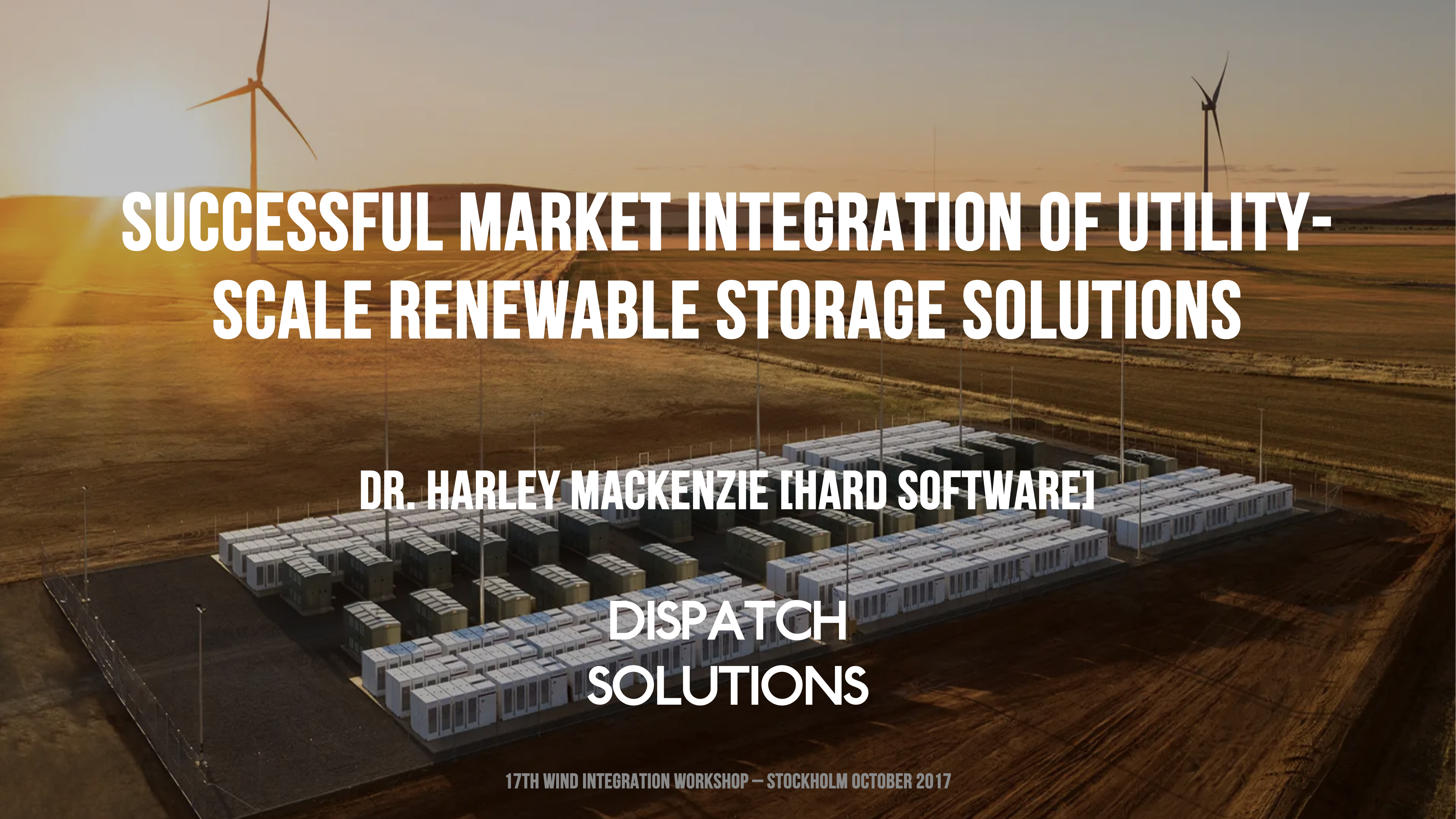


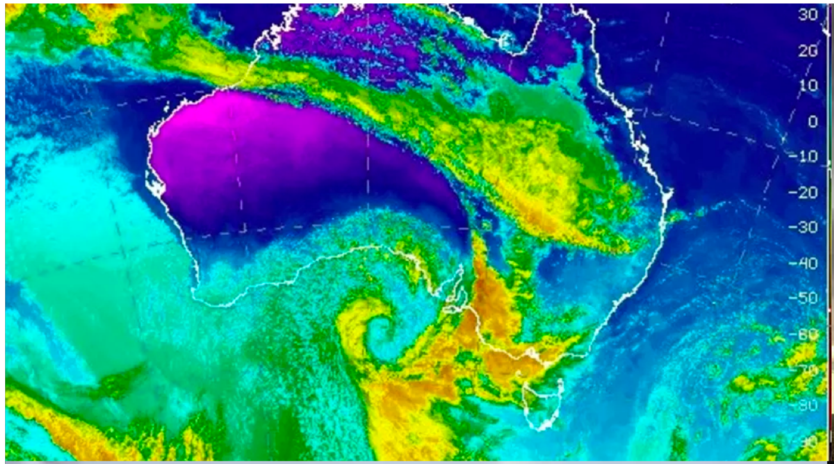
SUCCESSFUL MARKET INTEGRATION OF UTILITY-SCALE RENEWABLE STORAGE SOLUTIONS

DR. HARLEY MACKENZIE [HARD SOFTWARE]

