Feasibility of Energy Community Projects in Victoria

Towards Capturing their Whole-system Value

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The New Context in Australia

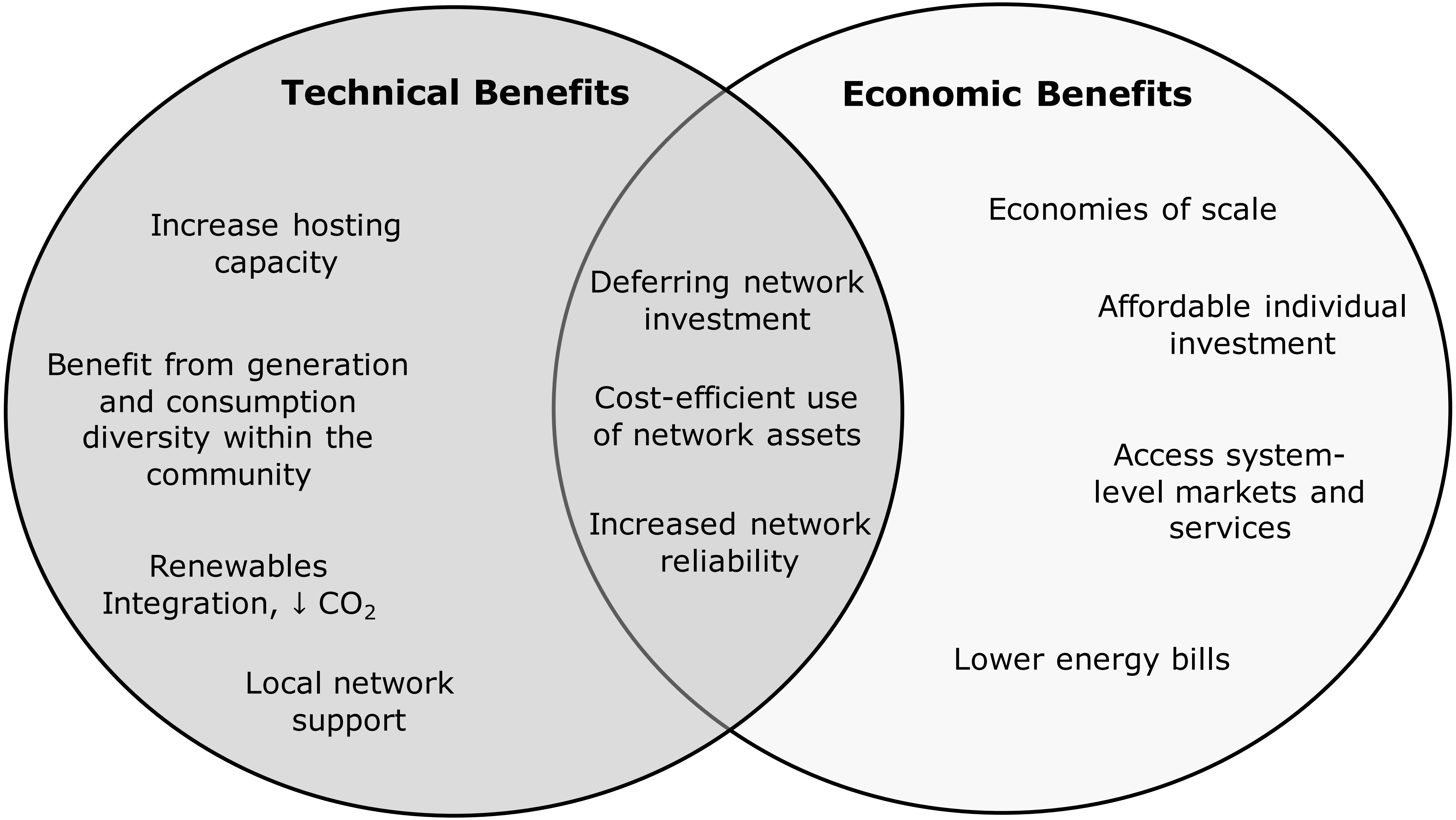
THE UNIVERSITY OF MELBOURNE

What are Energy Communities?

- European Commission:
  1. Energy communities organise **collective and citizen-driven energy actions** that help pave the way for a clean energy transition, while moving citizens to the fore.
  2. Community members and citizens, together with other market players, **team up** and jointly **invest in energy assets**.
  3. Energy communities can act as one entity and **access all suitable energy markets**, on a level-playing field with other market actors.

Community resources operated with a shared objective benefiting community members

Motivation for Energy Communities



Two Energy Community Projects in Victoria

Power Melbourne: Network of Community Batteries

Enable individuals to access more value from DER

City of Melbourne

Donald and Tarnagulla Microgrid Feasibility Study

Reliability and resilience benefits

Donald

Tarnagulla

Our Research Work on Energy Communities

1

Modelling: Optimal Investment & Operation

Energy communities can provide various system-level and local techno-economic benefits

We aim to capture and maximise all these benefits: **whole-system value**

2

Regulatory set-up

Are energy communities economically incentivized to provide these benefits?

Accessible value streams for the energy communities

3

Research question

What is the accessible whole-system value these energy communities can provide?

4

Outcome

Economic feasibility of energy communities & challenges to realize certain benefits

Modelling: Techno-Economic Framework Overview

Techno-economic optimization model to capture whole system value

Community Objective

Economic Value Streams

- Wholesale energy
- FCAS
- Network DR
- RERT
- Tariff arbitrage
- Peak demand
- STPIS

Strategic Value Streams

- Increase local renewable generation
- Local network support
- Carbon reduction
- Self-sufficiency

Community Costs

Microgrid DER OPEX & **CAPEX**

Microgrid control and IT costs

VCR

Community Techno-Economic Roles & Constraints

Customers

Passive: non-responsive

Active: responsive (in case via aggregators)

Aggregators

One or various actors, managing a set of DER in the community

DNSP

Network modelling and technical limits reflect DNSP role

Network reliability

Passing NUoS to retailers

Community Resources

Inter-temporal operation orchestrated to achieve community objectives

Investment

Investment model for optimal size and location of community DER

Retailer

Passing NUoS to customers

Retail tariffs for customers

Network-constrained value stacking co-optimization

Modelling: Key Features

- General and flexible techno-economic framework
  - Demonstrated in the application of two different use cases
- Quantify the economic impact of uncertainty in the future
- Whole system view
  - System-level markets + Local techno-economic operation of the network
  - The different roles in energy communities are included with all costs and benefits involved
- Not only an economic model: modelling the local community allows to understand
  - Co-optimisation trade-offs between provision of system-level and local benefits
  - Capture the true benefits of diversity within the community
  - Quantify technical benefits that are yet to be incentivized by the regulatory set-up

Regulatory set-up: Accessible value streams

- Energy communities can potentially provide various techno-economic benefits to the whole system

