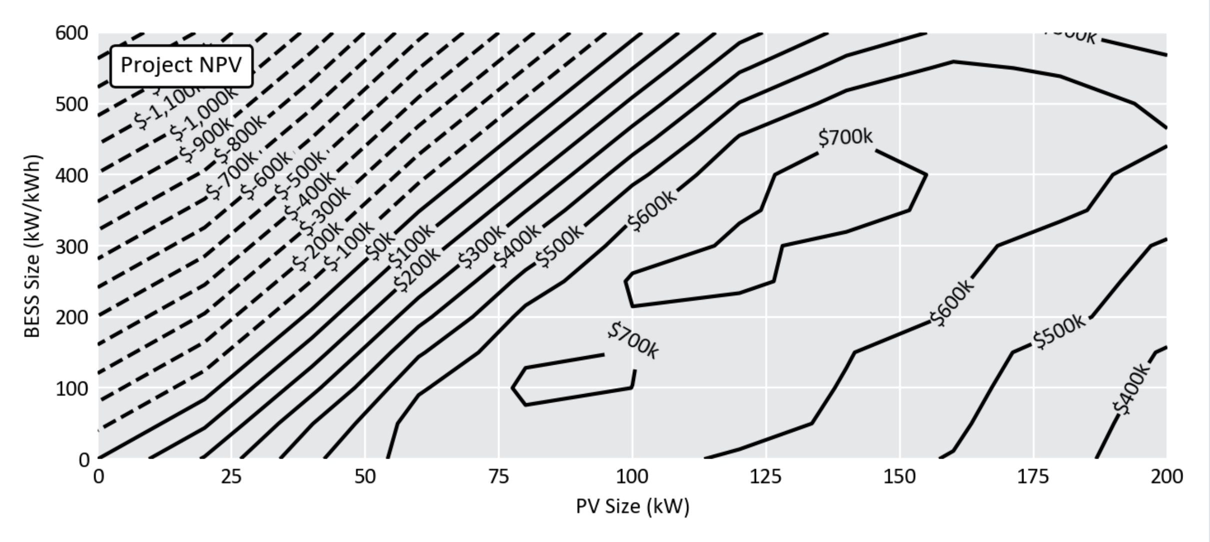
Input	Value					
Diesel starting price ($/litre)	$1.38 per litre (with specific diesel price forecast applied)					
Green energy certificate price ($/MWh)	2020	2021	2022	2023	2024	2025+
	$29	$10	$5	$3	$1	$0

Input	CAPEX	Index (i.e. Annual price change)
Solar PV ($/W)	$2.20 per Watt	- 4.0%
Inverter ($/W)	$0.15 per Watt	- 4.0%
Grid-forming BESS ($/kWh)	$1,200 per kWh	- 4.5%
Diesel Generator ($/kW)	$600 per kW	+ 2.5%
Fixed Capital ($)	$468,000	NA

Input	OPEX
Solar PV ($/$W_{DC}$)	$0.03 per Watt
Inverter Operational Life (years)	15 years
Grid-forming BESS ($/kWh)	$12 per kWh
BESS Expected Life (years)	10 years
Diesel Generator ($/kW/hour)	$0.03 per kW per hour
Maximum Diesel Generator Runtime (hours)	35,000 hours

Case Study: Optimisation

Net Present Value as a function of solar PV and BESS size



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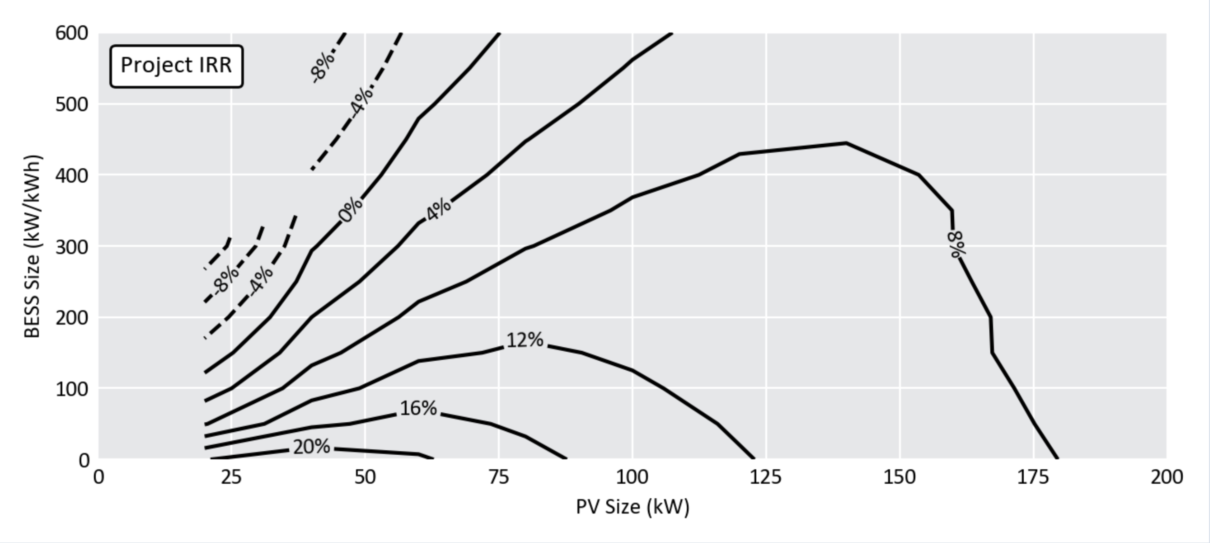
Case Study: Optimisation

