

HARD
SOFT
WARE



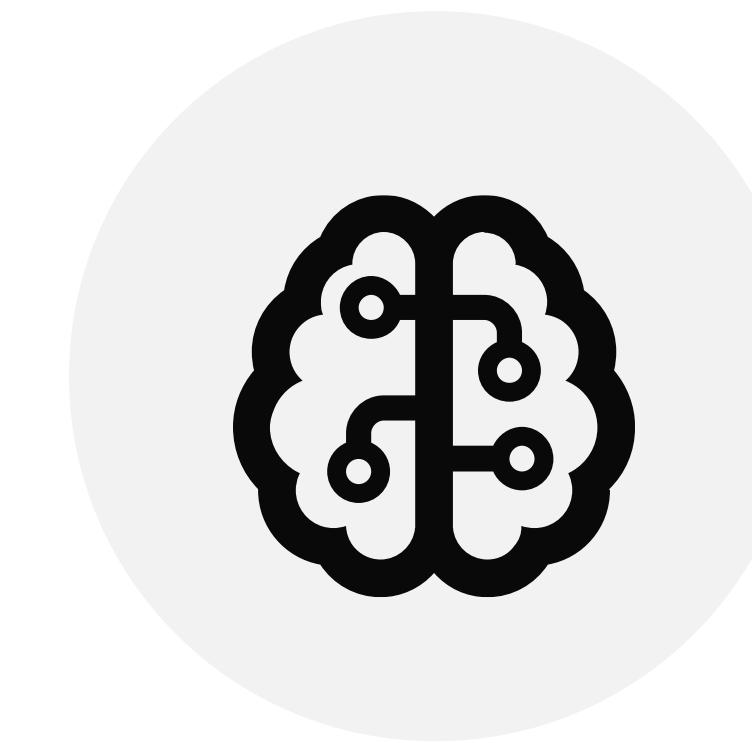
JuMP/HiGHS in the
Australian Electricity Market

OUR MAIN PRODUCTS



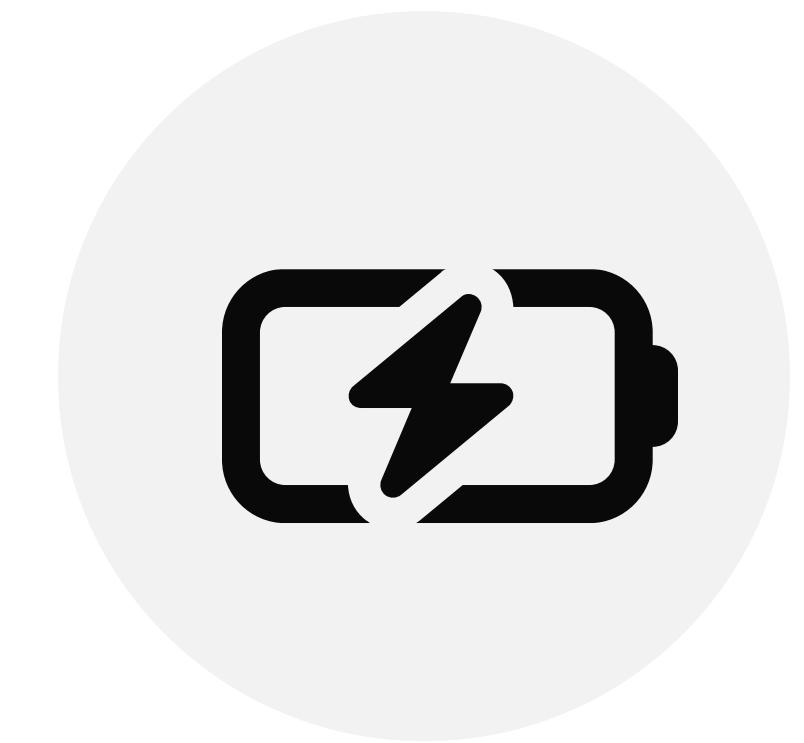
INFOLITE

Infolite a comprehensive solution that provides all the trading and operational requirements for profitably managing and running a renewable wind or solar farm in the Australian NEM.



AUTOMATED VRE TRADING

A recent development is enhancing our Infolite product with an automated bidding solution for solar and wind farms to provide optimized revenue trading at a much cheaper end-user cost than other automated solutions or 24 x 7 trading operations.



