Centre for Energy and Environmental Markets

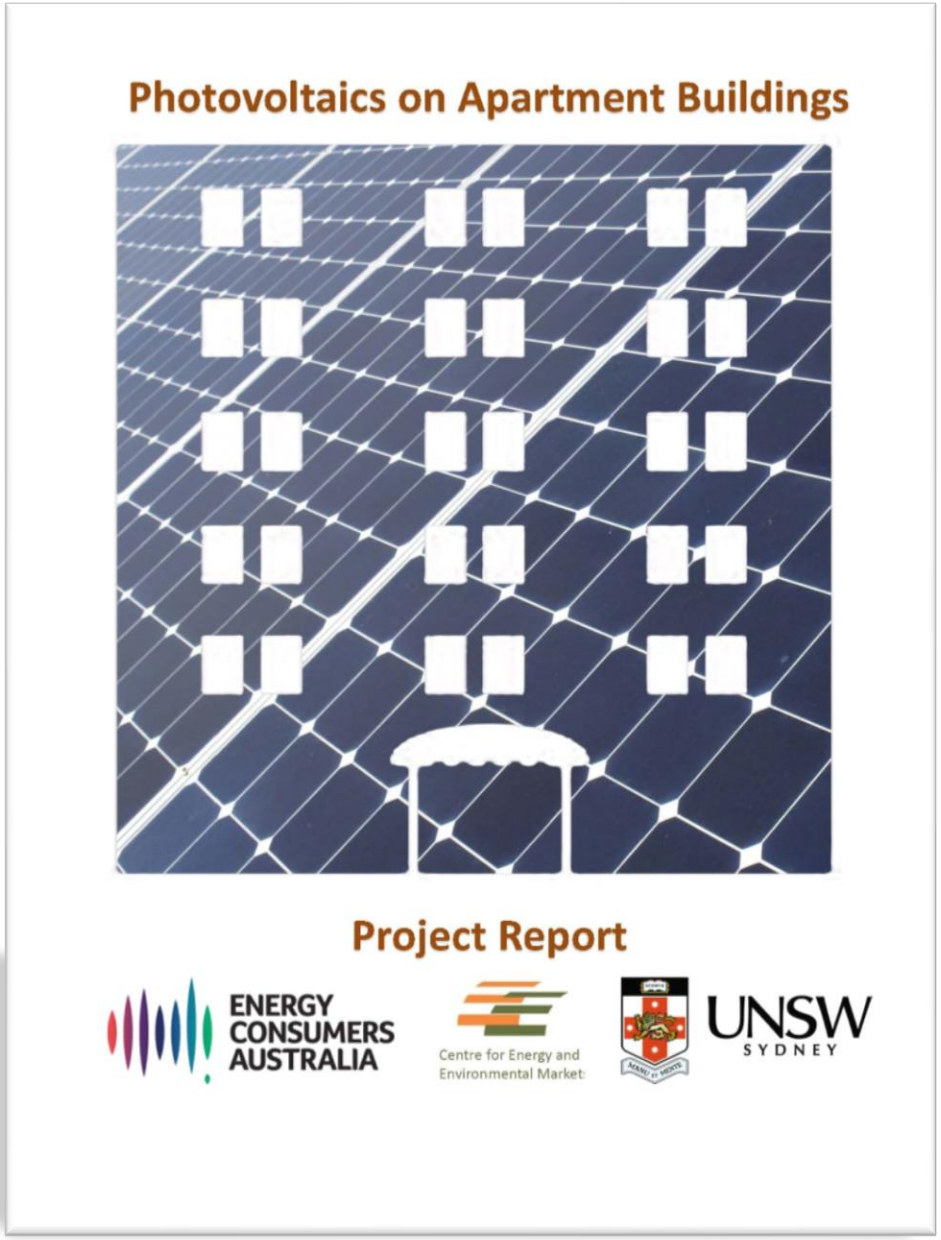
UNSW SYDNEY Australia's Global University

Solar Apartment Model

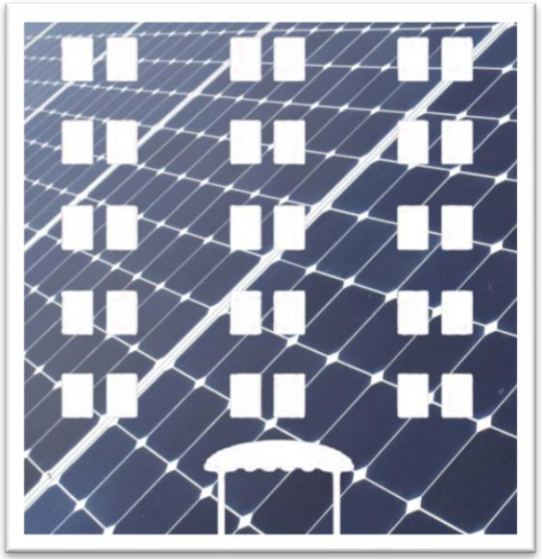
Mike Roberts

Background

- A 3-year “Solar Apartments” project funded by Energy Consumers Australia and CRC for Low Carbon Living, exploring opportunities and barriers for increasing PV deployment on Australian apartment buildings
- Developed a Python tool (*morePVs*) multi-occupancy residential energy PV and storage
- Report published April 2019 – available from www.ceem.unsw.edu.au



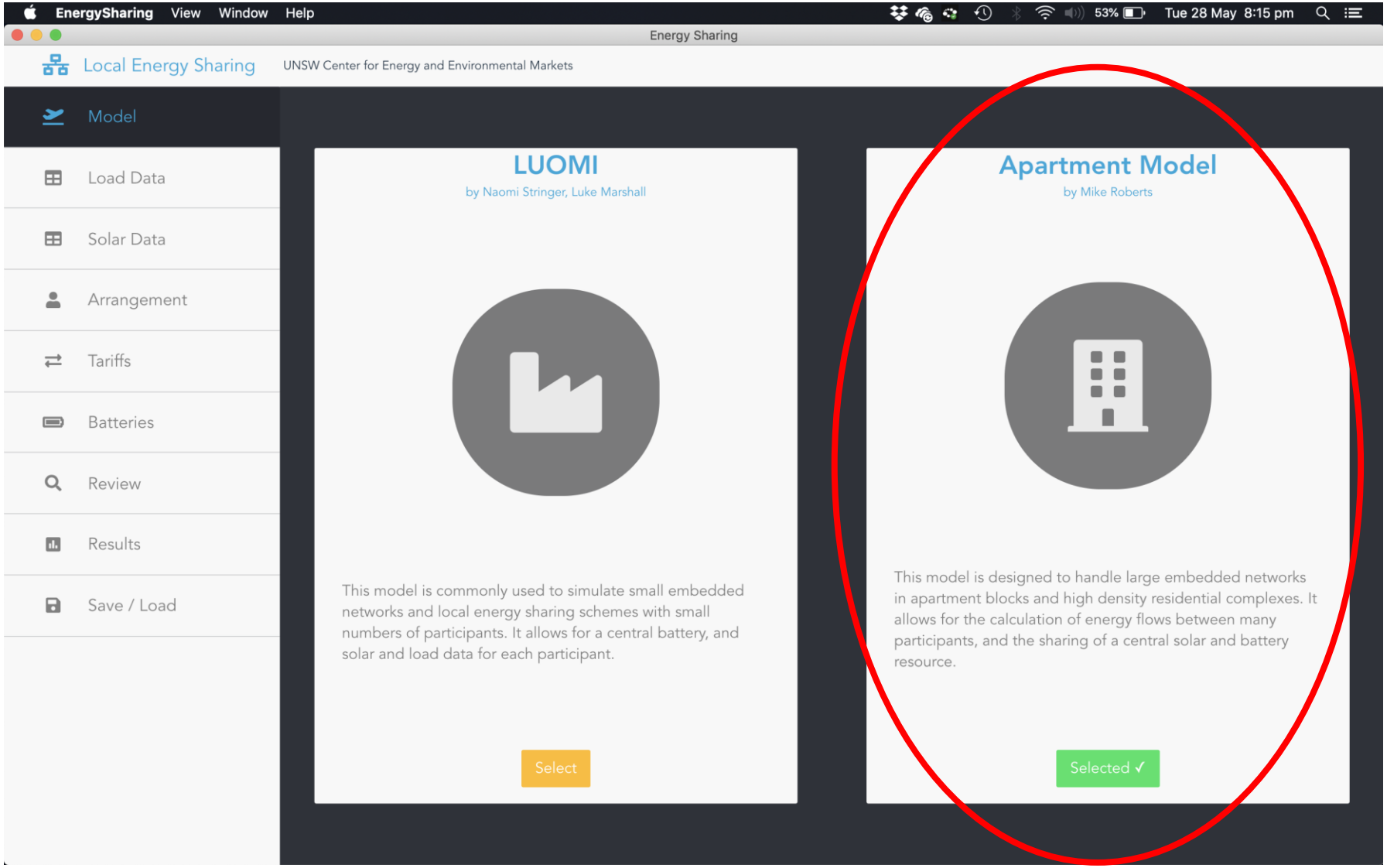
Why model Solar Apartments?



- Big untapped PV opportunity
- Complexity of strata decision-making
- A need for clear, accurate information
- Multiple technical arrangements
- Multiple financial options
- High Variability and Building-Specificity:
  - Rooftop PV Capacity
  - Load profiles
  - Existing electrical infrastructure

Centre for Energy and Environmental Markets

UNSW SYDNEY Australia's Global University



Potential Users

Centre for Energy and Environmental Markets

UNSW SYDNEY Australia's Global University

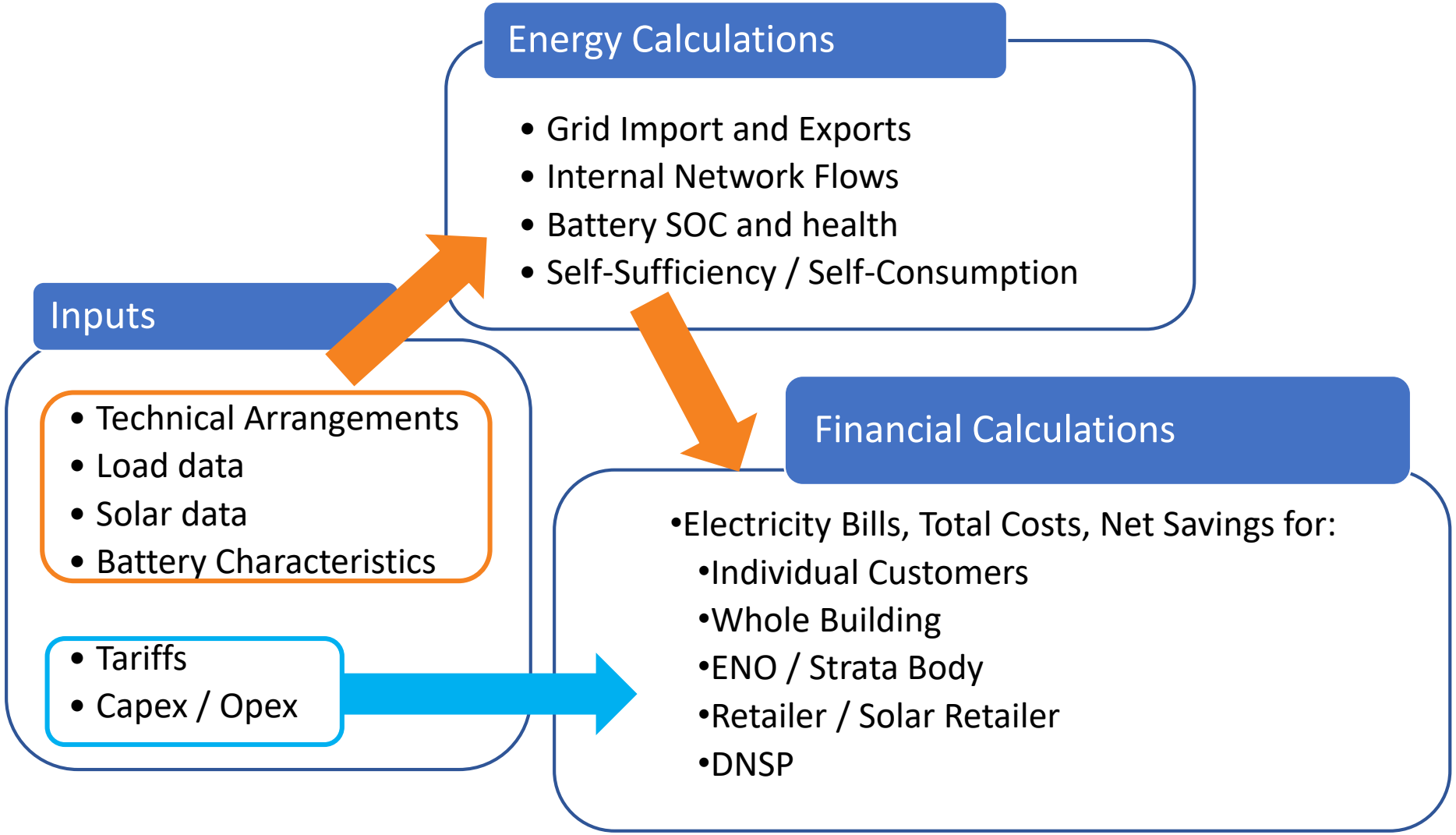
To inform customer decision making:

- Strata bodies – apartments / community title
- Advocacy / Advice agencies
- Local Councils
- Community Housing
- Energy Consultants

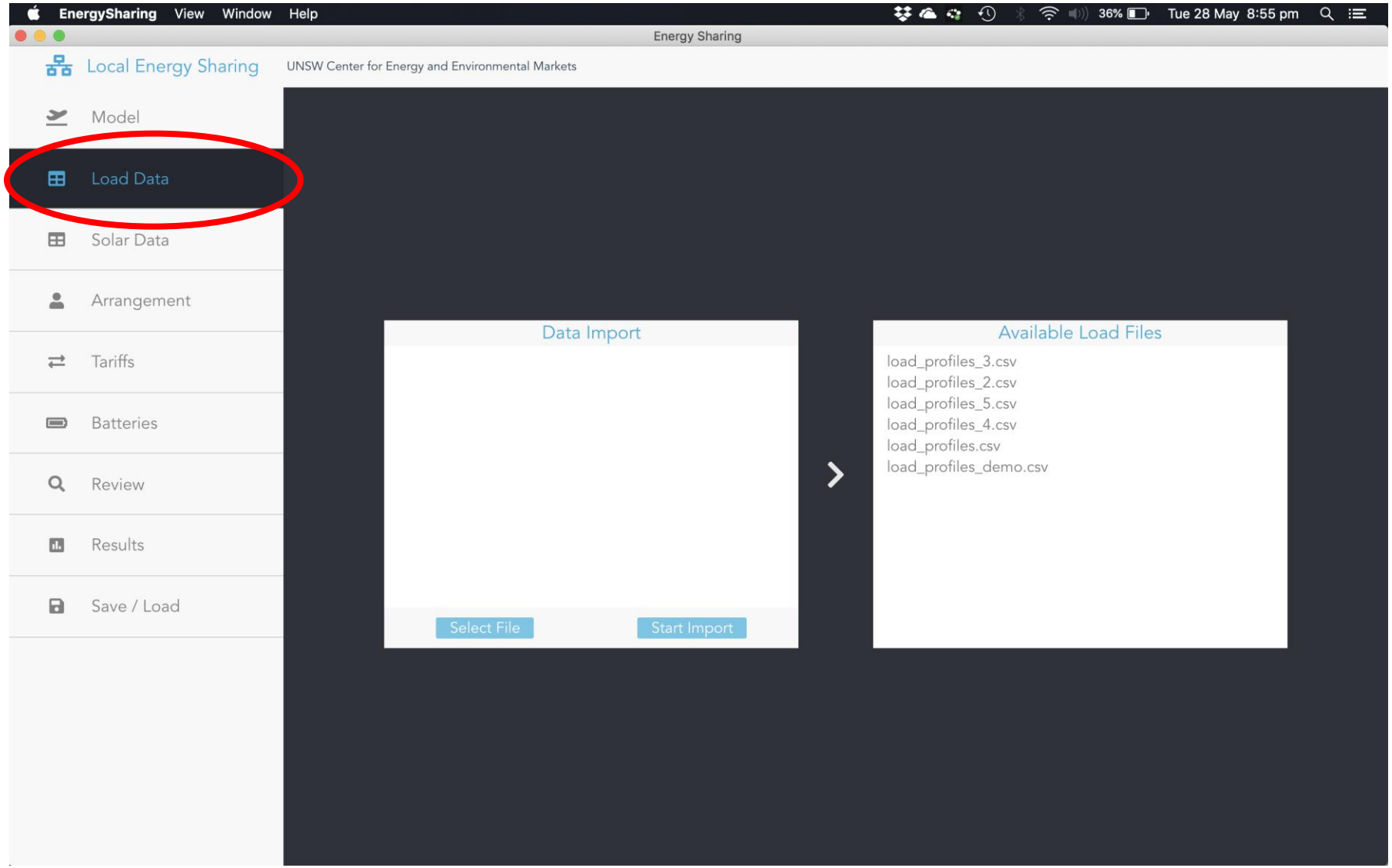
To assist planning:

- ENO's / ENM's / ENSP's
- Retailers

Model Outline

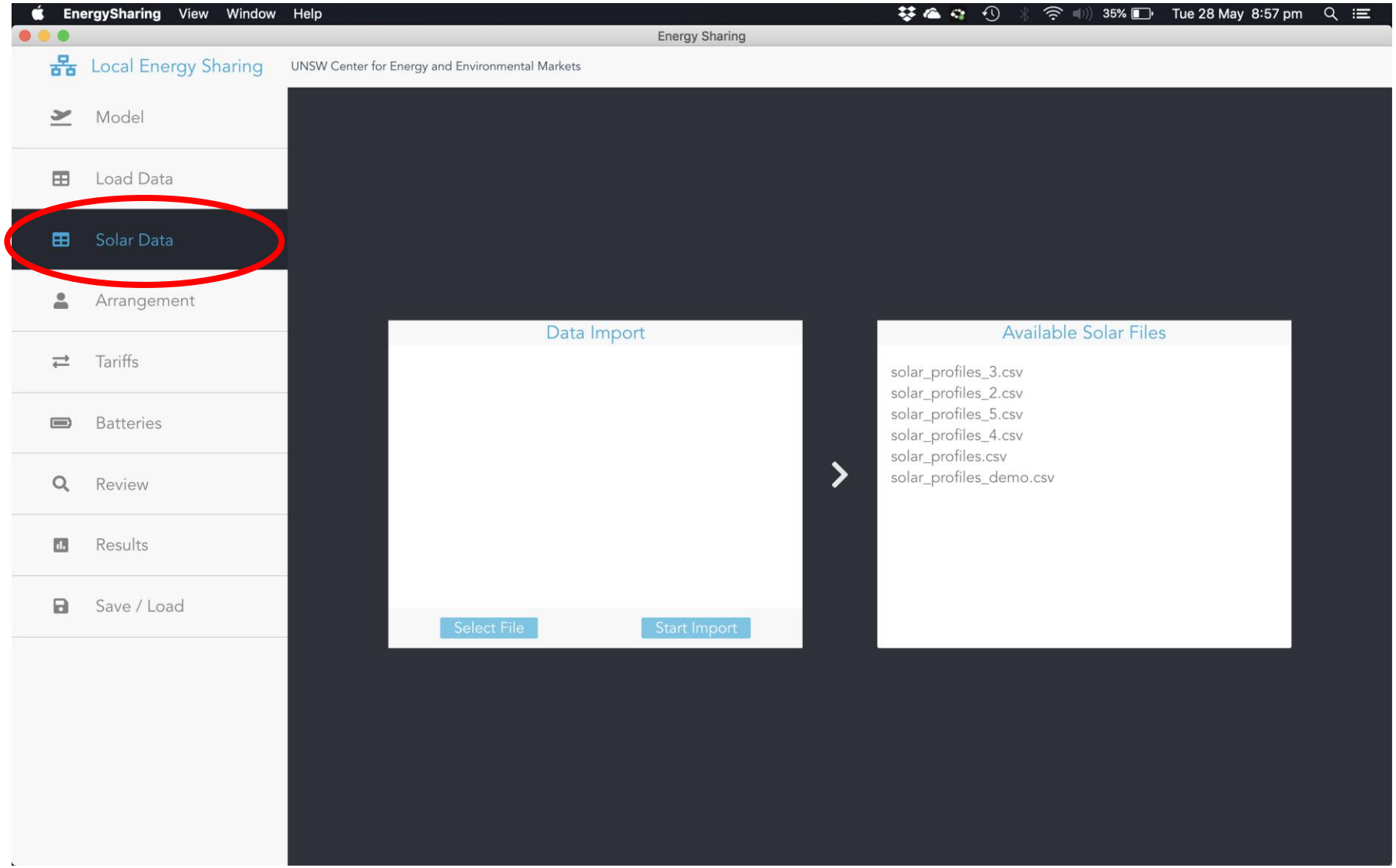


Input Data



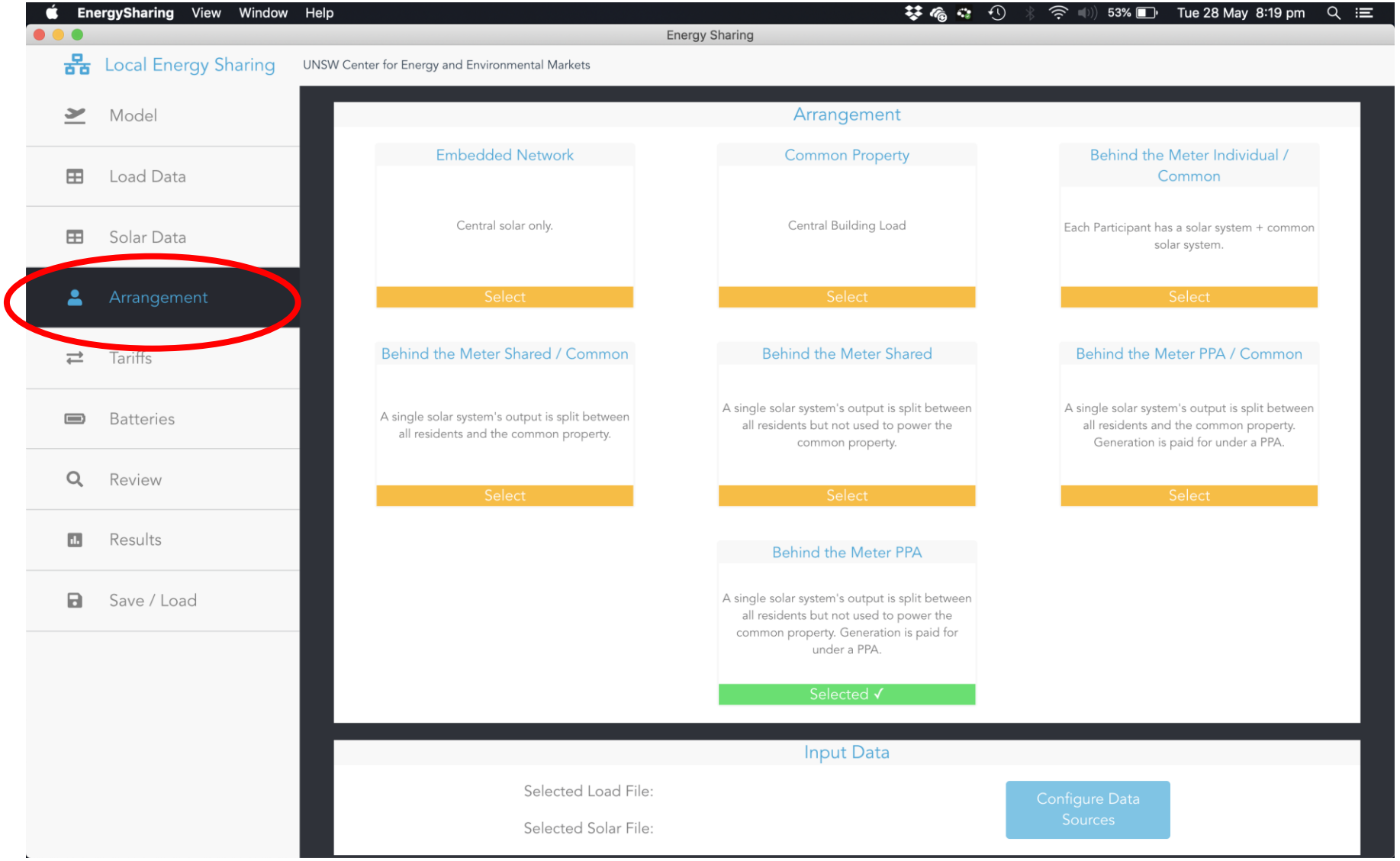
Centre for Energy and Environmental Markets