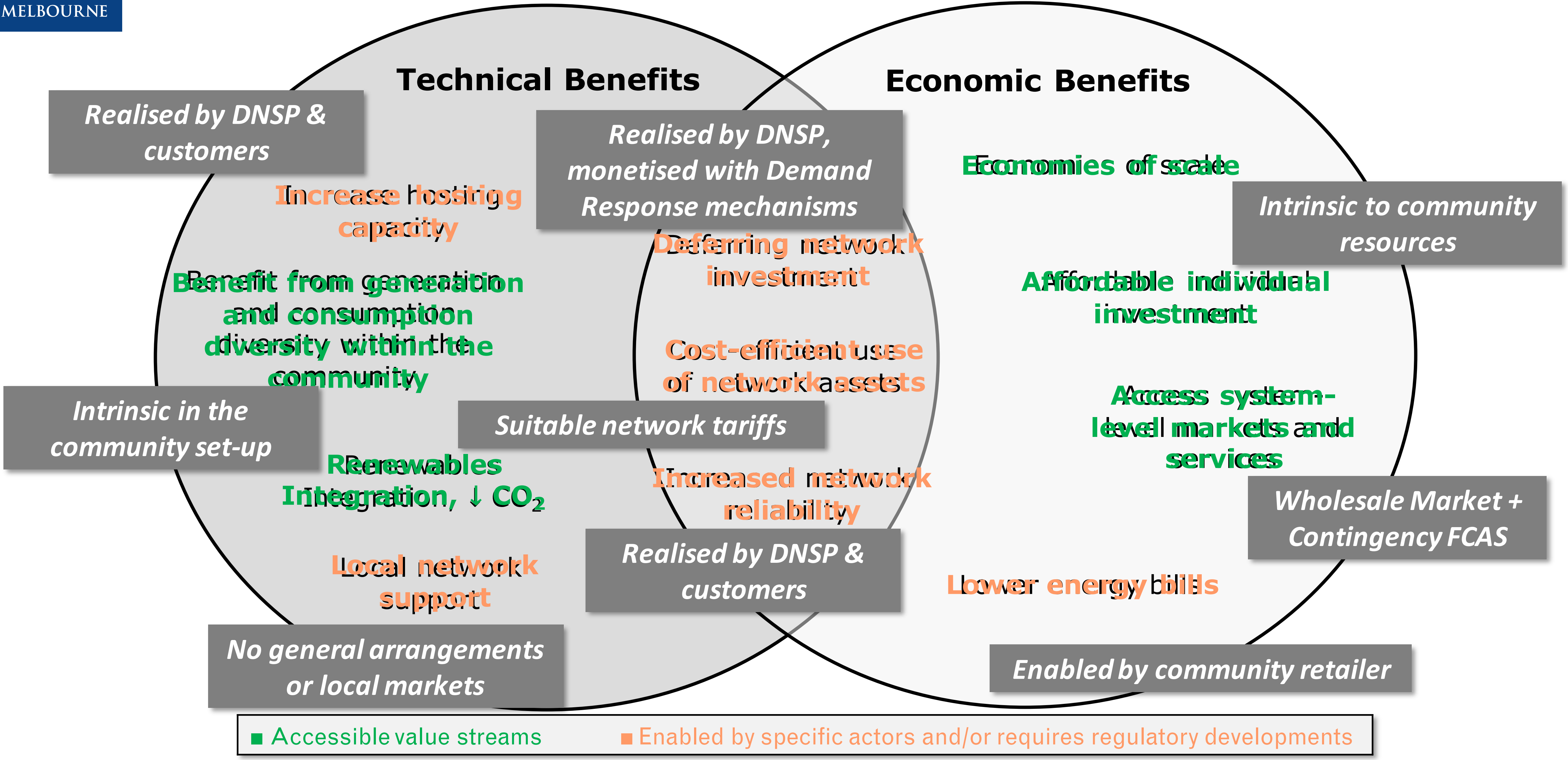
- The regulatory set-up will impact which of these benefits are actually realizable

Benefits that energy communities are incentivized to provide → *Accessible value streams* → *Economic feasibility*

- Our techno-economic model can include and quantify the different benefits energy communities can provide

- However, in the current regulatory set-up not all benefits can be accessed in a straightforward manner → impacting accessible value streams → economic feasibility

Regulatory set-up: Accessible value streams



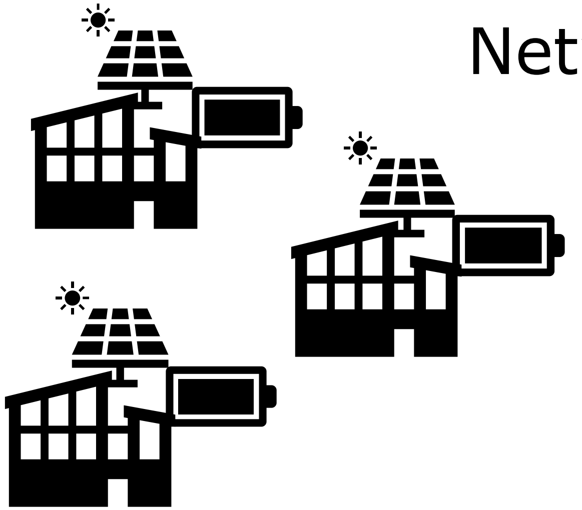
Regulatory set-up: Accessible value streams

- In summary:
  - Energy communities can relatively *easily* access some value streams:
    - Related to benefits from community-level resources (economies of scale, individual investment reduction) and community set-up
    - System-level markets: wholesale and FCAS
  - There are certain challenges on accessing other value streams:
    - Involving specific stakeholders is required to realize certain benefits
    - Some value streams require regulatory developments to be accessible

In our projects we aim to find solutions to access as many value streams as possible

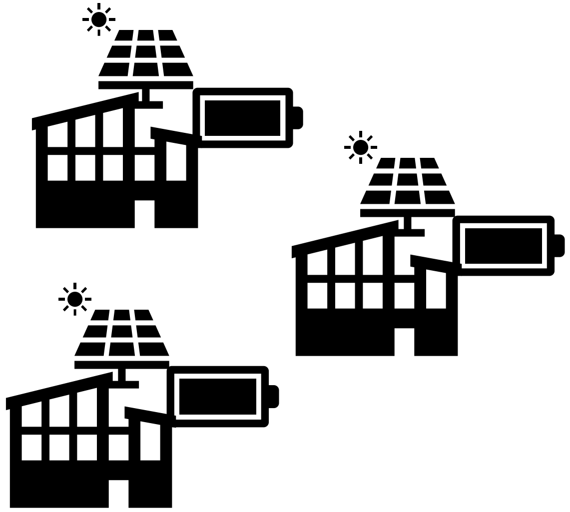
Power Melbourne

Network of Community Batteries



Power Melbourne: Project Overview

- Orchestrate a **network of community batteries** installed in different commercial buildings to maximise the benefits provided to the community
  - CB installed in commercial buildings with PV systems
  - No information on the larger community