OPTIGEN

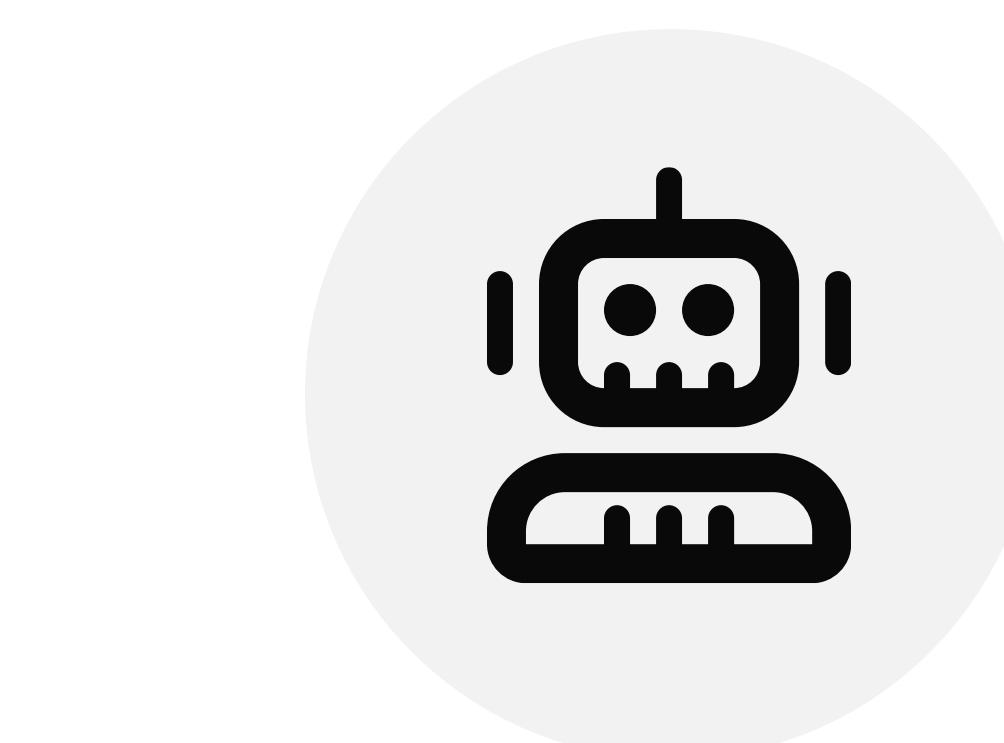
HARD software has recently launched Optigen, which is a cost-effective and reliable solution that seamlessly integrates with renewable energy generation and battery control systems to enhance revenue and manage risk.

COMPETITIVE ENERGY MARKET TRENDS



MULTI-MODAL SYSTEMS

Increasing numbers of renewable generators are looking to integrate BESS into their existing and planned sites. Proposed rule changes will make flexible optimization of these combined generation types necessary for generator profitability.



AUTOMATED TRADING

Automated trading of VRE generators is the most cost-effective solution for both single and multi-modal generation. Many existing alternatives have oversold the benefits or are too costly and many are now being replaced.



SYSTEMS SECURITY

Systems compliance and increasing security requirements for all the NEM trading and operational systems are becoming a priority for the security of the critical national infrastructure. It is expected that audits and penalties for non-compliance will become common.



HORNSDALE TESLA/NEOEN POWER RESERVE

SOFTWARE DESIGN STARTED 1 AUG 2017
IN PRODUCTION ON 1 DEC 2017

TESLA HORNSDALE TRADING SOLUTION

T

OVERVIEW

	89%
battery_instant_reactive_power	0.0
battery_target_power	-0.3
battery_instant_power	0.0
frequency	49.92
battery_nominal_full_pack_energy	116.9
max_charge_power	87.8
battery_expected_energy_remaining	104.3
max_discharge_power	104.0

BID VIEW

BID CONTROL

DISPATCH - HPRG1

DI HH	RRP	Init	Target	Avail	Conf	RReg	LReg	R6	R60	R5	L6	L60	L5
10:20	\$112.52	0	0	100	0	0	0	63	19	41	0	0	0
10:25	\$115.62	0	0	100	0	0	0	63	19	41	0	0	0
10:30	\$116.60	0	0	100	0	0	0	63	19	41	0	0	0
10:35	\$111.22	0	0	100	0	0	0	63	19	41	0	0	0
10:40	\$112.37	0	0	100	0	0	0	63	19	41	0	0	0
10:45	\$143.72	0	0	100	0	0	0	63	19	41	0	0	0
10:50	\$148.00	0	0	100	0	0	0	63	19	41	0	0	0

BID CONTROL

DISPATCH - HPRL1

DI HH	RRP	Init	Target	Avail	Conf	RReg	LReg	R6	R60	R5	L6	L60	L5	
10:20	\$112.52	0	0	32	0	0	0	0	0	0	0	0	19	7
10:25	\$115.62	0	0	32	0	0	0	0	0	0	0	0	0	7
10:30	\$116.60	0	0	33	0	0	0	0	0	0	0	0	0	7
10:35	\$111.22	0	0	33	0	0	0	0	0	0	0	0	0	7
10:40	\$112.37	0	0	33	0	0	0	0	0	0	0	0	0	7
10:45	\$143.72	0	0	34	0	0	0	0	0	0	0	0	0	7
10:50	\$148.00	0	0	34	0	0	0	0	0	0	0	0	0	7