UNSW SYDNEY Australia's Global University


EnergySharing View Window Help
35% Tue 28 May 8:57 pm
Energy Sharing
Local Energy Sharing
UNSW Center for Energy and Environmental Markets
Model
Load Data
Solar Data
Arrangement
Tariffs
Batteries
Review
Results
Save / Load
Data Import
Select File
Start Import
Available Solar Files
solar_profiles_3.csv
solar_profiles_2.csv
solar_profiles_5.csv
solar_profiles_4.csv
solar_profiles.csv
solar_profiles_demo.csv

Technical Arrangements

PV Installation Arrangements



PV Installation Arrangements

Centre for Energy and Environmental Markets

UNSW SYDNEY Australia's Global University

BAU

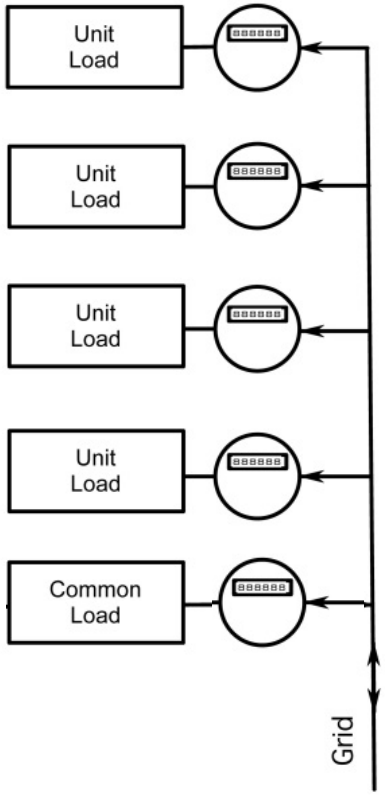
Individual BTM

Shared BTM

Embedded Network

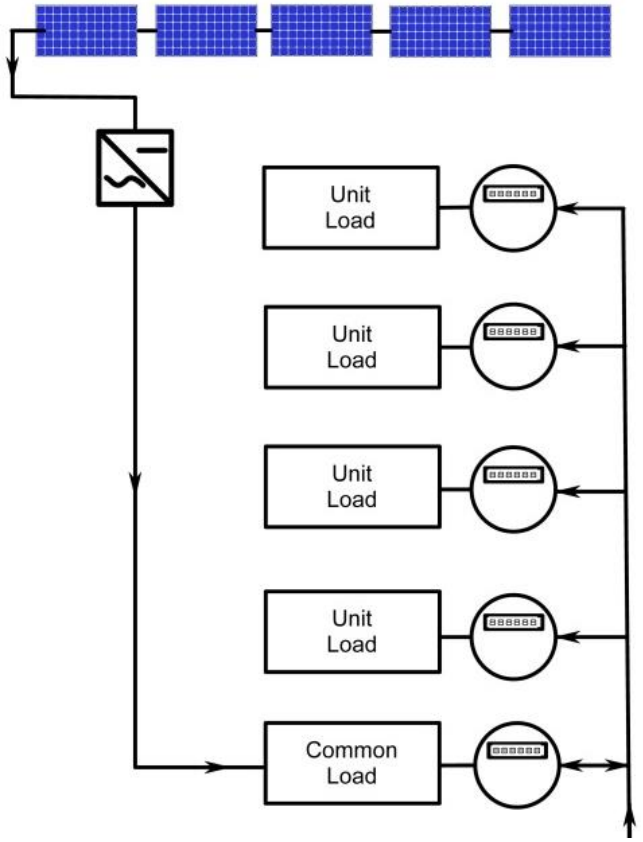
BAU

- All Customers on-market with a retailer of their choice
- No PV

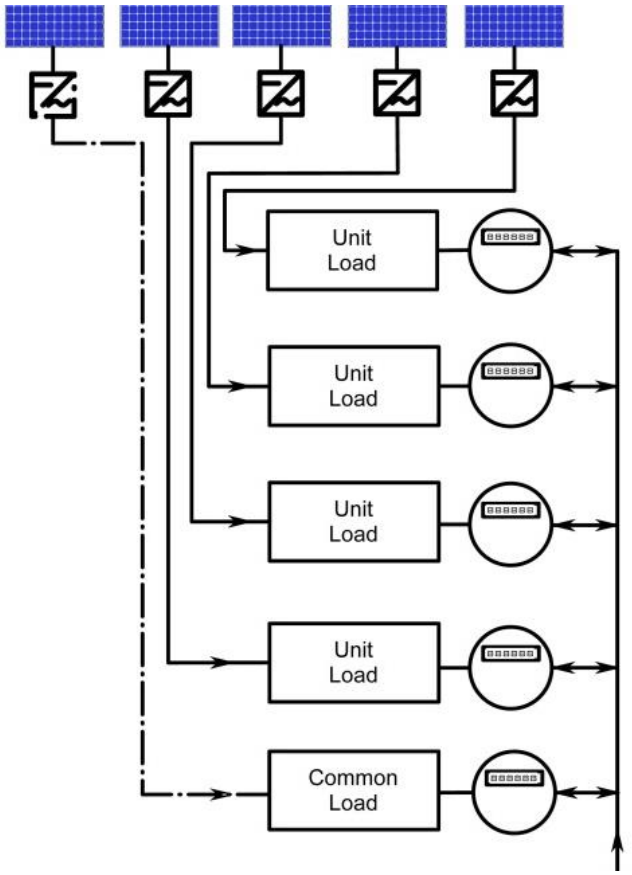


Not implemented in Beta

Individual Behind The Meter

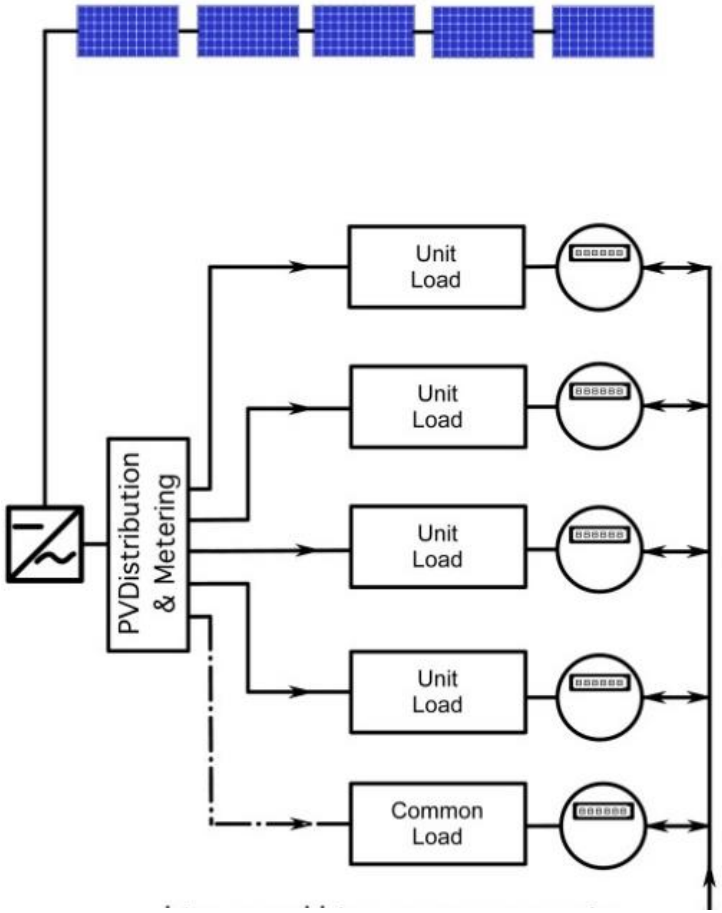


Common Property



Units (& Common Property)

Shared Behind the Meter



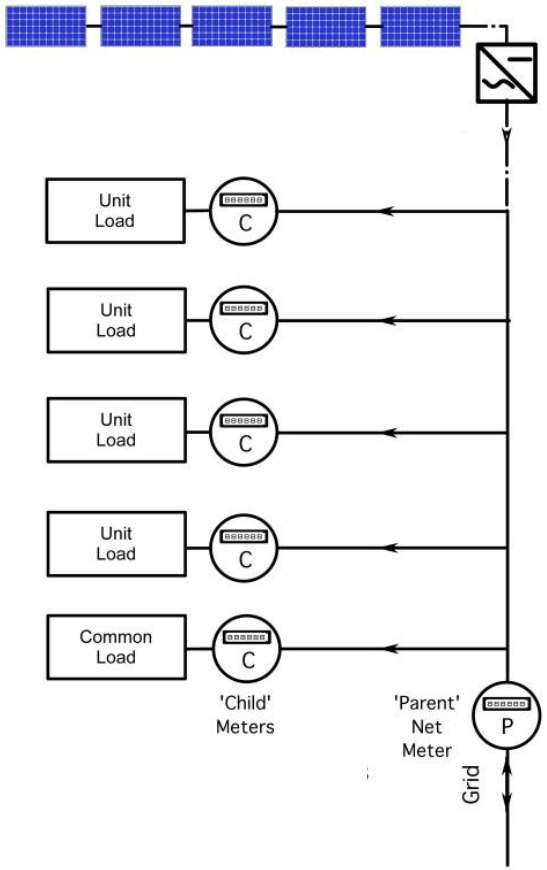
- All Customers on-market with a retailer of their choice
- PV distributed BTM by 'Solar retailer' (e.g. Allume)
- Units or Units + CP
- Generation allocated proportional to instantaneous load

Solar PPA with 2 rates:

- Solar consumption at Solar tariff
- Export at rate = FiT

Or capex and opex paid by strata body

Embedded Network



- All Customers off-market (buy from ENO)
- Shared PV owned by ENO or by Strata Body
- ENO purchases from retailer at ’Parent Tariff’
- (Individual PV not in this model)