Internal Rate of Return as a function of solar PV and BESS size



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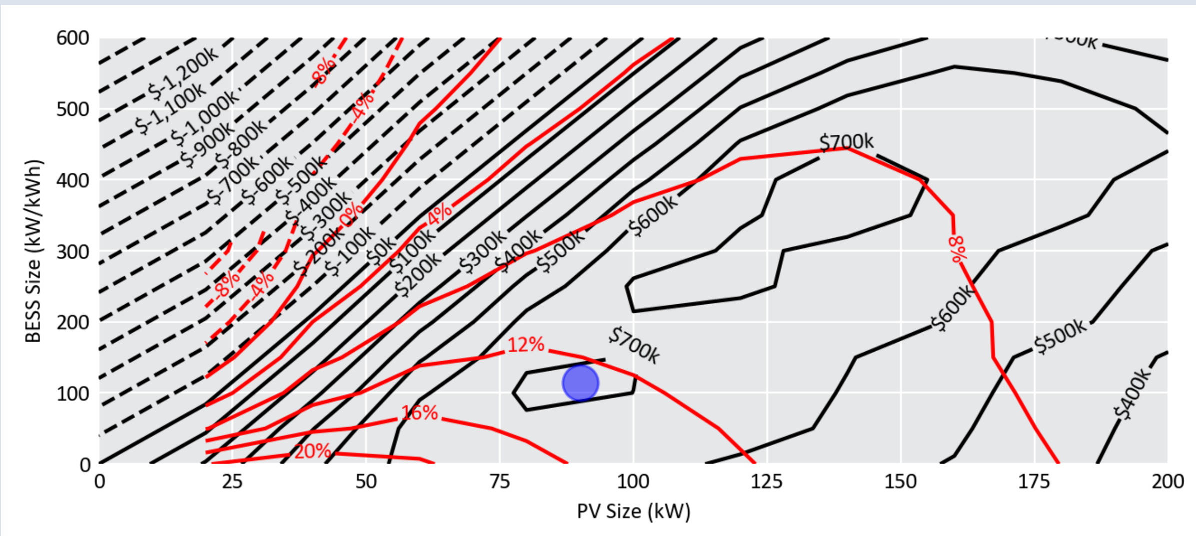
Case Study: Optimisation

Hierarchy of Client's goals:

1) Net Present Value (i.e. maximise)
2) Internal Rate of Return (maximise)



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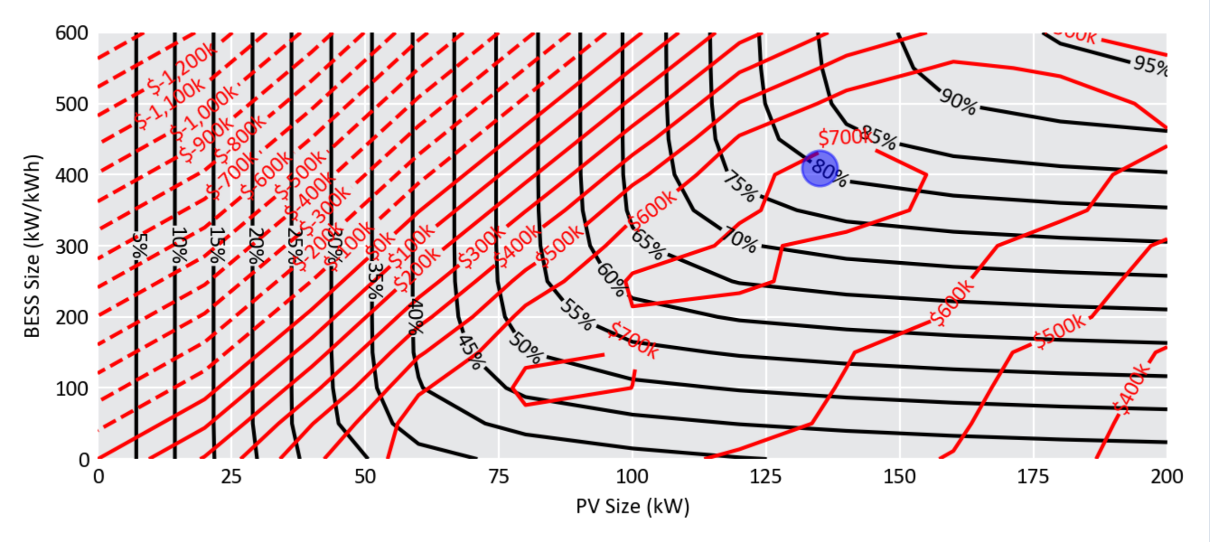
Case Study: Optimisation and sensitivity