Auto Bidding ✓ active

- Manual Bidding
- Under Direction
- NLCAS Activated

COMMUNICATION

- AEMO
- Tesla
- Facility
- Syd DC

[10:44] Offer id: 114571 version id: 52 for trading date: '2019-01-17' has been successfully submitted and is VALID

[10:44] Offer id: 114571 version id: 52 for trading date: '2019-01-17' has been transferred to AEMO

[10:41] Offer id: 114571 version id: 52 for trading date: '2019-01-17' has been submitted from 'TESLA'

[10:40] Offer id: 114569 version id: 50 for trading date: '2019-01-17' acknowledgment could not be found within: 300 seconds

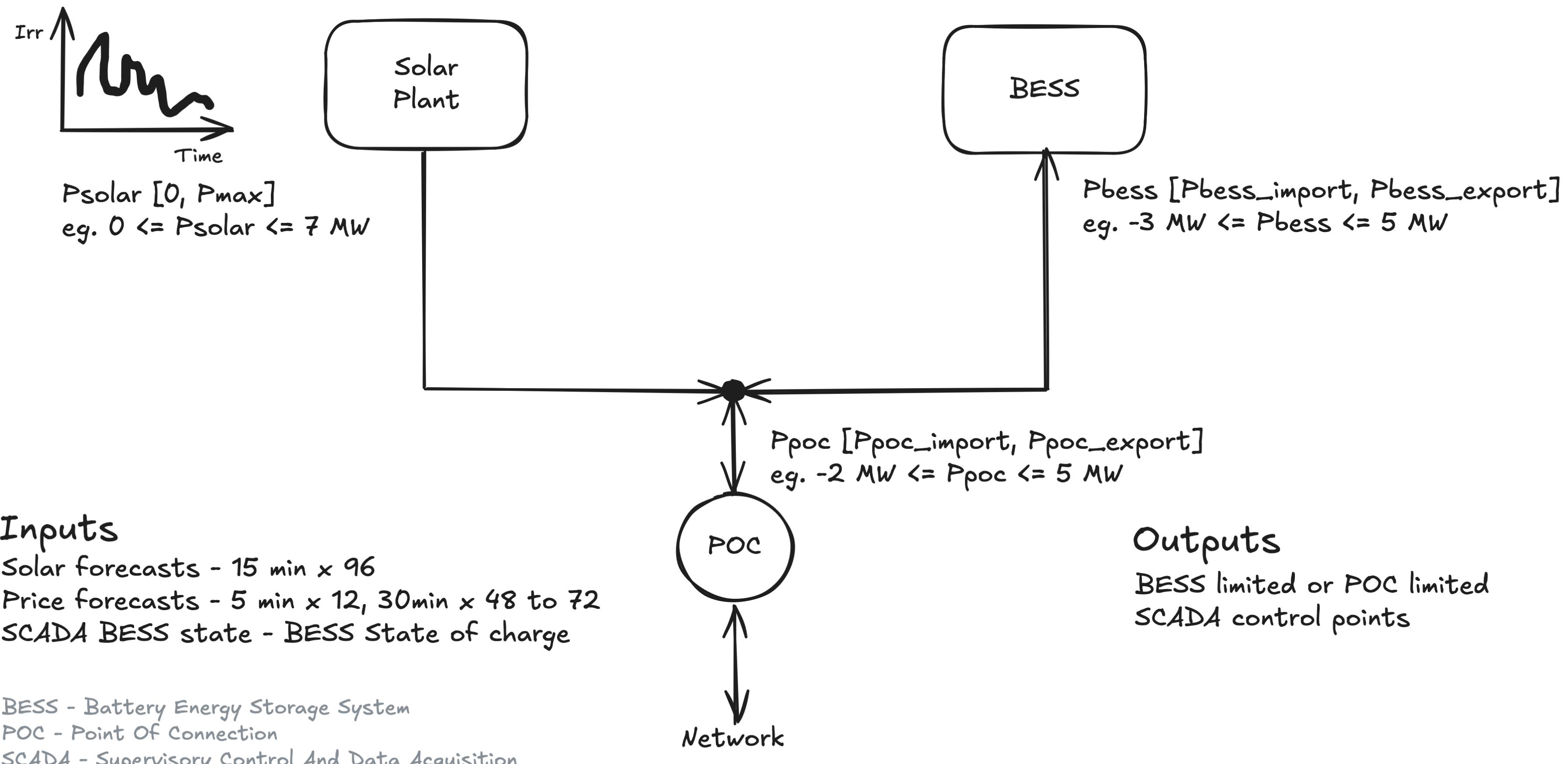
[10:38] Offer id: 114570 version id: 51 for trading date: '2019-01-17' has been successfully submitted and is VALID