PV Installation Arrangements

Centre for Energy and Environmental Markets

UNSW SYDNEY Australia's Global University

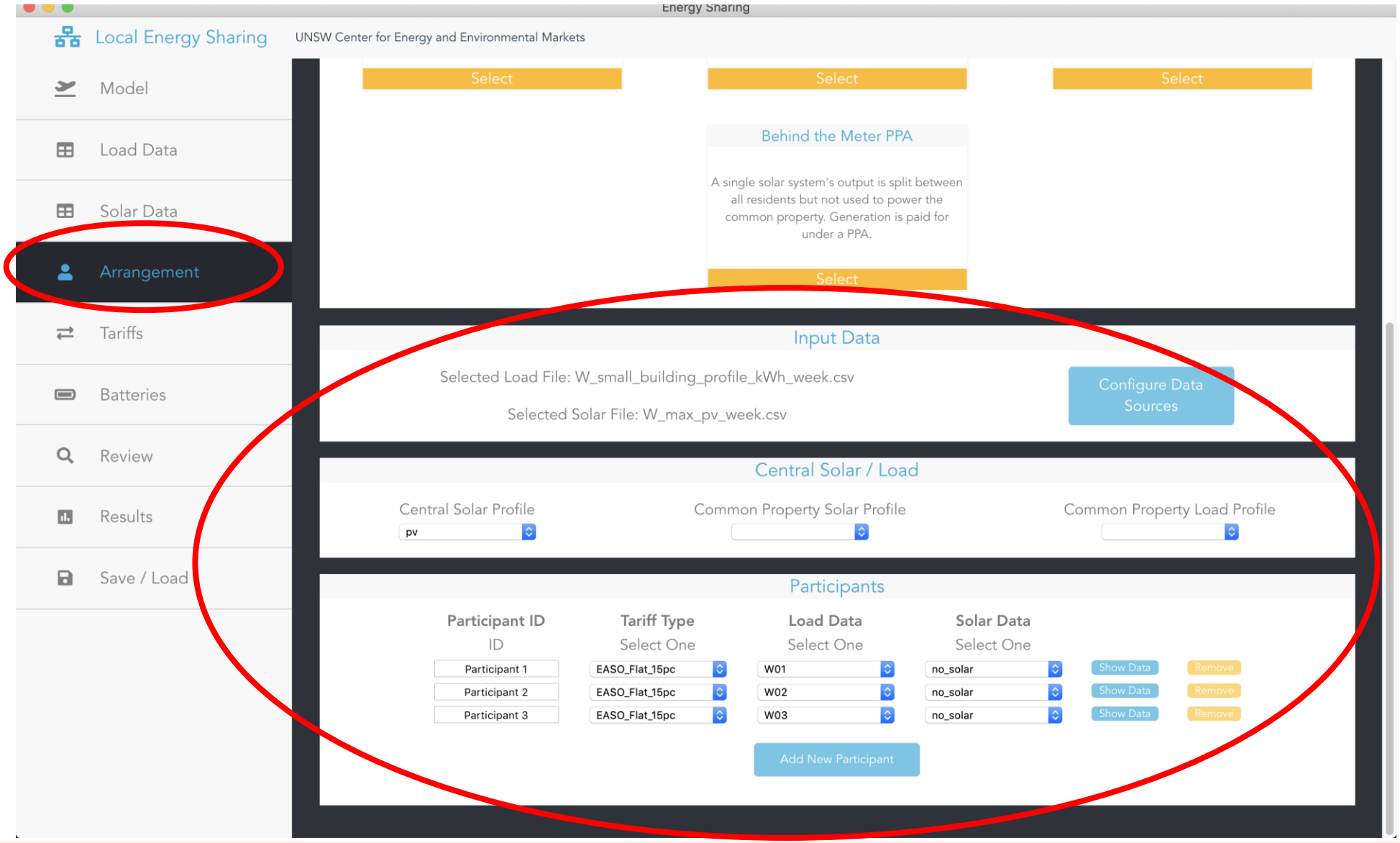
BAU

	Individual BTM	Shared BTM	Embedded Network
LOAD	Common Property, Units	Common Property, Units	Common Property, Units
OWNERSHIP	Strata / Unit owners	Solar PPA, Strata Owned	ENO, Strata Owned, Individual PV

This model doesn't include peer to peer or off-site PV

Not implemented in Beta

Tariffs

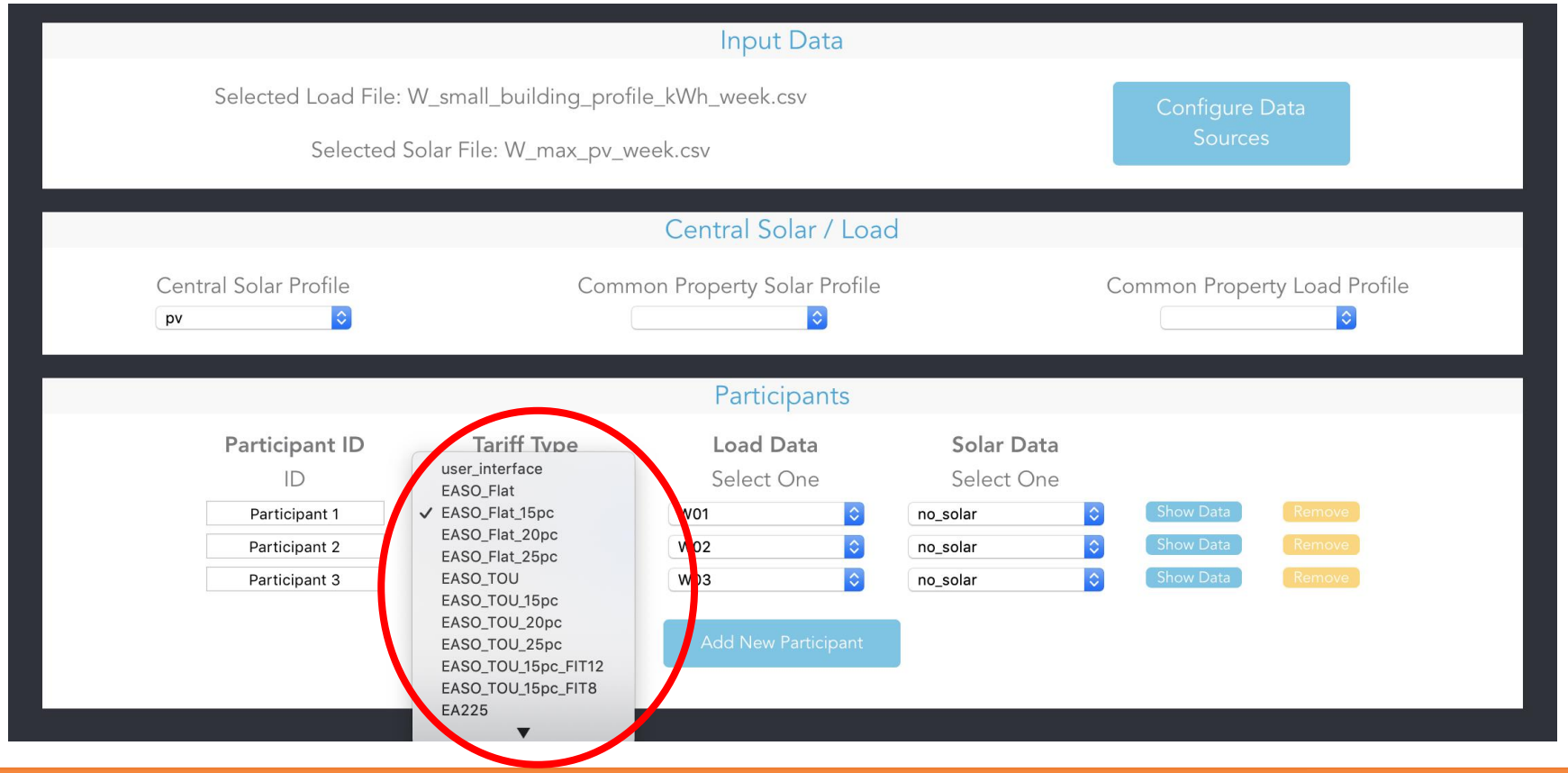

Energy Sharing
Local Energy Sharing
UNSW Center for Energy and Environmental Markets
Model
Load Data
Solar Data
Arrangement
Tariffs
Batteries
Review
Results
Save / Load
Select
Select
Select
Behind the Meter PPA
A single solar system's output is split between all residents but not used to power the common property. Generation is paid for under a PPA.
Select
Input Data
Selected Load File: W_small_building_profile_kWh_week.csv
Selected Solar File: W_max_pv_week.csv
Configure Data Sources
Central Solar / Load
Central Solar Profile
pv
Common Property Solar Profile
Common Property Load Profile
Participants
Participant ID
ID
Tariff Type
Select One
Load Data
Select One
Solar Data
Select One
Participant 1
EASO_Flat_15pc
W01
no_solar
Show Data
Remove
Participant 2
EASO_Flat_15pc
W02
no_solar
Show Data
Remove
Participant 3
EASO_Flat_15pc
W03
no_solar
Show Data
Remove
Add New Participant

Tariffs

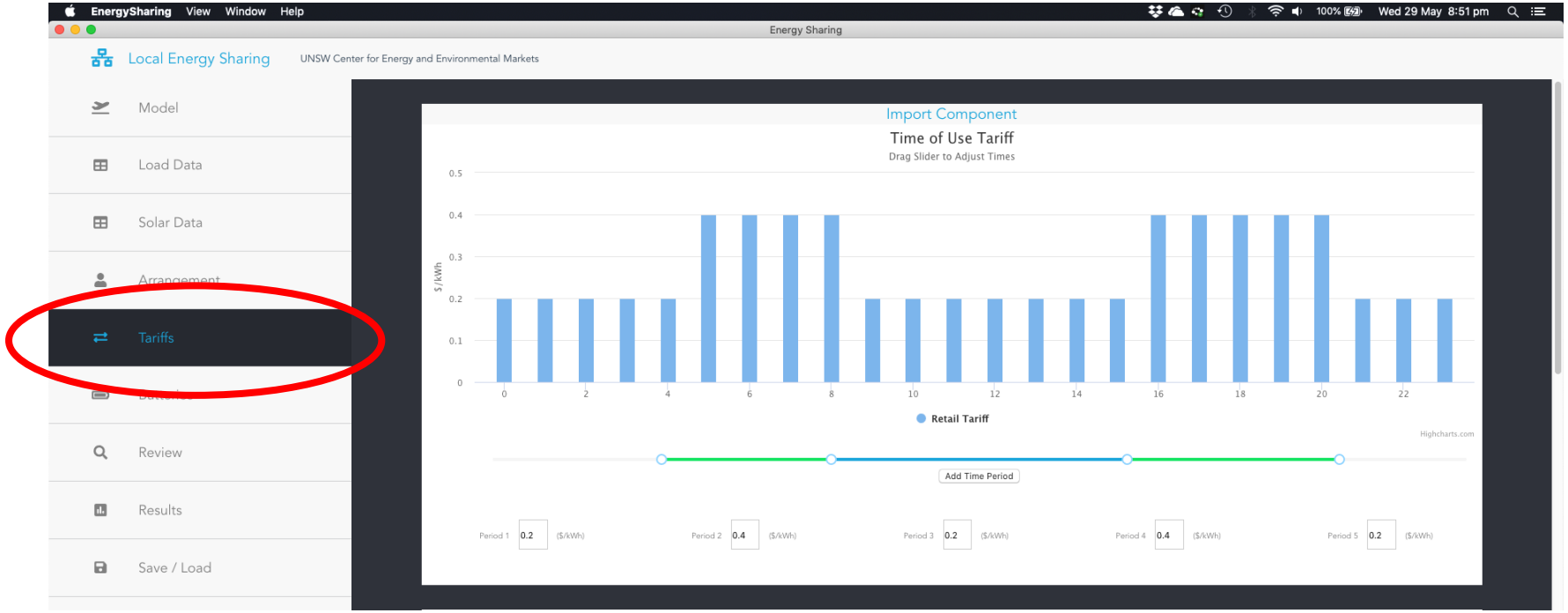
- Customer Retail Tariffs
- Solar Tariff (for Solar PPA)

- Parent Tariff (for EN)
- Network Tariff

Not implemented in Beta



Tariffs: *user_interface*



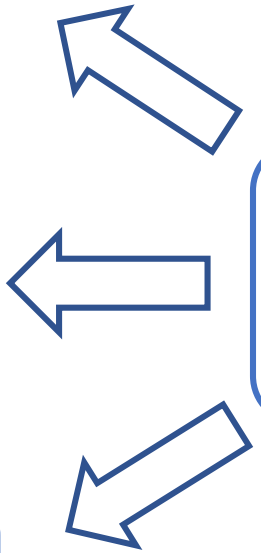
- Flat rate
- TOU rates – multiple periods and rates
- Block tariffs
- Fixed charges
- Demand charges

Capex / Opex / Finance

PV CAPEX:
- System $
- Inverter $
- Inverter Lifetime

EN Capex / Opex:
- Capex $ / unit
- Capex $ / building
- Opex $ / unit

Battery Capex:
- Total System or $/kWh
- Inverter cost
- Battery Life (cycles / yrs)
- Inverter Life (years)