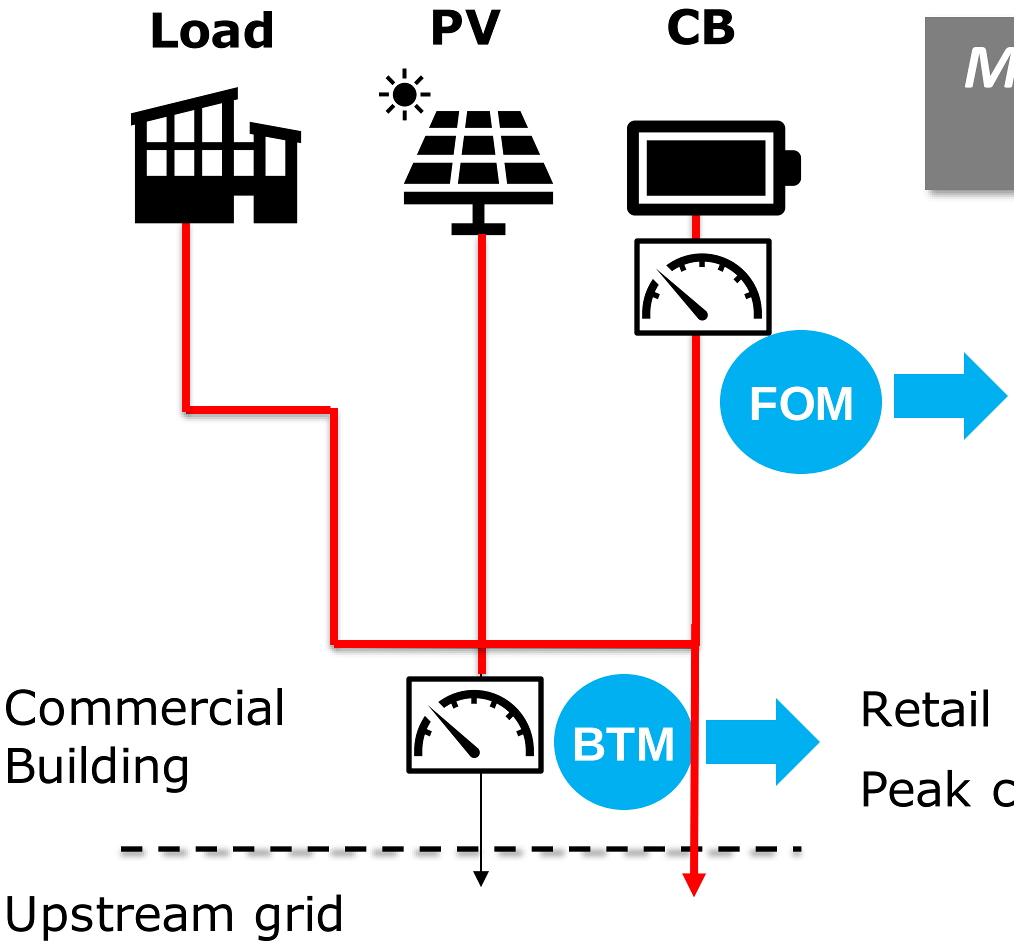
Power Melbourne: Project Overview

- We analyzed different community battery architectures within the commercial buildings
- We studied different commercial buildings with different network tariffs
  - Peak demand charged according to monthly peak
  - Peak demand charged annually
- We tested different community battery sizes with similar power/energy ratio
  - 50kW/135kWh
  - 100kW/200kWh
  - 200kW/400kWh
- We studied different system-level market conditions

- The project is commercially sensitive and therefore financial details must be withheld