[10:37] Offer id: 114570 version id: 51 for trading date: '2019-01-17' has been transferred to AEMO

[10:36] Offer id: 114570 version id: 51 for trading date: '2019-01-17' has been

TYPICAL GENERATION PLANT SCHEMATIC

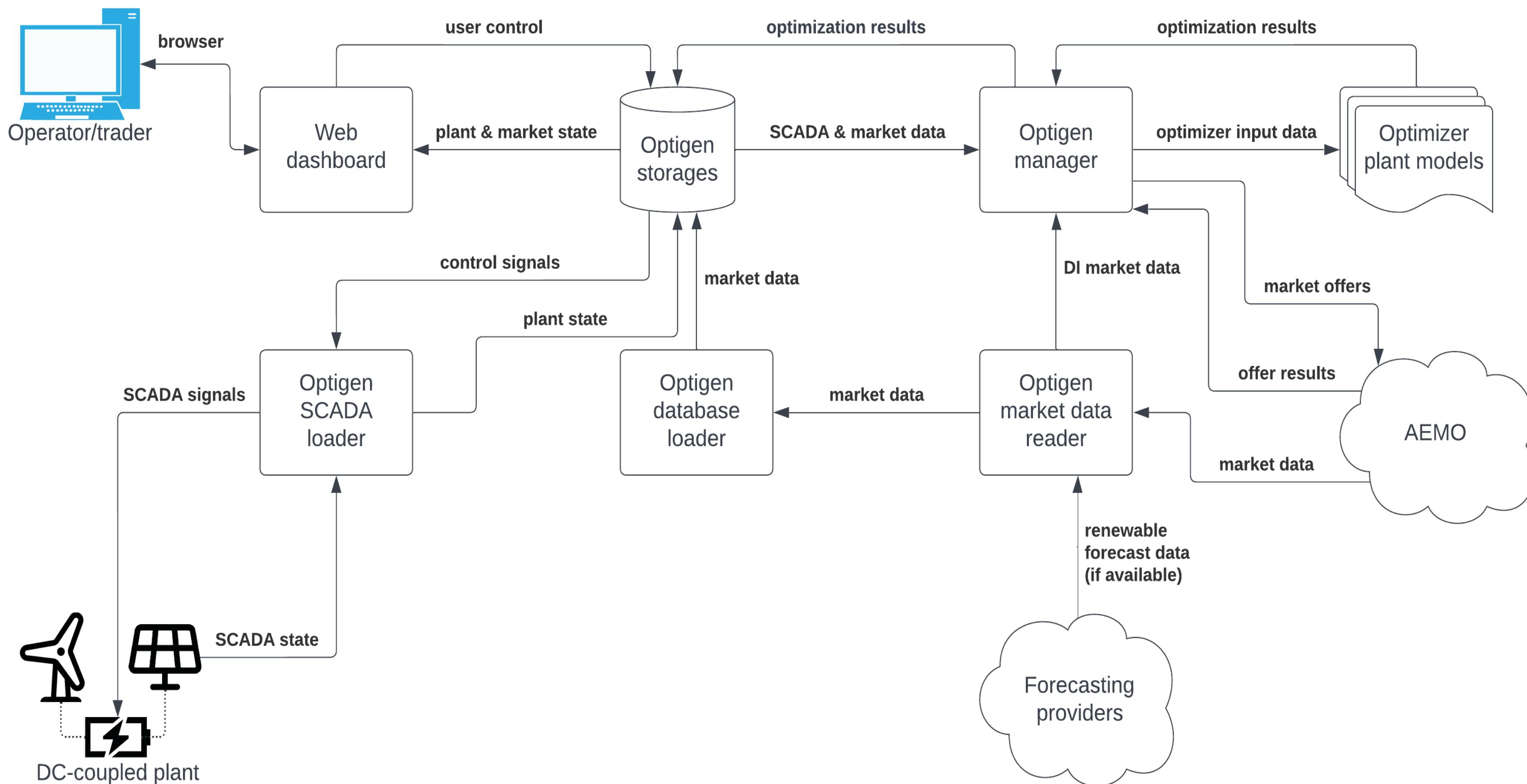
BESS with DC-coupled Solar



OPTIGEN OPTIMISED TRADING SOLUTION

Optigen scalable hosted solution logical diagram

February 2024



OPTIGEN CONTROL SYSTEM INTERFACE



OPTIGEN TECHNOLOGY

JULIA/JUMP

The optimisation multi-threaded module is written entirely in Julia using JuMP to interface to HiGHS.

DISCRETE MODULES

Each other component of the Optigen framework is entirely independent and uses a unified Python multi-threaded architecture.

MESSAGING

All inter-process communication is implemented using a unified messaging framework and message format.