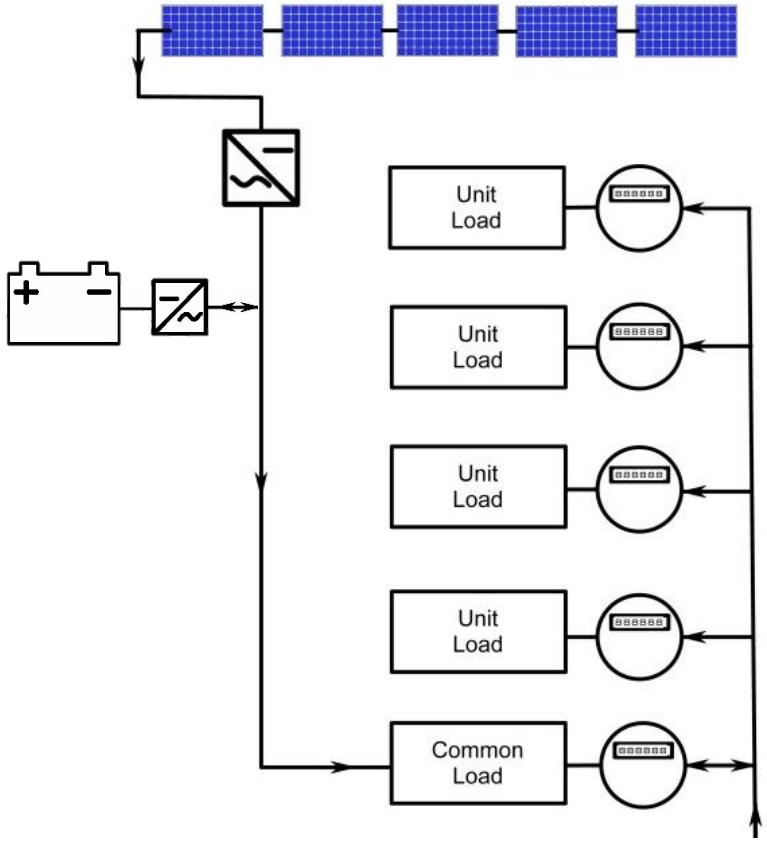


Financial Settings:
- Discount % Rate
- Amortization Term

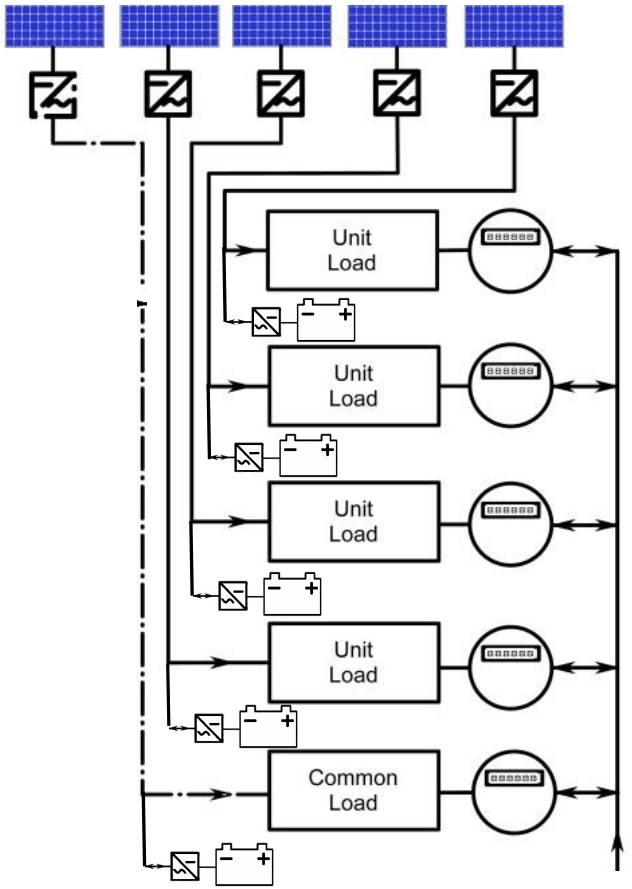
Not implemented in Beta

Batteries

Individual Battery - BTM



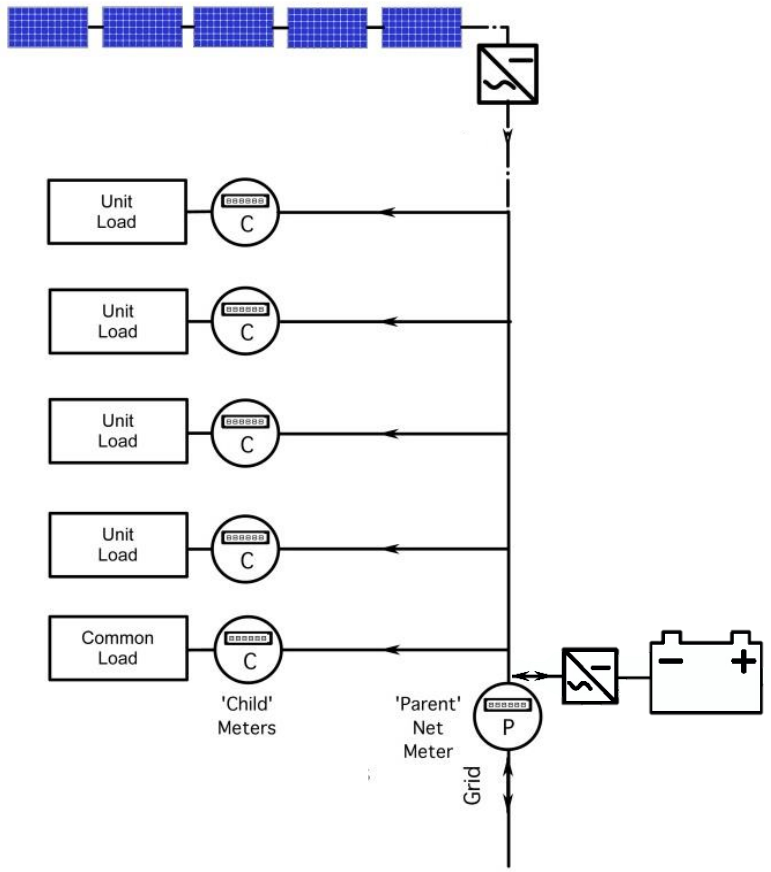
Common Property



Units (& Common Property)

Individual batteries (AC coupled)

Central Battery - Embedded Network

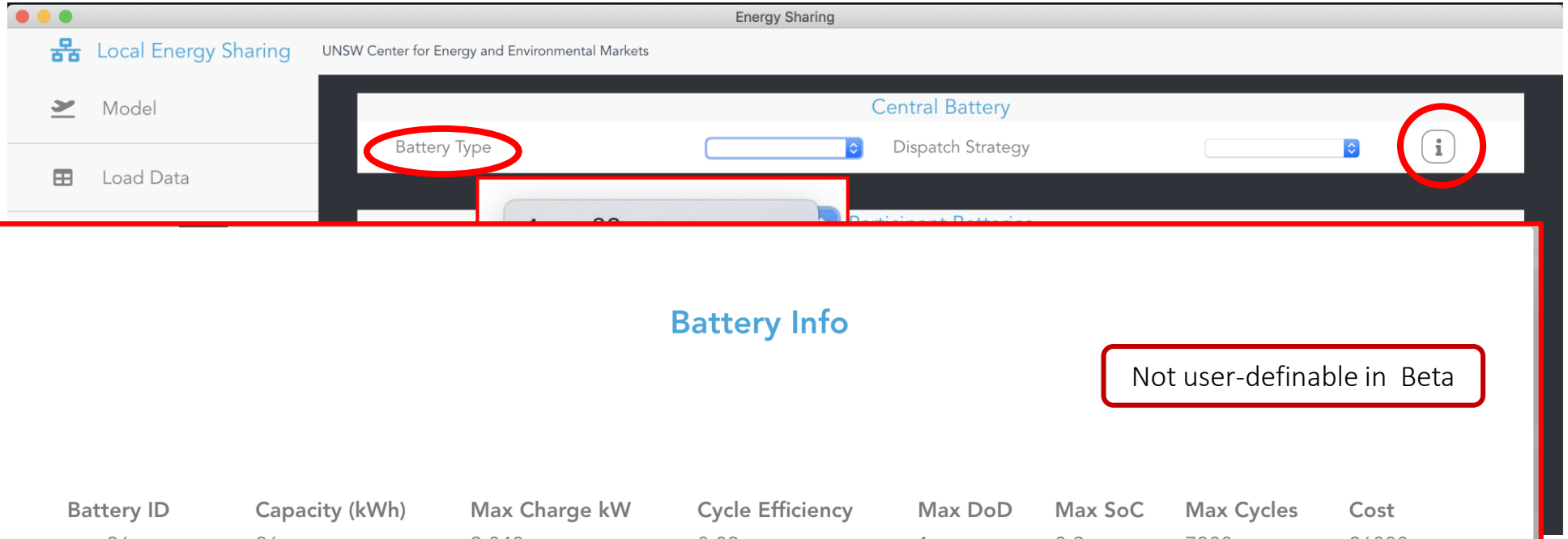


Central battery (AC coupled)

Batteries

Centre for Energy and Environmental Markets

UNSW SYDNEY Australia's Global University

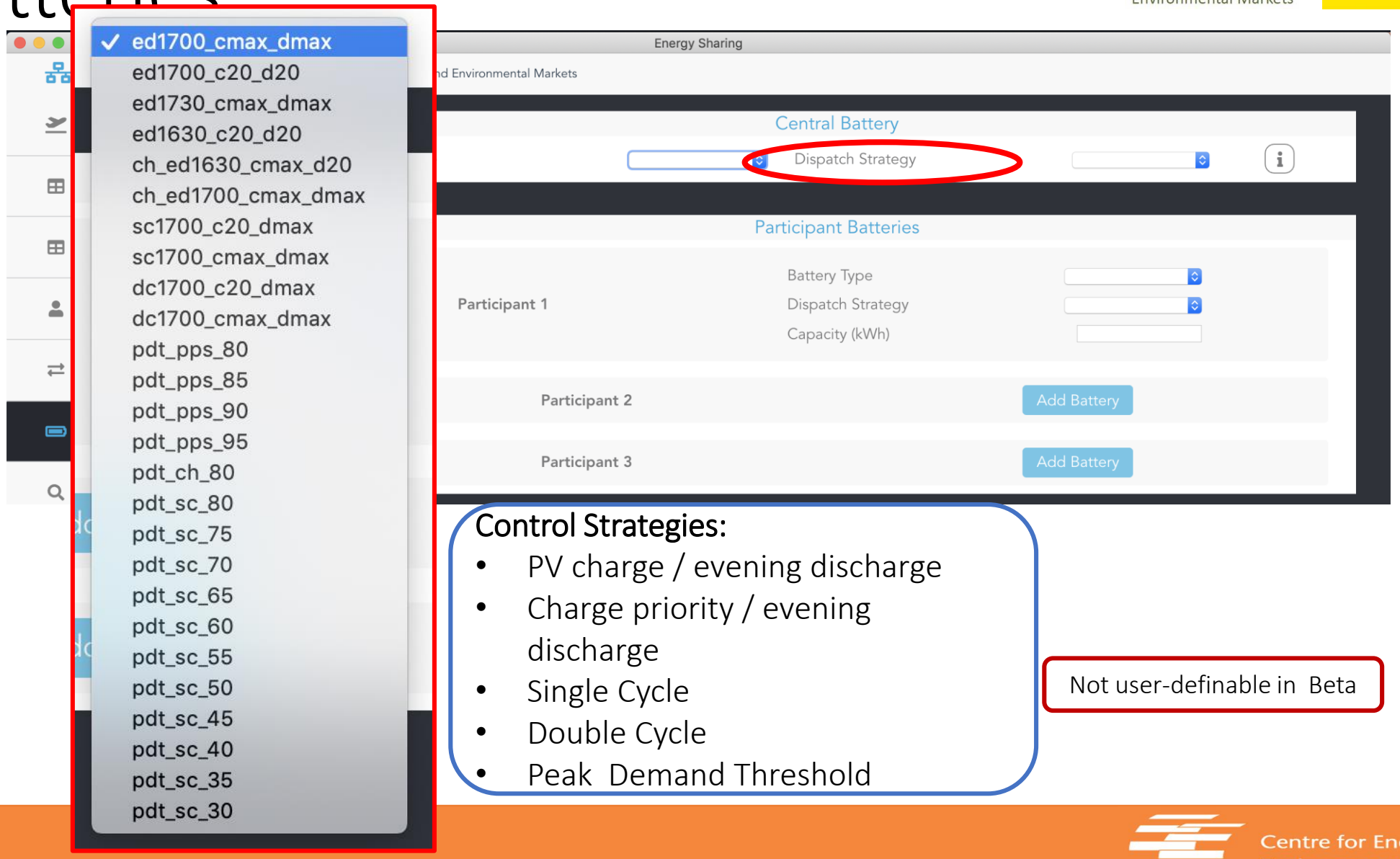


Battery Info

Not user-definable in Beta

Battery ID	Capacity (kWh)	Max Charge kW	Cycle Efficiency	Max DoD	Max SoC	Max Cycles	Cost
pw_26	26	9.848	0.89	1	0.9	7300	26000
pw_52	52	19.697	0.89	1	0.9	7300	52000
pw_78	78	29.545	0.89	1	0.9	7300	78000
pw_104	104	39.394	0.89	1	0.9	7300	104000
pw_scale	1	0.378787879	0.89	1	0.9	7300	
powerwall2_1	13.2	5	0.89	1	0.9	7300	12500
powerwall2_2	26.4	10	0.89	1	0.9	7300	24000
powerwall2_3	39.6	15	0.89	1	0.9	7300	34500
powerwall2_4	52.8	20	0.89	1	0.9	7300	45000