DISPATCH
SOLUTIONS

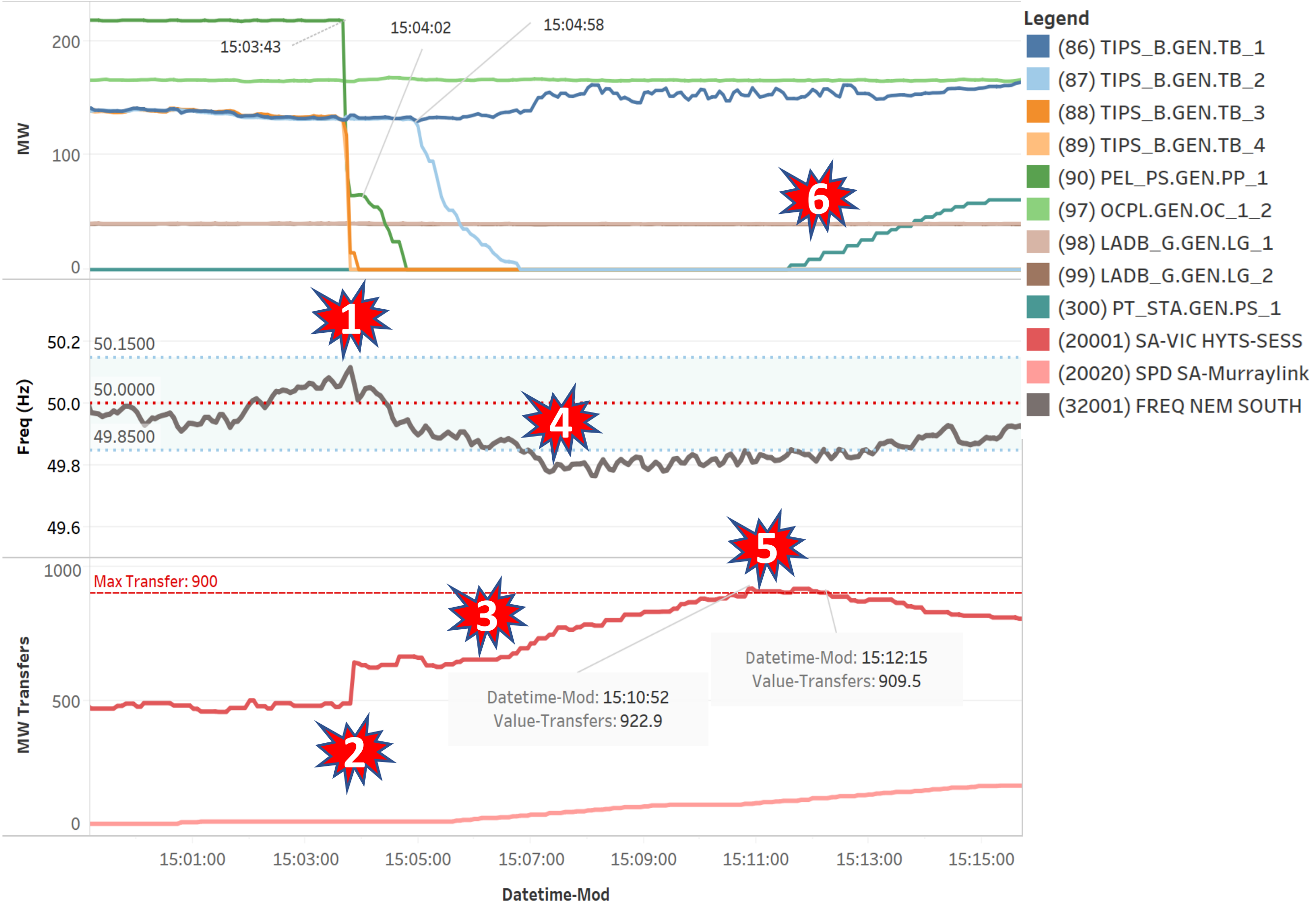
17TH WIND INTEGRATION WORKSHOP – STOCKHOLM OCTOBER 2017

SOUTH AUSTRALIAN BLACKOUT - 28 SEP 2016





LIFE ON THE EDGE IN SOUTH AUSTRALIA – 3 MAR 2017



1. TORRENS ISLAND EXPLOSION – 2 OFF & PP
2. SA-VIC TRANSFER STARTS TO INCREASE
3. SA-VIC APPROACHING LIMIT
4. TB2 OFF AND SA-VIC CLIMBS
5. SA-VIC SHOULD HAVE TRIPPED
6. GAS GENERATION ONLINE

HOW QUICKLY CAN GENERATION/STORAGE BE BUILT?

MINERALS COUNCIL AUSTRALIA (COAL LOBBY GROUP)

Item	Report	UoM	Black Coal HELE USC (or SC)	Black coal HELE USC plus CCS	NG CCGT - Large	NG CCGT plus CCS	NG OCGT F-Class	Wind	Solar PV FFP	Large Scale Battery Storage
Lead Time for Development (incl. construction)	ACIL	Years	6	8	4	4	2	4	4	3
	APGT		Unspecified	Unspecified	Unspecified	Unspecified	Unspecified	Unspecified	Unspecified	Unspecified
	JACOBS		Unspecified	Unspecified	Unspecified	Unspecified	Unspecified	Unspecified	Unspecified	Unspecified
	Range		*6*	*8*	*4*	*4*	*2*	*4*	*4*	*3*
Construction Lead Time	ACIL	Years	4	4	2	2	1	2	2	2
	APGT		4	4	2	3	1	2	1	Unspecified
	JACOBS		Unspecified	Unspecified	Unspecified	Unspecified	Unspecified	Unspecified	Unspecified	Unspecified