Power Melbourne: Architecture to Maximize Accessible Value Streams

Meter architecture can limit the accessible value streams



Wholesale market arbitrage

FCAS

Network DR *(dependent on DNSP needs)*

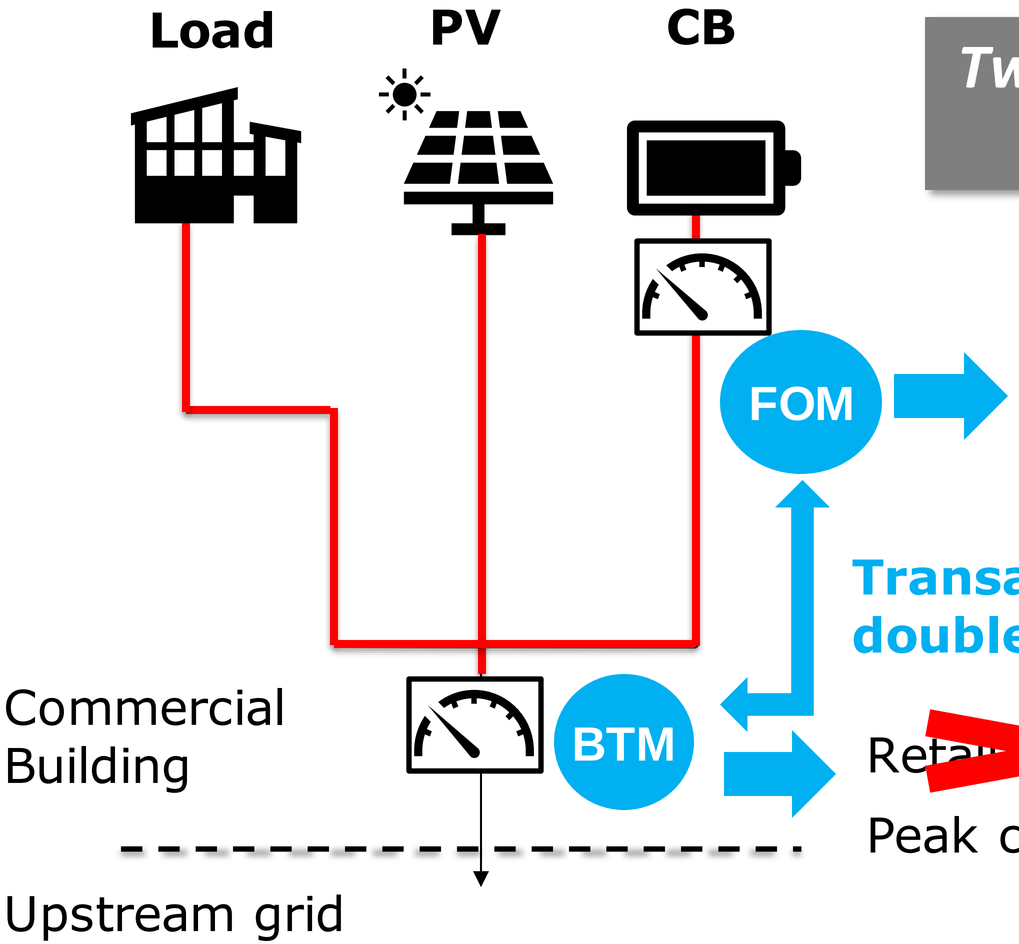
Retail tariff arbitrage

Peak charge reduction

BTM = Behind-the meter

FOM = Front of meter

Power Melbourne: Architecture to Maximize Accessible Value Streams



Two-meter architecture to access BTM and FOM value streams

Wholesale market arbitrage

FCAS

Network DR *(dependent on DNSP needs)*

Transactions to avoid double-counting energy

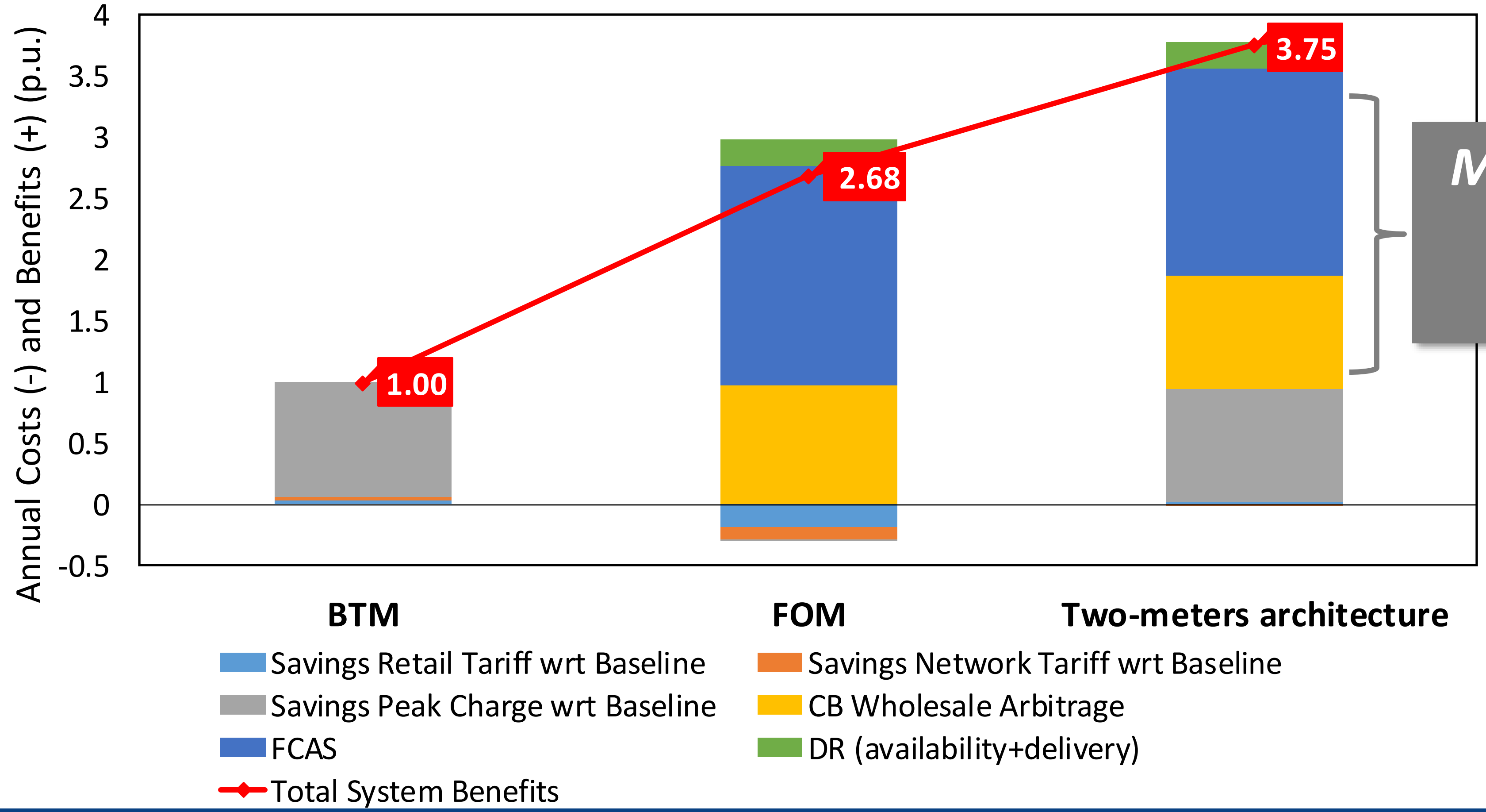
~~Reta[illegible]rbitrage~~

Peak charge reduction

Commercial building is a net-zero sum agent

Power Melbourne: Architecture to Maximize Accessible Value Streams (50kW/135kWh Battery)

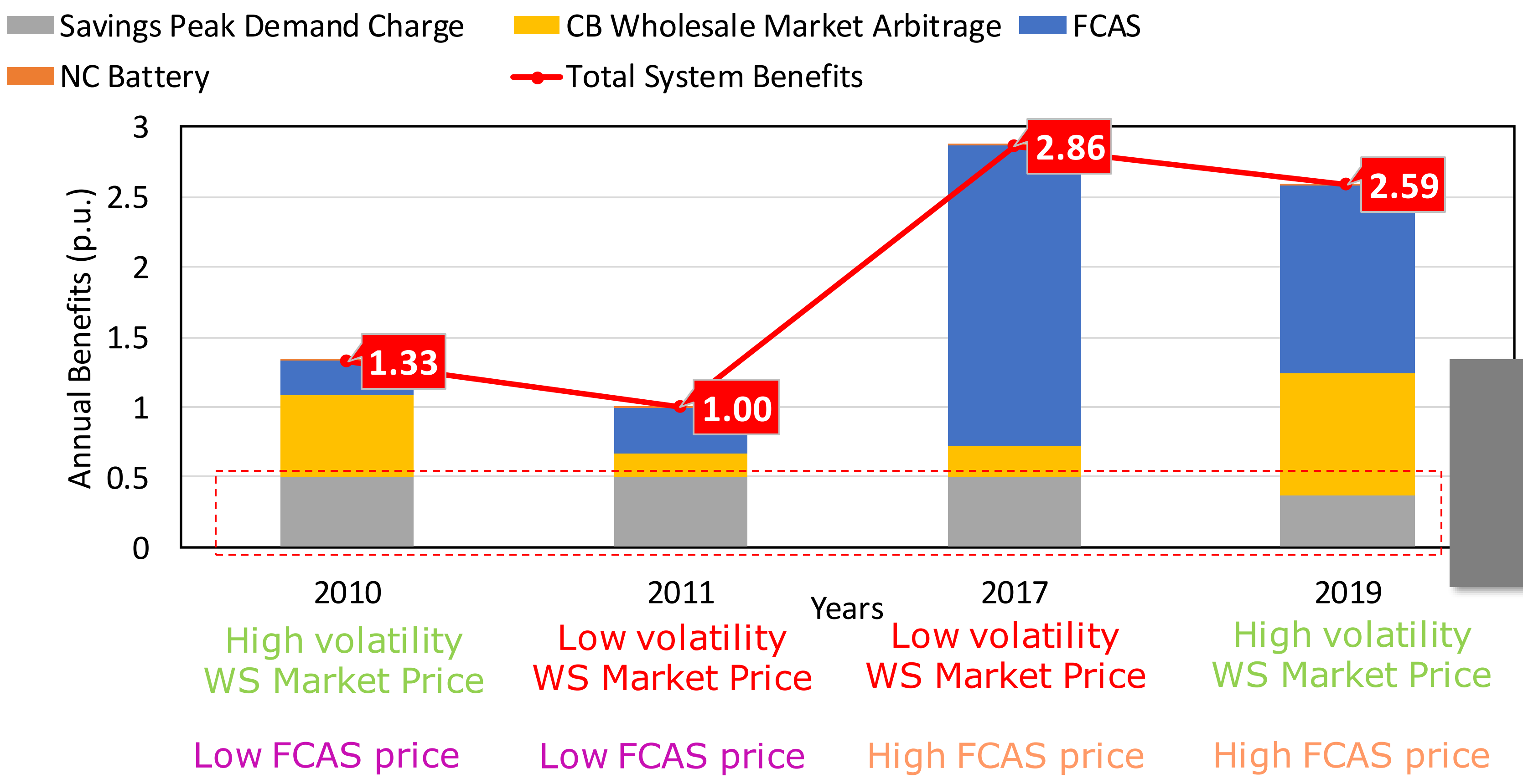
- Even when considering the issue of double counting energy, the two-meter architecture results in larger annual revenues