Hierarchy of Client's goals:

1) Renewable energy fraction (target = 80%)
2) Net Present Value (maximise)



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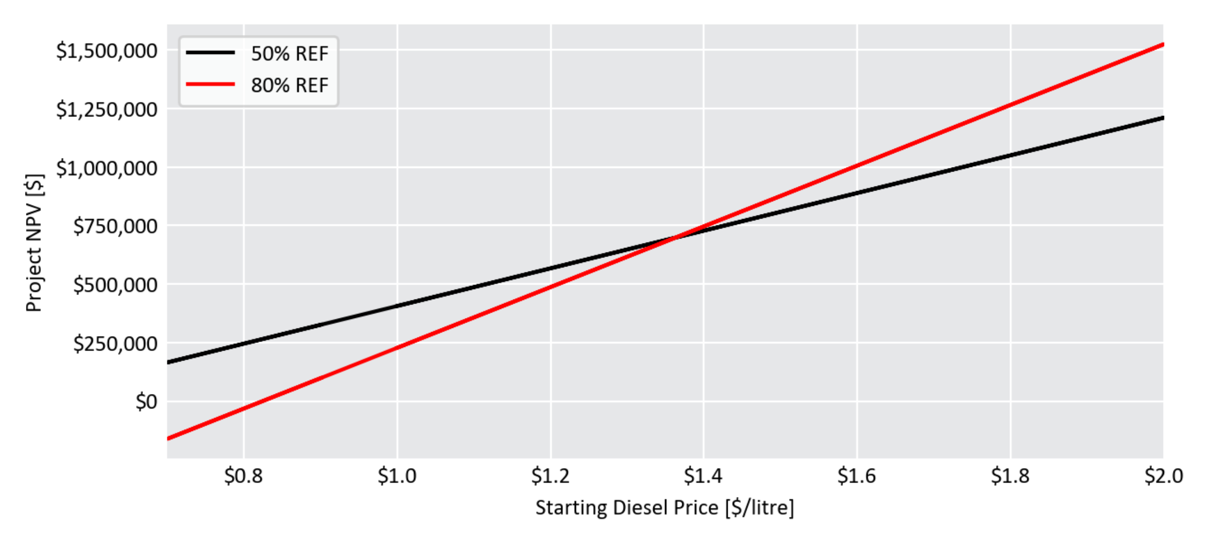
Case Study: Sensitivity

Client wishes to understand their exposure to fluctuating diesel prices under a 50% vs. 80% renewable energy fraction system:

- Returns (w.r.t. business as usual – 100% diesel) are more sensitive for an 80% REF vs. a 50% REF system.



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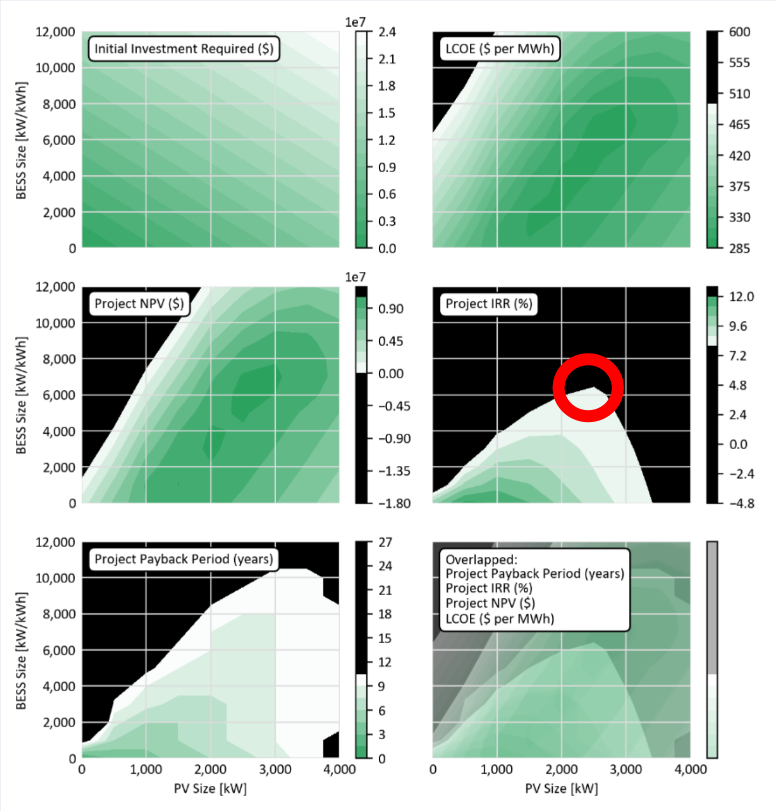
Case Study: Sensitivity



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Thank you

Please reach out to me if you're willing and able to contribute to Task 18.

We would really appreciate input from a range of people that have different experiences conducting feasibility studies on off-grid and edge-of-grid power systems.

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