Batteries

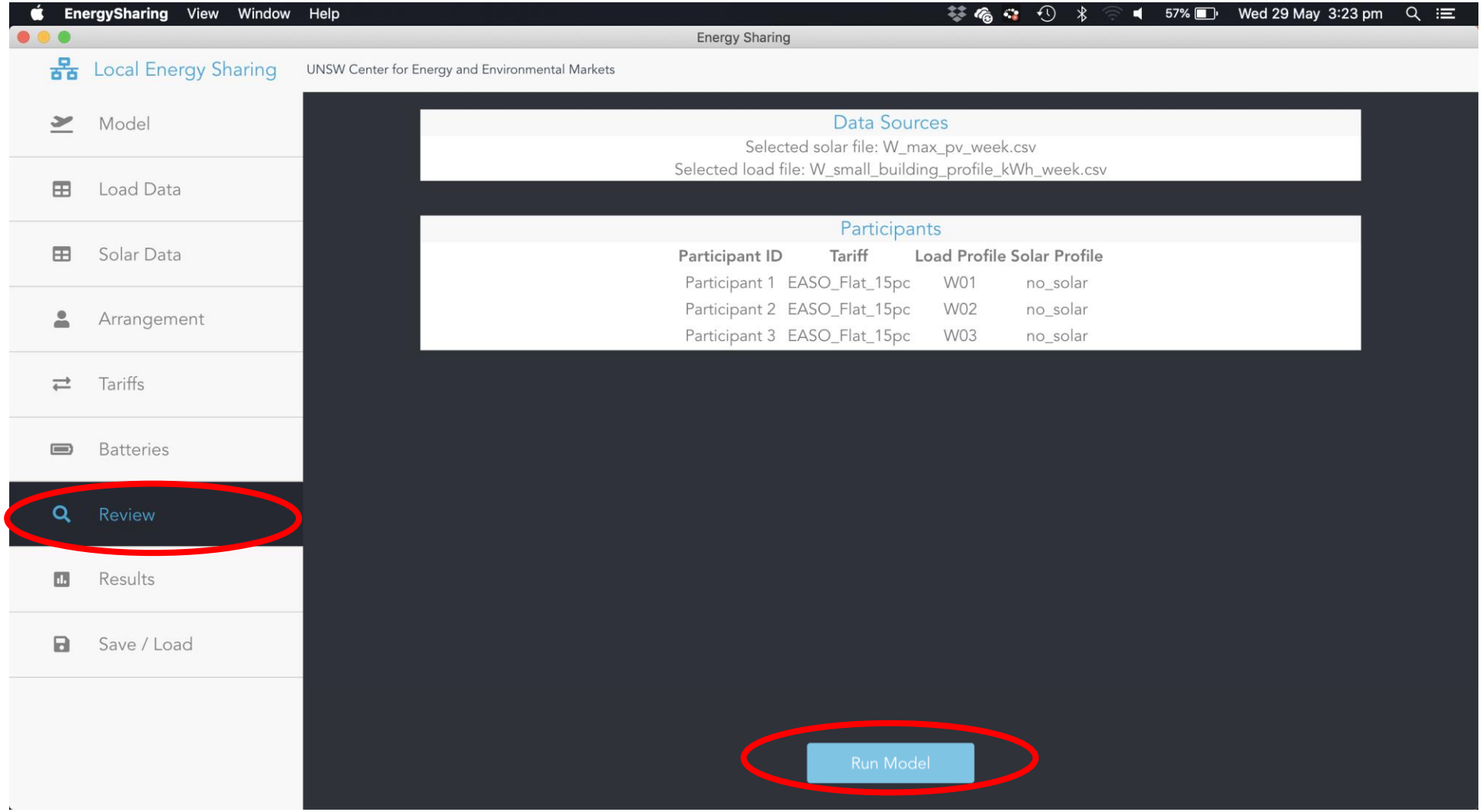


Control Strategies:

- PV charge / evening discharge
- Charge priority / evening discharge
- Single Cycle
- Double Cycle
- Peak Demand Threshold

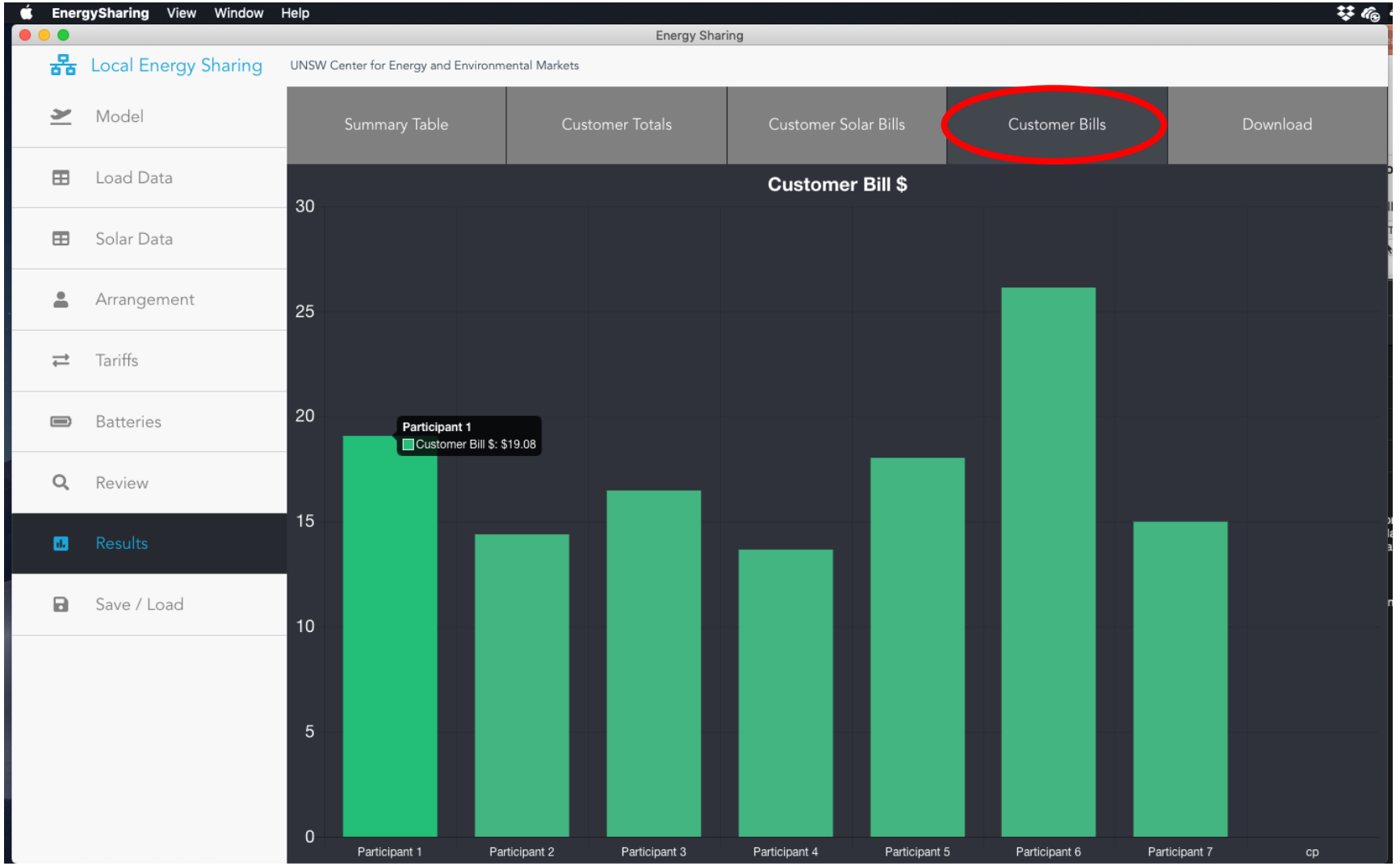
Not user-definable in Beta

Review

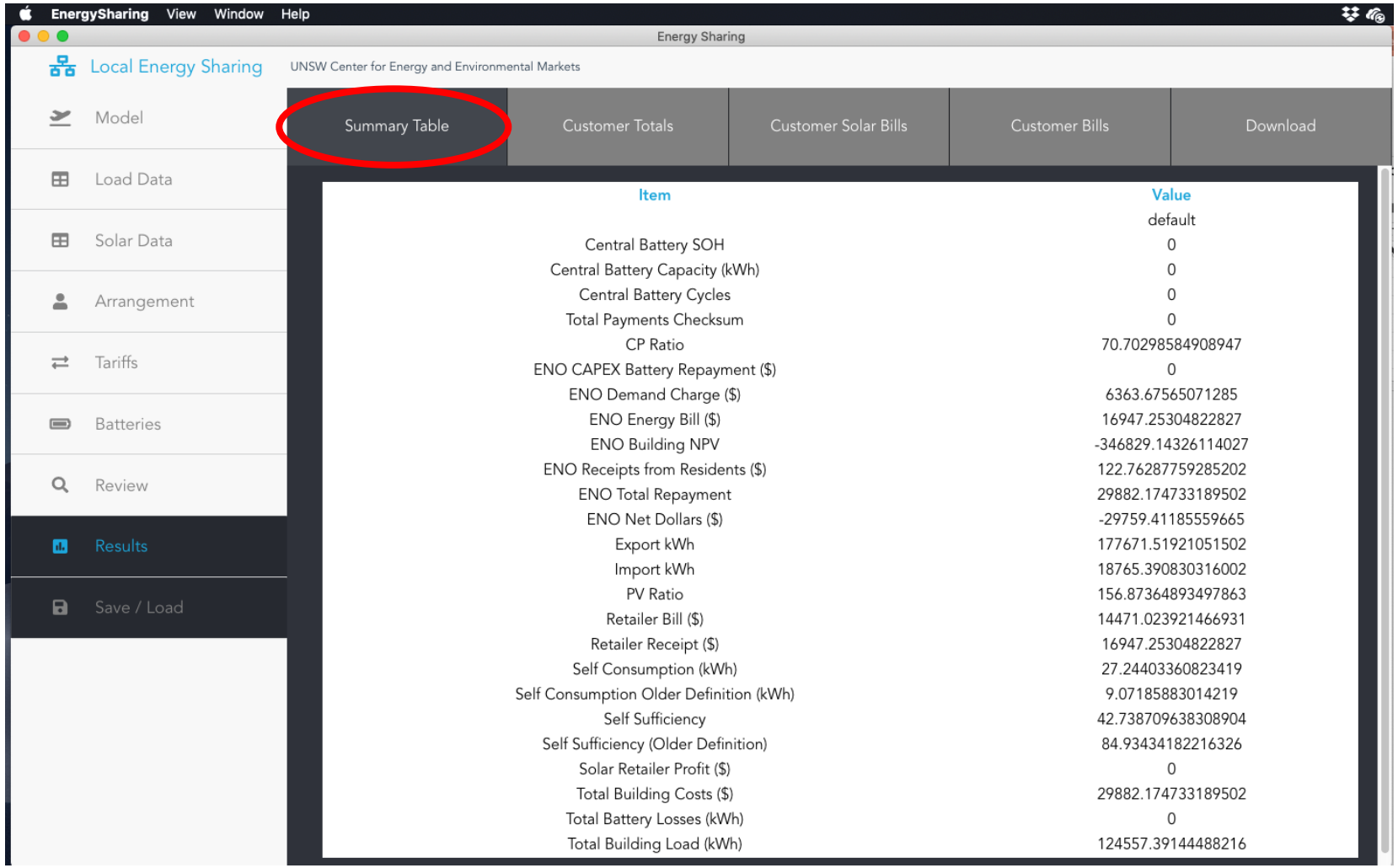

EnergySharing View Window Help
57% Wed 29 May 3:23 pm
Energy Sharing
Local Energy Sharing
UNSW Center for Energy and Environmental Markets
Model
Load Data
Solar Data
Arrangement
Tariffs
Batteries
Review
Results
Save / Load
Data Sources
Selected solar file: W_max_pv_week.csv
Selected load file: W_small_building_profile_kWh_week.csv
Participants
Participant ID Tariff Load Profile Solar Profile
Participant 1 EASO_Flat_15pc W01 no_solar
Participant 2 EASO_Flat_15pc W02 no_solar
Participant 3 EASO_Flat_15pc W03 no_solar
Run Model