Most revenues come from system-level market participation

Power Melbourne: The impact of System-Level Markets (200kW/400kWh)

- With current accessible value streams **revenues** are **highly dependent on system-level markets** increasing the uncertainty in the feasibility of the project
- Co-optimization of BTM and FOM value streams is valuable for economic feasibility

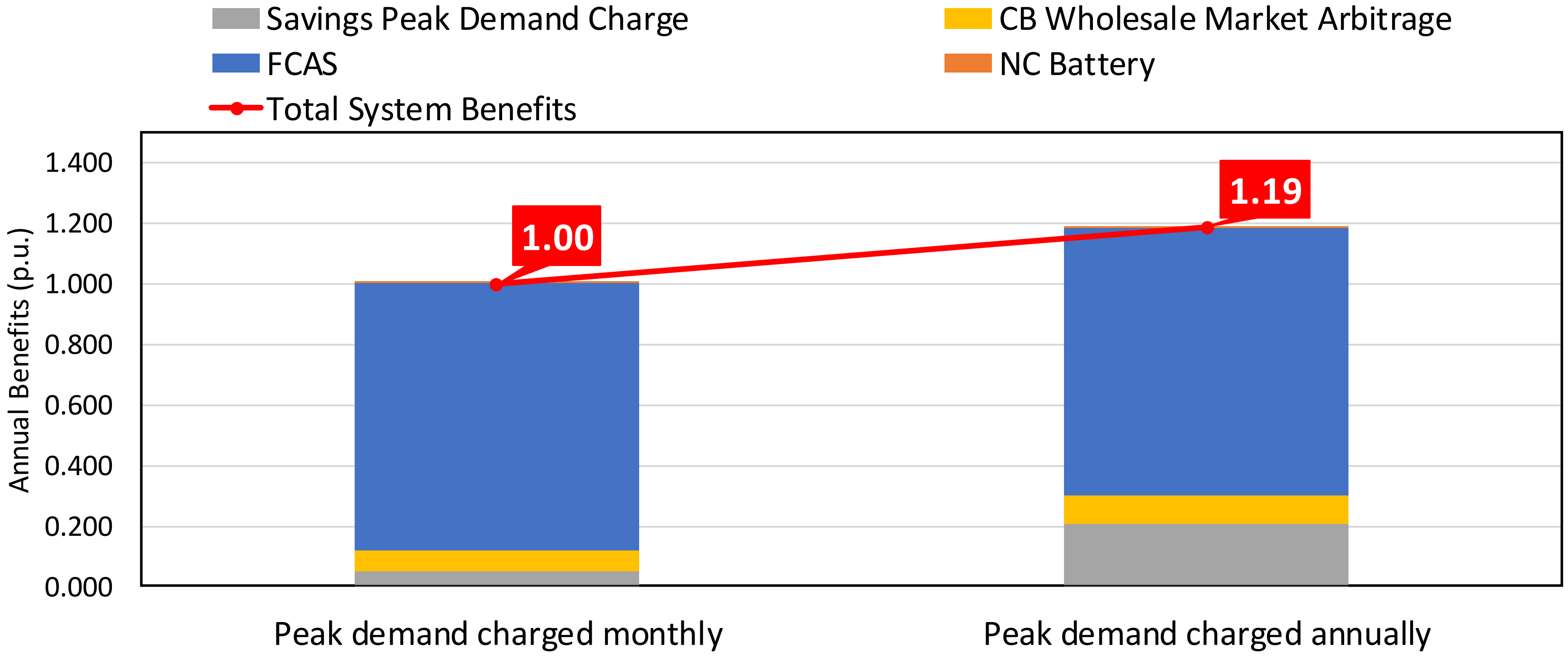


Peak demand savings remain fairly constant

Power Melbourne: Trade-offs in Co-optimization & Value-Stacking (200kW/400kWh)

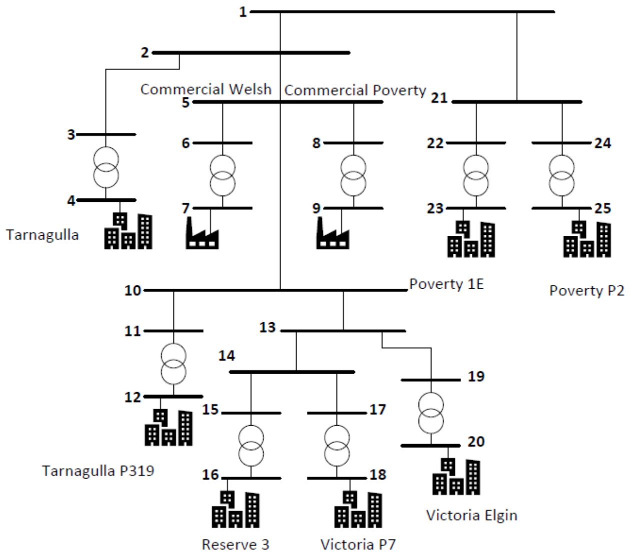
- Trade-offs arise when co-optimizing of local (BTM) and system-level (FOM) benefits
- Given same system-level market prices more flexibility in BTM price signals results in
  - Further participation in system-level markets
  - Reduction of peak demand in critical instances