MULTI-TENANTED

A principal feature of the design is to be able to run multiple site models on a single instance to allow for scaling the solution.

OPEN SOURCE

All programming & modelling languages, application infrastructure & operating systems are open source.

DEPLOYMENT

A small, economical industry standard RTU device is used to provide the interface directly to the plant SCADA.

OPTIGEN OPTIMISED TRADING SOLUTION

OptiGen Logout

Coleambally East BESS & Solar		Dubbo BESS & Solar		Moyhall BESS & Solar		Narrandera BESS & Solar		Port Pirie BESS & Solar		Toora Wind Farm		Prices										
 0.04 MW	AUTO MODE ✓ MANUAL MODE	 0.05 MW	AUTO MODE ✓ MANUAL MODE	 0.04 MW	AUTO MODE MANUAL MODE	 0.06 MW	AUTO MODE ✓ MANUAL MODE	 0.05 MW	AUTO MODE ✓ MANUAL MODE	 -0.11 MW	AUTO MODE MANUAL MODE	PRICE NSW1 QLD1 SA1 VIC1										
Units Generating: 0 / 4 Units Available: 0 / 4 Possible Power: MW Irradiance: 0 W/m ² Temperature: 0 ° C	POC Voltage: 322.6 kV HSW Setpoint: 0.00 MW Plant Setpoint: MW Reason:	Units Generating: 0 / 4 Units Available: 0 / 4 Possible Power: MW Irradiance: 0 W/m ² Temperature: 0 ° C	POC Voltage: 106.8 kV HSW Setpoint: 0.00 MW Plant Setpoint: MW Reason:	Units Generating: 0 / 4 Units Available: 4 / 4 Possible Power: MW Irradiance: 583 W/m ² Temperature: 0 ° C	POC Voltage: 32.5 kV HSW Setpoint: 0.00 MW Plant Setpoint: MW Reason:	Units Generating: 0 / 4 Units Available: 0 / 4 Possible Power: MW Irradiance: 0 W/m ² Temperature: 0 ° C	POC Voltage: 106.2 kV HSW Setpoint: 0.00 MW Plant Setpoint: MW Reason:	Units Generating: 0 / 4 Units Available: 0 / 4 Possible Power: MW Irradiance: 1090 W/m ² Temperature: 0 ° C	POC Voltage: 0.3 kV HSW Setpoint: 0.00 MW Plant Setpoint: MW Reason:	Turbines Generating: 0 / 12 Turbines Available: 12 / 12 Possible Power: 0 MW Wind Speed: 11.3 m/s Temperature: 11.7 ° C	POC Voltage: 127.5 kV HSW Setpoint: 0.00 MW Plant Setpoint: 0.00 MW Reason: no generation - lgc: \$10.25	Last Heartbeat received: 11 Nov 2025 4:45:15 pm (+11:00) Last SCADA received: 11 Nov 2025 4:45:15 pm (+11:00)	Last Heartbeat received: 11 Nov 2025 4:45:15 pm (+11:00) Last SCADA received: 11 Nov 2025 4:45:15 pm (+11:00)	Last Heartbeat received: 11 Nov 2025 4:45:10 pm (+11:00) Last SCADA received: 11 Nov 2025 4:45:10 pm (+11:00)	Last Heartbeat received: 11 Nov 2025 4:45:10 pm (+11:00) Last SCADA received: 11 Nov 2025 4:45:10 pm (+11:00)	Last Heartbeat received: 11 Nov 2025 4:45:17 pm (+11:00) Last SCADA received: 11 Nov 2025 4:45:17 pm (+11:00)	Last Heartbeat received: 11 Nov 2025 4:45:17 pm (+11:00) Last SCADA received: 11 Nov 2025 4:45:17 pm (+11:00)	Last Heartbeat received: 11 Nov 2025 4:45:17 pm (+11:00) Last SCADA received: 11 Nov 2025 4:45:17 pm (+11:00)	Last Heartbeat received: 11 Nov 2025 4:45:17 pm (+11:00) Last SCADA received: 11 Nov 2025 4:45:17 pm (+11:00)	Last Heartbeat received: 11 Nov 2025 4:45:17 pm (+11:00) Last SCADA received: 11 Nov 2025 4:45:17 pm (+11:00)	Last Heartbeat received: 11 Nov 2025 4:45:17 pm (+11:00) Last SCADA received: 11 Nov 2025 4:45:17 pm (+11:00)	Last Heartbeat received: 11 Nov 2025 4:45:17 pm (+11:00) Last SCADA received: 11 Nov 2025 4:45:17 pm (+11:00)

Filters

```
Optimiser ✕ app ✕ DUBBO ✕ MOBI ✕ PORTPIRIE ✕ COLEAMBALLY ✕
NARRANDERA ✕ MOYHALL ✕ TOORAWF ✕
```