Results

Results


EnergySharing View Window Help
Energy Sharing
Local Energy Sharing
UNSW Center for Energy and Environmental Markets
Model
Load Data
Solar Data
Arrangement
Tariffs
Batteries
Review
Results
Save / Load
Summary Table
Customer Totals
Customer Solar Bills
Customer Bills
Download
Customer Bill $
30
25
20
15
10
5
0
Participant 1
Customer Bill $: $19.08
Participant 1
Participant 2
Participant 3
Participant 4
Participant 5
Participant 6
Participant 7
cp

Results



Item	Value
	default
Central Battery SOH	0
Central Battery Capacity (kWh)	0
Central Battery Cycles	0
Total Payments Checksum	0
CP Ratio	70.70298584908947
ENO CAPEX Battery Repayment ($)	0
ENO Demand Charge ($)	6363.67565071285
ENO Energy Bill ($)	16947.25304822827
ENO Building NPV	-346829.14326114027
ENO Receipts from Residents ($)	122.76287759285202
ENO Total Repayment	29882.174733189502
ENO Net Dollars ($)	-29759.41185559665
Export kWh	177671.51921051502
Import kWh	18765.390830316002
PV Ratio	156.87364893497863
Retailer Bill ($)	14471.023921466931
Retailer Receipt ($)	16947.25304822827
Self Consumption (kWh)	27.24403360823419
Self Consumption Older Definition (kWh)	9.07185883014219
Self Sufficiency	42.738709638308904
Self Sufficiency (Older Definition)	84.93434182216326
Solar Retailer Profit ($)	0
Total Building Costs ($)	29882.174733189502
Total Battery Losses (kWh)	0
Total Building Load (kWh)	124557.39144488216

Results – Summary Table

Centre for Energy and Environmental Markets

UNSW SYDNEY Australia's Global University

Energy Metrics:

- Total load (kWh)
- CP Ratio (%)
- Total Generation (kWh)
- PV Ratio (%)
- Self-Consumption (%)
- Self-Sufficiency (%)
- Total Import (kWh)
- Total Export (kWh)

Battery Metrics:

- Total Cycles
- State of Health (%)
- Total Losses (kWh)

Financial Metrics:

- Total Energy Costs for whole building($)
- Average Resident Bill ($)
- Average Resident Total Cost ($)
- CP Bill ($)

Embedded Network Financials:

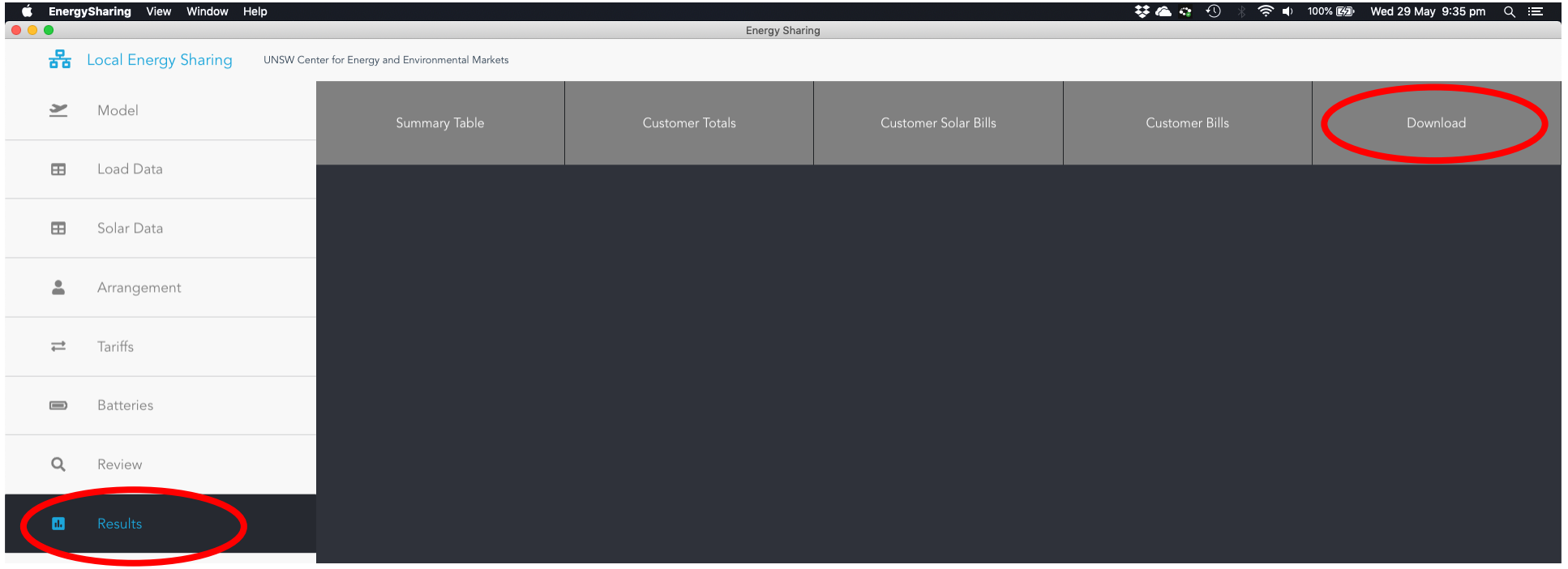
- Demand Charge ($)
- Total Bill ($)
- Capex Repayments ($)
- Total EN Payments, Receipts, Net Profit ($)

External Financials:

- ? Retailer Receipts and Payments ($)
- ? DNSP Receipts ($)