Increased economic benefits

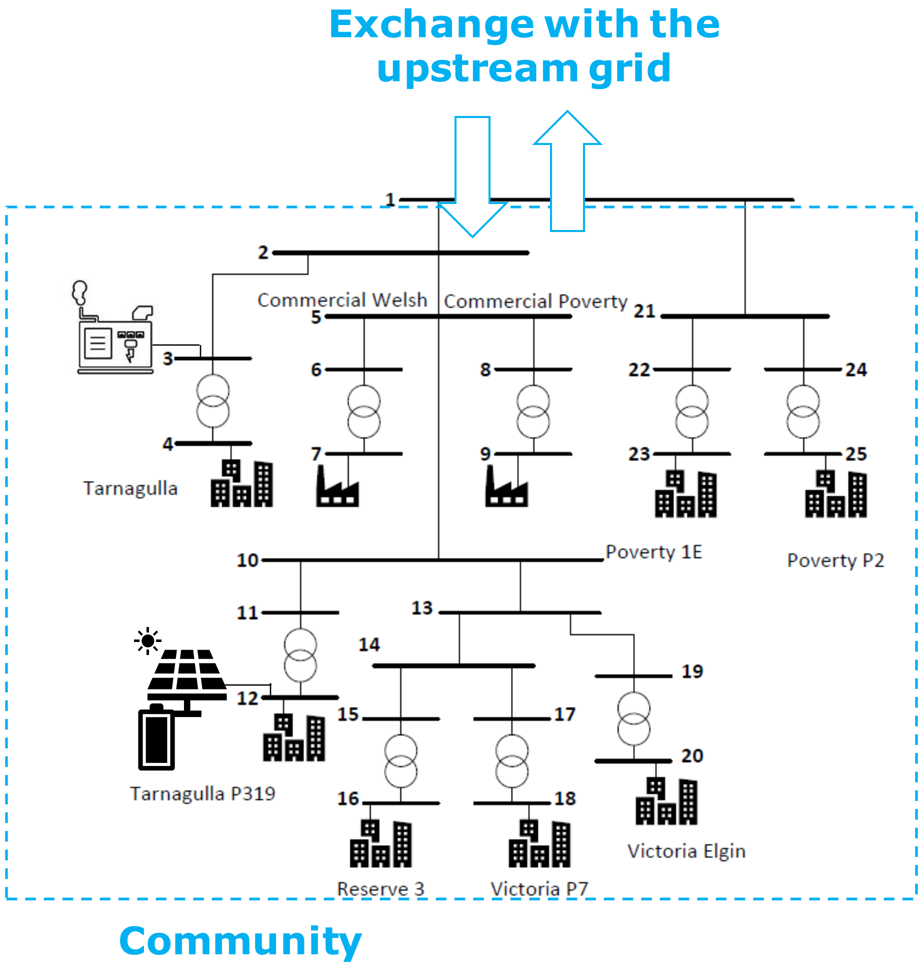


Donald and Tarnagulla Microgrid Feasibility Study

Economic and Risk Assessment

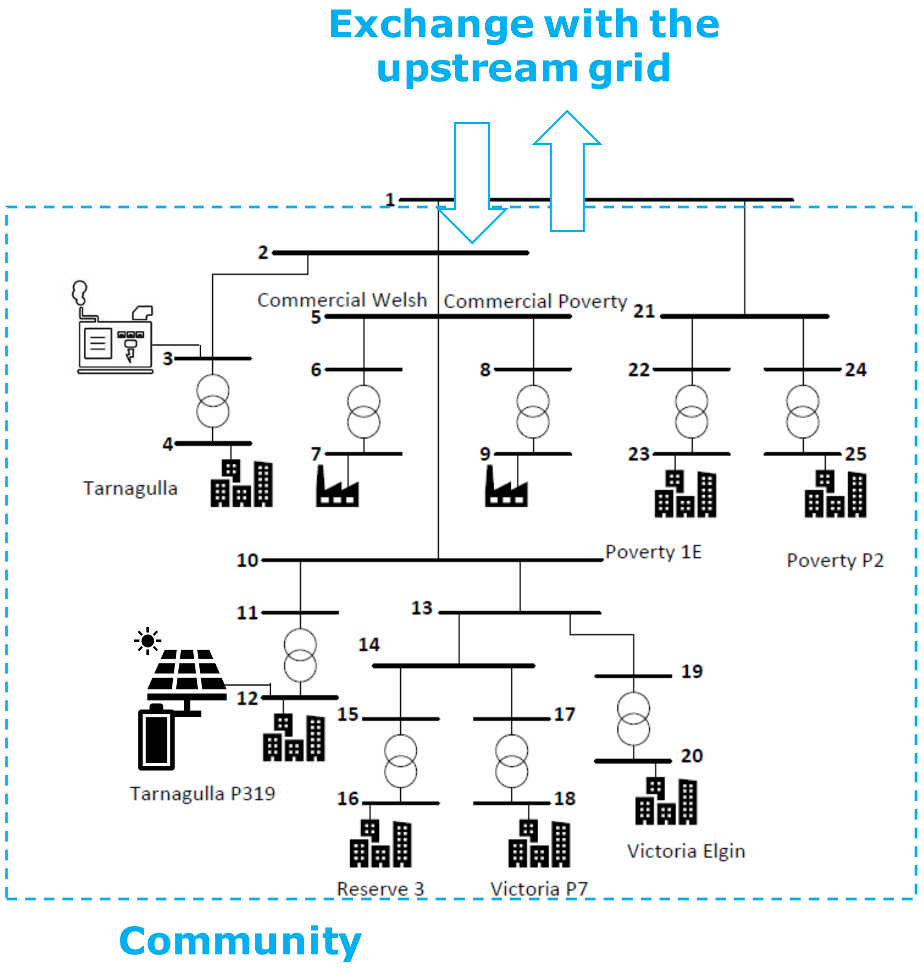


Microgrid Feasibility Study: Project Overview



- Main motivation for the energy community is to reduce the impact of extreme weather events
  - Install DER (PV, battery and diesel generator)
- Additionally, DER can benefit the community during *normal operation* by accessing various value streams
- We have information of the whole community
- Coordinate operation of the whole community with respect to the upstream grid
  - Capturing the benefit from diversity within the community