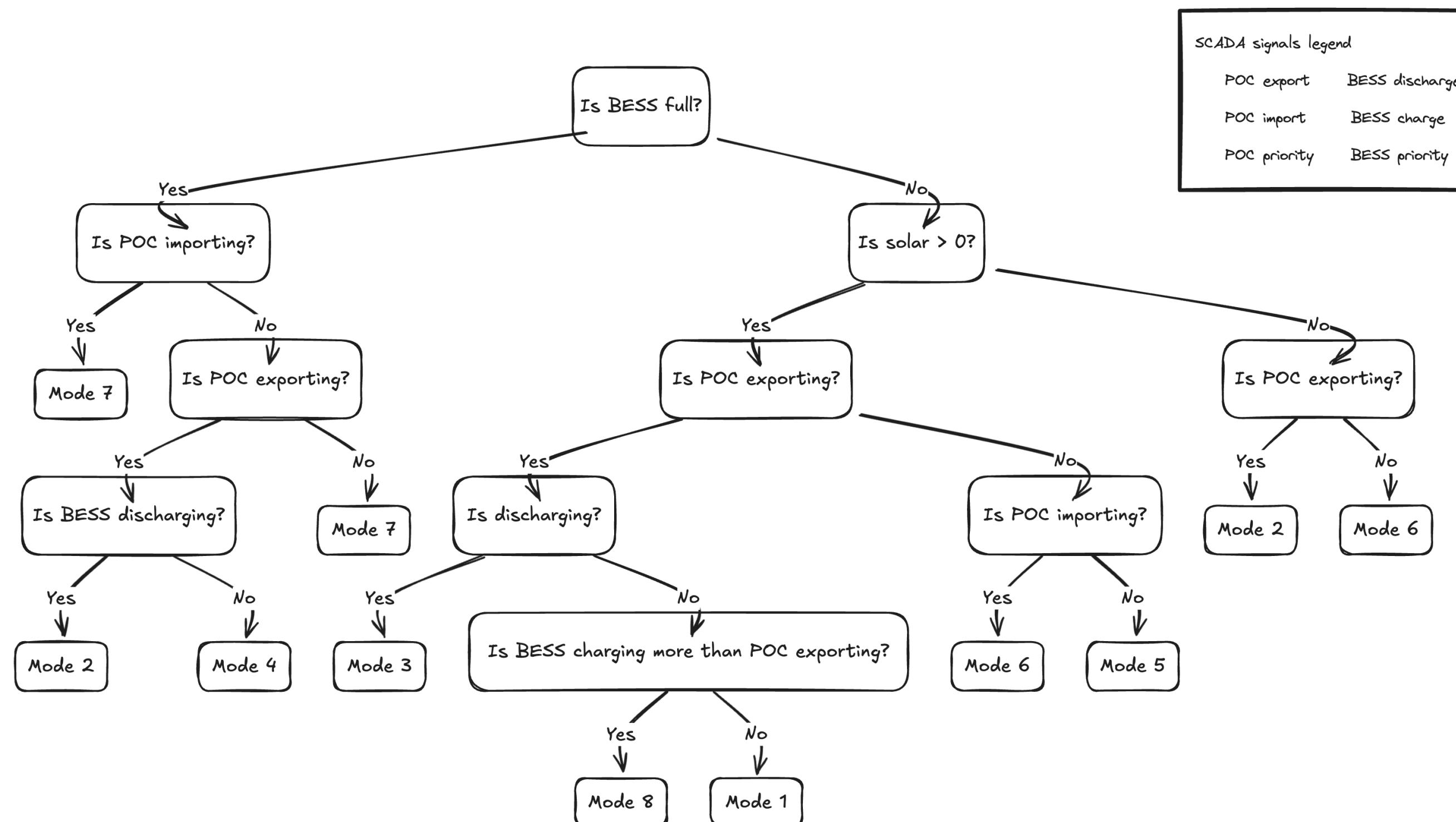
```
[2025-11-11T15:42:15.238000][INFO][MOYHALL] Finished processing optimiser decision: ''
[2025-11-11T15:42:15.151000][INFO][MOBI] Finished processing optimiser decision: ''
[2025-11-11T15:42:15.075000][INFO][PORTPIRIE] Finished processing optimiser decision: ''
[2025-11-11T15:42:14.988000][INFO][COLEAMBALLY] Finished processing optimiser decision: ''
[2025-11-11T15:42:14.910000][INFO][NARRANDERA] Finished processing optimiser decision: ''
[2025-11-11T15:42:14.750000][INFO][TOORAWF] Finished processing optimiser decision: 'no generation - lgc: $10.25'
[2025-11-11T15:42:14.687000][INFO][MOYHALL] Sending message to optimiser with request id 'e4283e7f-f838-49ab-aec7-2ea6574f998'
[2025-11-11T15:42:14.685000][INFO][DUBBO] Finished processing optimiser decision: ''
```