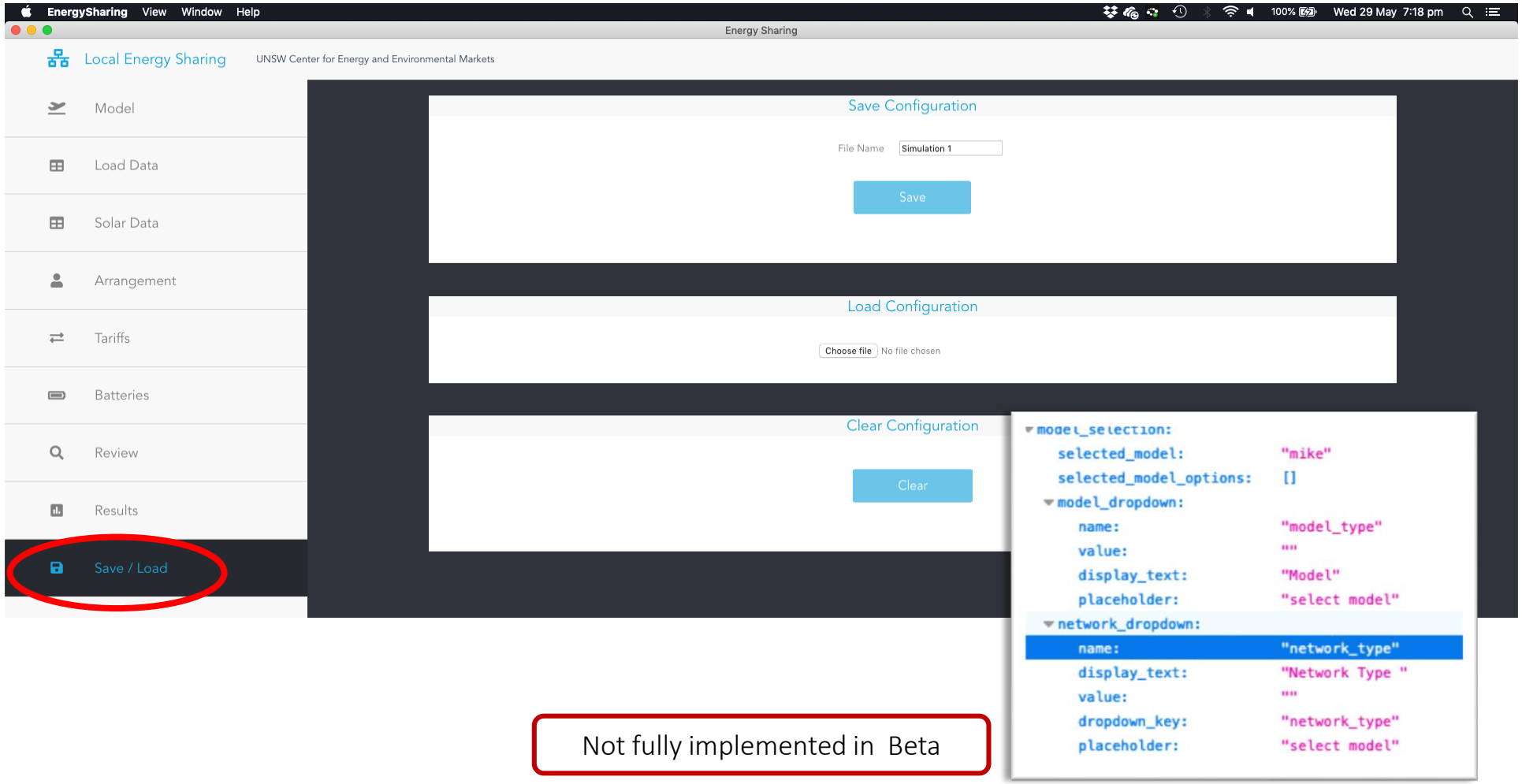
Not implemented in Beta

Download results



Not implemented in Beta

Save configuration file

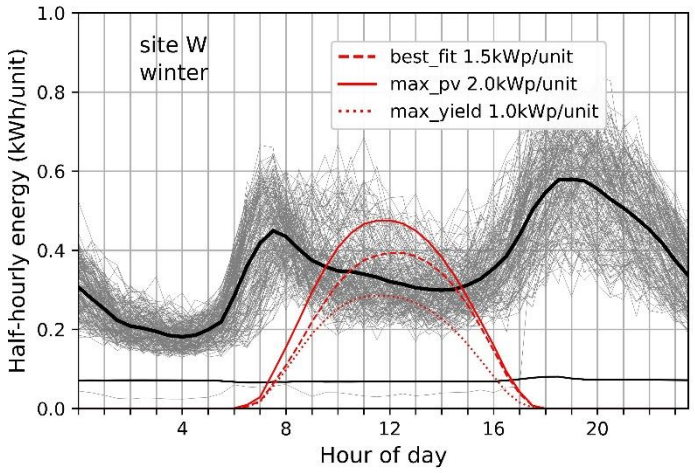


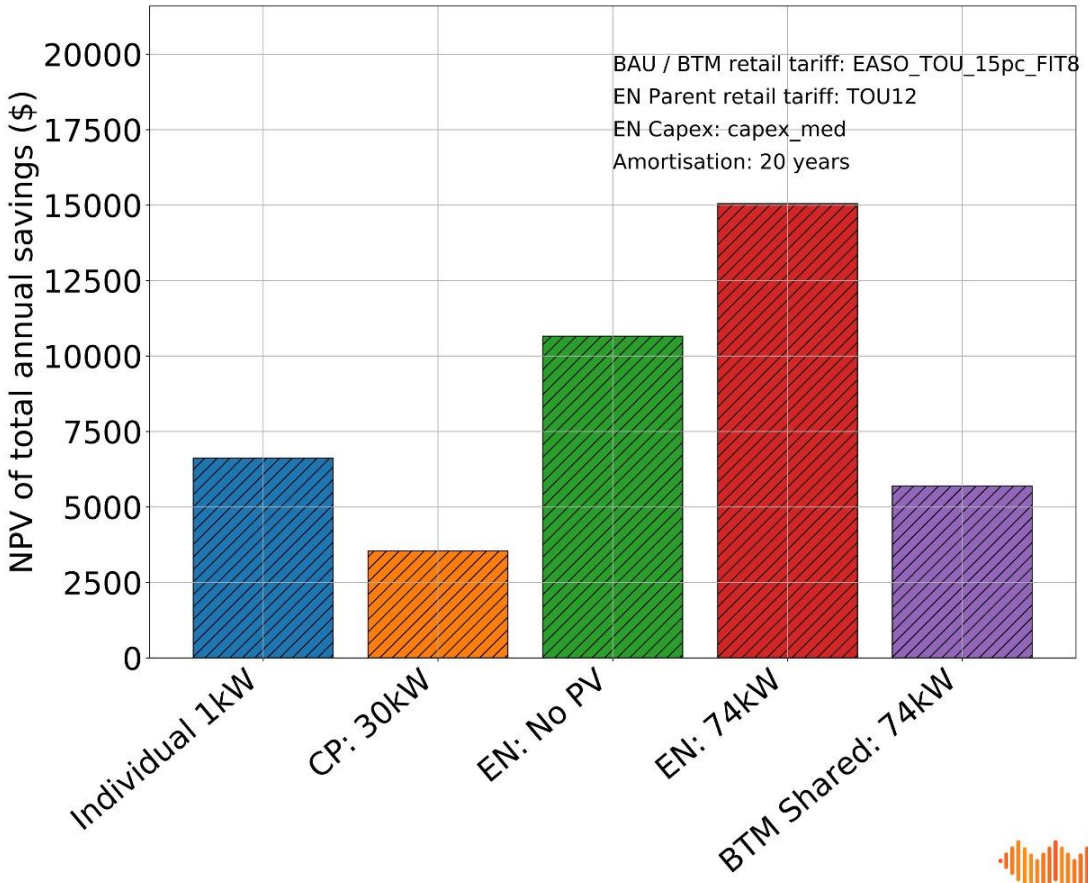
Not fully implemented in Beta

Example Results

Case Study W

72 apartments
3 floors
Lifts, carparks, etc
CP is 22% of load



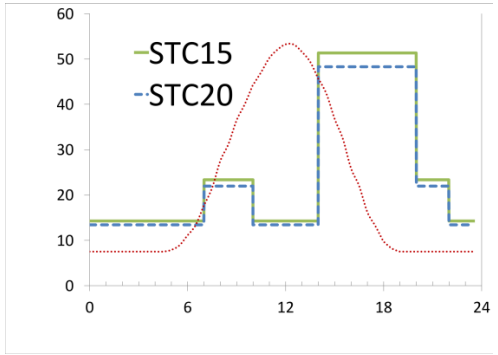


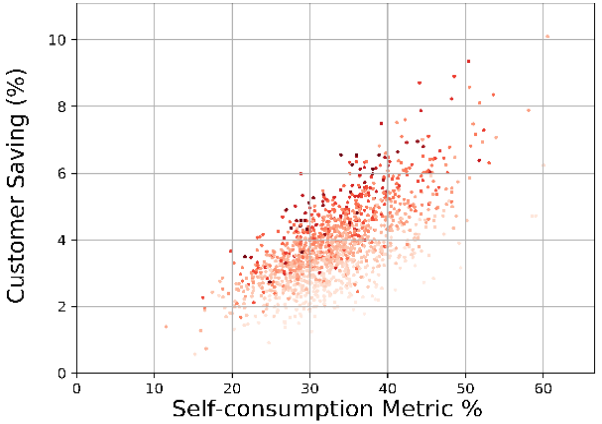
Case Study W – Embedded Network

Centre for Energy and Environmental Markets

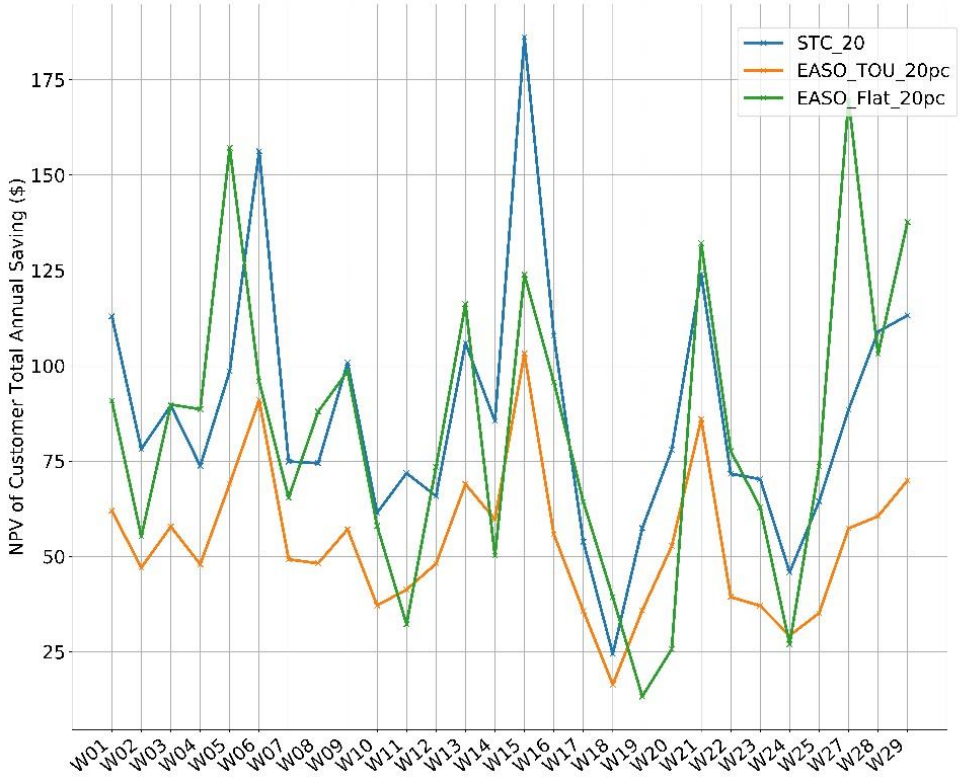
UNSW SYDNEY Australia's Global University

Solar TOU Tariff (STC)

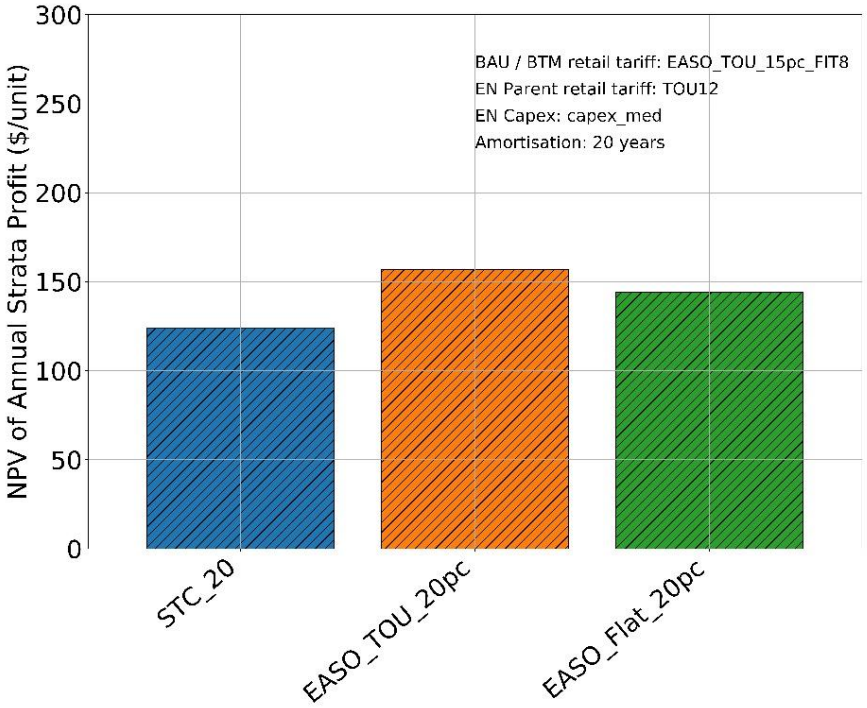




Customer Benefit



ENO Profit



wattwatchers DIGITAL ENERGY

Further Development ?

Possible Extensions

Centre for Energy and Environmental Markets

UNSW SYDNEY Australia's Global University

Tariff Functionality:

- ? Tariff structures
- ? Tariff tool compatibility

Beyond Apartments:

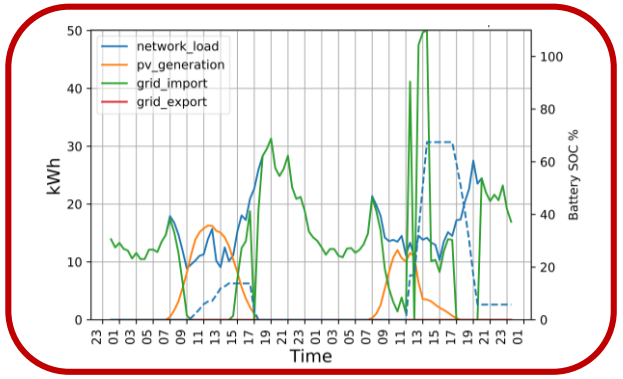
- ? Individual PV & Battery in EN
- ? 'Horizontal' Strata / Townhouses
- ? Microgrids

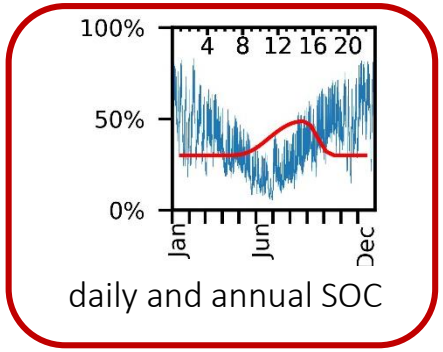
Results:

- ? Timeseries data
- ? Battery Usage
- ? Other metrics

Interface:

- ? Presentation
- ? Functionality





daily and annual SOC

Questions & Suggestions ?

M.B. Roberts, A. Bruce, and I. MacGill, *A comparison of arrangements for increasing self-consumption and maximising the value of distributed photovoltaics on apartment buildings.* Solar Energy, under review.

M.B. Roberts, A. Bruce, and I. MacGill, *Impact of shared battery energy storage systems on photovoltaic self-consumption and electricity bills in apartment buildings.* Applied Energy, 2019. **245**: p. 78-95.

M.B. Roberts, N. Haghdadi, A. Bruce, and I. MacGill, *Characterisation of Australian apartment electricity demand and its implications for low-carbon cities.* Energy, 2019. **180**: p. 242-257.

M.B. Roberts, A. Bruce, and I. MacGill, *Opportunities and barriers for photovoltaics on multi-unit residential buildings: Reviewing the Australian experience.* Renewable and Sustainable Energy Reviews, 2019. **102**: p. 95-110.