Microgrid Feasibility Study: Accessible Value Streams



Accessible Value Streams

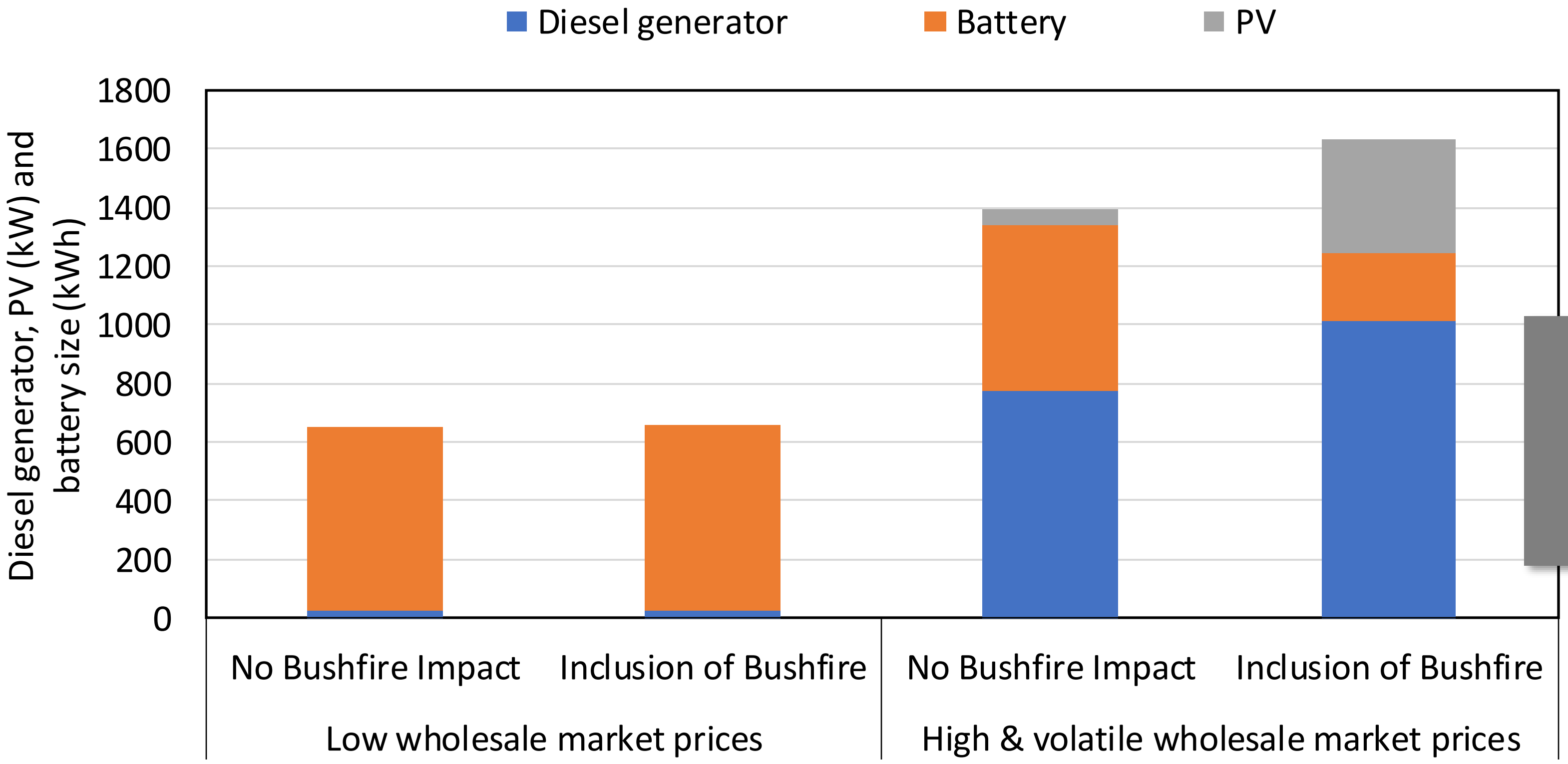
- Wholesale market arbitrage
- FCAS
- Increased reliability in extreme weather events
- Network DR *(dependent on DNSP needs)*

Challenges Accessing Value Streams

- Network tariffs applied to customer-level
- Local support can be provided but it is not directly monetized

Microgrid Feasibility Study: Optimal Investment in DER

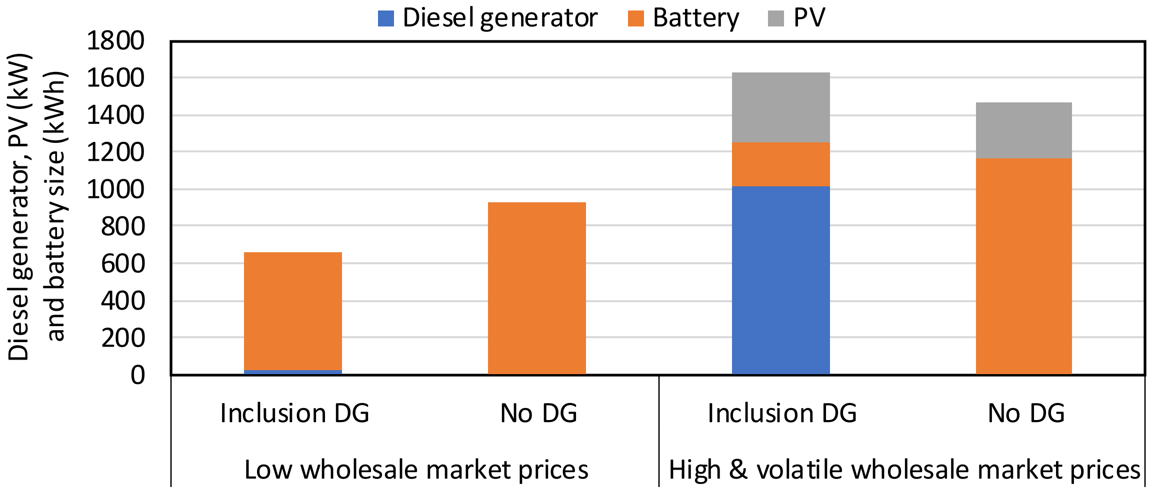
- There are synergies between the required investment for normal operation and to withstand extreme weather events, like bushfires
- Wholesale prices are the main uncertain parameter affecting investment decisions