OPTIGEN CONTROL LOGIC

BESS DC-coupled solar optimisation scenarios

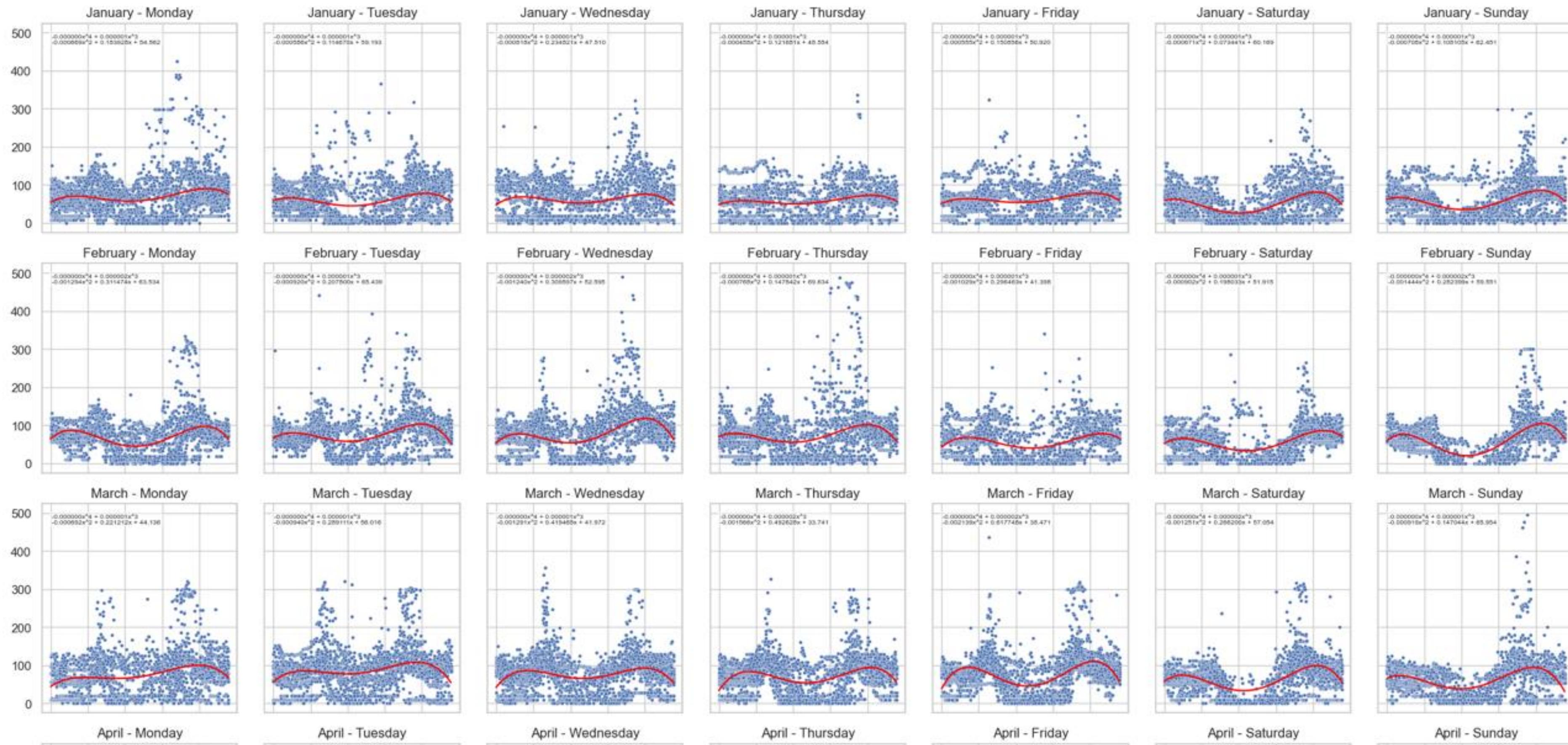
29 January 2025 - Dr. Harley Mackenzie
HARD software

Mode 1	Mode 2	Mode 3	Mode 4	Mode 5	Mode 6	Mode 7	Mode 8
max POC exp excess BESS	max POC exp & no BESS imp	max POC exp & BESS exp/imp	No BESS POC export	solar to import BESS	max imp BESS & POC import	No BESS or solar	max imp BESS & POC export
TF FT TF	TT FF TF	TT FT TF	TF FF TF	FF FT FT	FF TT FT	FF FF TF	TF FT FT