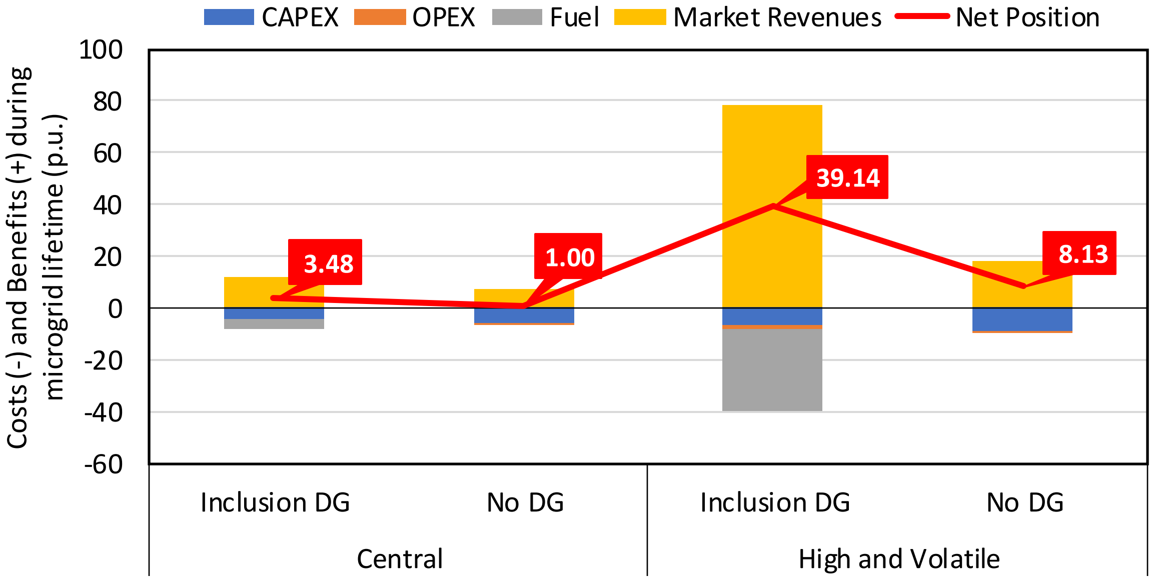


Diesel generator to be dispatched in high price periods

Microgrid Feasibility Study: Environmental Considerations

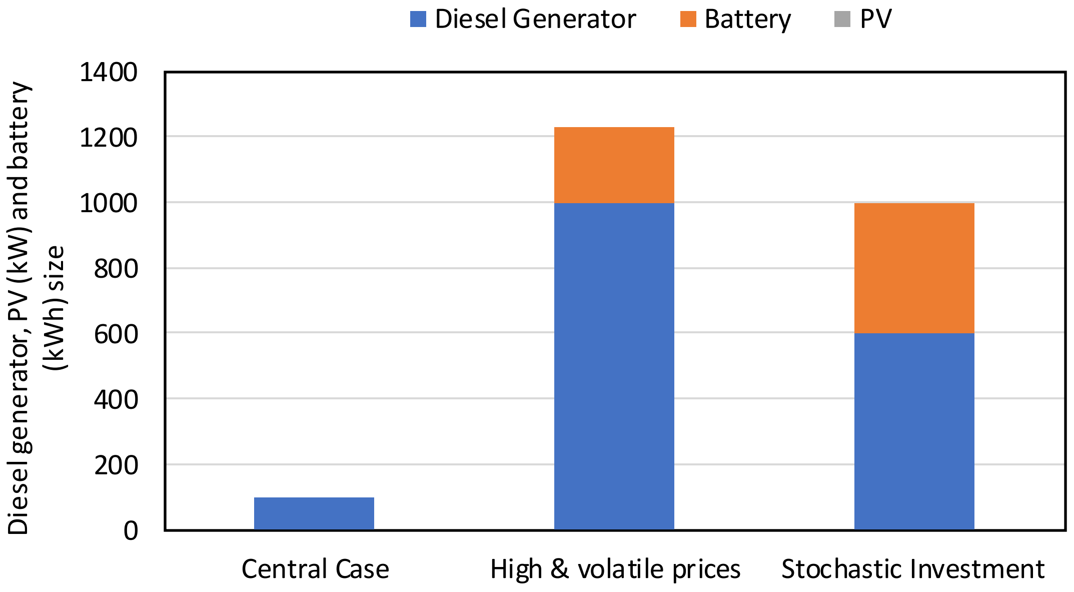
- Energy communities are often motivated by environmental aspects
  - Is investment in diesel generator (DG) really needed?
- Tested the microgrid investment & operation with no diesel generator
  - Increase investment in batteries as flexible assets
  - Reduction in economic benefits
- Investing in batteries enables to remove an additional uncertainty: **fuel cost**
  - Assumption: \$300/MWh fuel cost
  - **Break even fuel cost ≈ \$500/MWh**





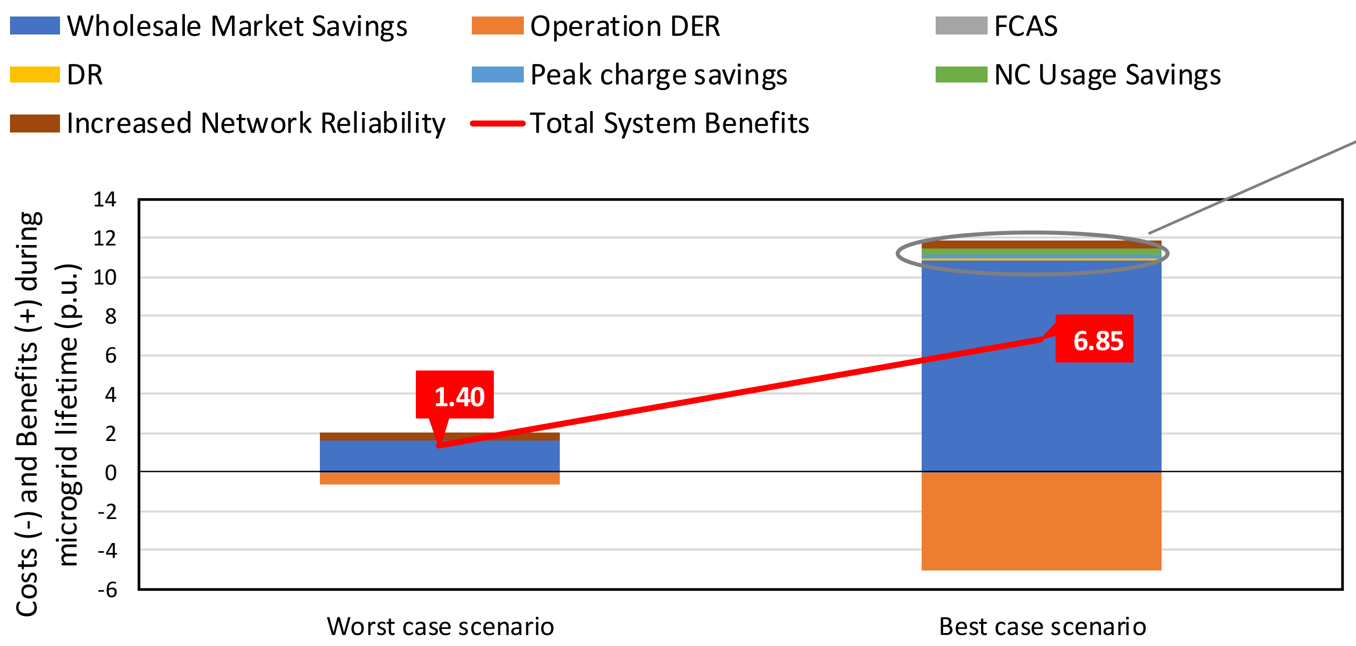
Microgrid Feasibility Study: Flexible Assets to Withstand Uncertainty

- There is value on making decisions robust to uncertain system-level market conditions
  - Stochastic investment analysis allows us to implicitly capture the value of flexible assets that can provide benefits to the community in different conditions
- Decisions might not be optimal for a specific scenario, but when considering the impact of uncertainty, they bring considerable value to the energy community



Microgrid Feasibility Study: Value Stream Breakdown

- Stochastic decision applied to two extremes of value the microgrid can provide
  - Worst-case scenario: low system-level market prices, no additional value streams
  - Best-case scenario: high system-level market prices, regulatory developments for additional value streams: **community network tariff & DR to defer investment**
- Considerable differences in the value provided: due to system-level market prices



Additional value streams ≈15% of the total profits

Steady source of revenues through the lifetime

Economic feasibility less dependent on system markets

Microgrid Feasibility Study: Technical Benefits

- With our modelling we can **quantify significant technical benefits** energy communities can provide
  - Requires a whole-system view and modelling of local community & different stakeholders
- While there is relevant **potential** the **regulatory set-up** does **not** properly **incentivize** the provision of **local services**

Value stream	Performance
Cost-efficient use of network	200 kW monthly average peak reduction
Deferring network investment	48 kW demand reduction during summer peak
Increase hosting capacity through local voltage management	24.34 MVArh average monthly reactive power support provided

Key Insights

- **Sharing of resources** in community energy systems can provide **multiple additional techno-economic benefits** relative to more distributed resources
- Our modelling allows to **capture the whole-system value** of energy communities, quantify and maximise relevant benefits via **multi-service value stack co-optimization**
- **Flexible assets** can **reduce risk** across multiple futures with **different prices** and **stochastic investment** analysis is required to **capture their full value**
- The way forward: **involving various stakeholders** (retailers, DNSP) allows energy communities to **access more value streams** (e.g., increased network reliability) which **improves economic feasibility** reducing the impact of uncertain system-level market prices

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