STORAGE VALUATION APPROACH

Scatter Plots of RRP by Time of Day for VIC1 since 2022-01-01



OPTIGEN MONITORING DASHBOARD

MQTT Broker: 192.168.32.21:1883 Client ID: mqtt_dashboard_5818				
Market Data	Dispatch Interval: 2025-11-11 14:00	TOORAWF	Dispatch Interval: 2025-11-11 14:00 Region: VIC1	
Prices:	2025-11-11 13:55:43 5 MIN forecasts: 2025-11-11 13:57:37	SCADA readings:	11/11/2025 13:57:37	
NSW1:	-\$16.77 [-\$20.35, -\$20.77, -\$21.81, -\$21.72, -\$21.69, -\$20.98, -\$20.88, -\$21.86, -\$21.45, -\$20.95, -\$20.88, -\$20.88]	request:	2025-11-11 13:57:33 response:	2025-11-11 13:57:35
QLD1:	-\$10.82 [-\$14.53, -\$14.53, -\$14.53, -\$10.82, -\$10.85, -\$14.53, -\$13.89, -\$14.53, -\$15.81, -\$14.53, -\$14.53, -\$14.53]	generation:	-0.118 MW	
SA1 :	-\$16.77 [-\$19.14, -\$19.88, -\$17.81, -\$17.81, -\$18.85, -\$17.98, -\$18.94, -\$19.88, -\$20.83, -\$19.98, -\$18.24]	no available:	12	
TAS1:	\$23.18 [\$23.13, \$23.13, \$23.13, \$23.13, \$21.93, \$23.13, \$22.04, \$21.38, \$20.98,	solution status:	OPTIMAL	
		HSW setpoint:	0.000 MW	
			plant setpoint: 21.000 MW	
MOBI	Dispatch Interval: 2025-11-11 14:00 Region: SA1	PORTPIRIE	Dispatch Interval: 2025-11-11 14:00 Region: SA1	
SCADA readings:	N/A forecast:	11/11/2025 13:57:32	forecast:	2025-11-11 13:43:05
request:	2025-11-11 13:57:34 response:	request:	2025-11-11 13:57:34 response:	2025-11-11 13:57:35
POC active power:	N/A solar generation:	0.048 MW	solar generation:	0.045 MW
irradiance:	N/A temperature:	1112.00 W/m*m	temperature:	1.9 Deg C
no available:	N/A no generating:	0	no generating:	0
BESS storage:	N/A BESS output:	0.000 MWh	BESS output:	0.000 MW
solution status:	OPTIMAL modes:	OPTIMAL	modes:	MODE_2 [1, 1, 0, 0, 1, 0]
HSW setpoint:	N/A POC setpoint:	N/A	POC setpoint:	0.050 MW
NARRANDERA	Dispatch Interval: 2025-11-11 14:00 Region: NSW1	MOYHALL	Dispatch Interval: 2025-11-11 14:00 Region: SA1	
SCADA readings:	11/11/2025 13:57:28 forecast:	11/11/2025 13:57:48	forecast:	2025-11-11 13:43:04
request:	2025-11-11 13:57:34 response:	request:	2025-11-11 13:57:35 response:	2025-11-11 13:57:35
POC active power:	0.066 MW solar generation:	0.046 MW	solar generation:	0.065 MW
irradiance:	0.00 W/m*m temperature:	0.0 Deg C	temperature:	14.8 Deg C
no available:	0 no generating:	N/A	no generating:	N/A
BESS storage:	0.000 MWh BESS output:	-0.003 MW	BESS output:	0.000 MW
solution status:	OPTIMAL modes:	MODE_2 [1, 1, 0, 0, 1, 0]	modes:	MODE_7 [0, 0, 0, 0, 1, 0]
HSW setpoint:	N/A POC setpoint:	4.700 MW	POC setpoint:	0.004 MW
Status: Connected & Listening Total Messages: 2303 Active Sections: 8/8				
q Quit r Refresh				

JuMP LESSONS FROM OPTIGEN



- ENERGY/MARKET OPTIMISATION & JuMP
Energy/market optimisation is a “killer app” for JuMP: many users of JuMP are interested in power-systems modelling, scheduling & market bidding.
- DATA QUALITY IS EVERYTHING
Market data needs to “productionised” eg. actual versus forecast data needs to be consistent, and control system interfaces must be reliable and consistent.
- CONTINUOUS MONITORING REQUIRED
Data quality and timing need to always be monitored. Issues can arise when delivery of data is inconsistent and variable (prices 20s to 90s into DI, forecasts 90s to 210s).
- SOLUTION TIME IS NOT ALWAYS CRITICAL
Model for BESS and solar solution typically runs in under 1s, allowing for multi-tenanted solutions. Mapping optimisation results to controls is not as straightforward.
- JuMP MODELLING IS QUICK AND EASY
AMPL is easier to learn only due to the available educational resources and example implementations. JuMP is a serious contender in the Open Source and energy / market modelling community, and the availability & quality of resources are improving all the time.



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