	Range		*4*	*4*	*2*	*3*	*1*	*2*	*2*	*2*
Plant Life	ACIL	Years	50	50	40	40	30	20	25	10
	APGT		30	30	30	30	30	20	30	?
	JACOBS		35	30	30	30	30	25	20	10
	Range	*Years (Low)*	*30*	*30*	*30*	*30*	*30*	*20*	*20*	*10*
		Years (High)	*50*	*50*	*40*	*40*	*30*	*25*	*30*	*10*
Nominal capacity	ACIL	MW	750	750	390	363	530	500	100	20
	APGT		695	595	451	417	281	200	50	Unspecified
	JACOBS		743	480	559	524	284	100	50	Unspecified
	Range	*MW (Low)*	*695*	*480*	*390*	*363*	*281*	*100*	*50*	*20*
		MW (High)	*750*	*750*	*559*	*524*	*530*	*500*	*100*	*20*

THE PERCEIVED STATE OF THE ART

"UTILITY-SCALE BATTERIES WERE ABOUT '10 TO 20 YEARS AWAY' FROM PROVIDING MEANINGFUL CONTRIBUTIONS TO THE GRID"

AEMO CHAIRMAN TONY MARXSEN AUG 2016

HORNSDALE POWER RESERVE PROJECT

- LARGEST LITHIUM-ION BATTERY IN THE WORLD
- 100MW/129MWH PROPOSED TO BE DELIVERED IN 100 DAYS FROM SIGNING CONTRACT (DELIVERED IN 62 DAYS)
- REPORTED COST OF $AUS 90 MILLION WITH THE SOUTH AUSTRALIAN GOVERNMENT COMMITTING TO $AUS 4 MILLION EBITA FOR 10 YEARS
- 70 MW – SYSTEM PROTECTION SYSTEM
- 30 MW – ACTIVELY TRADED AS MERCHANT

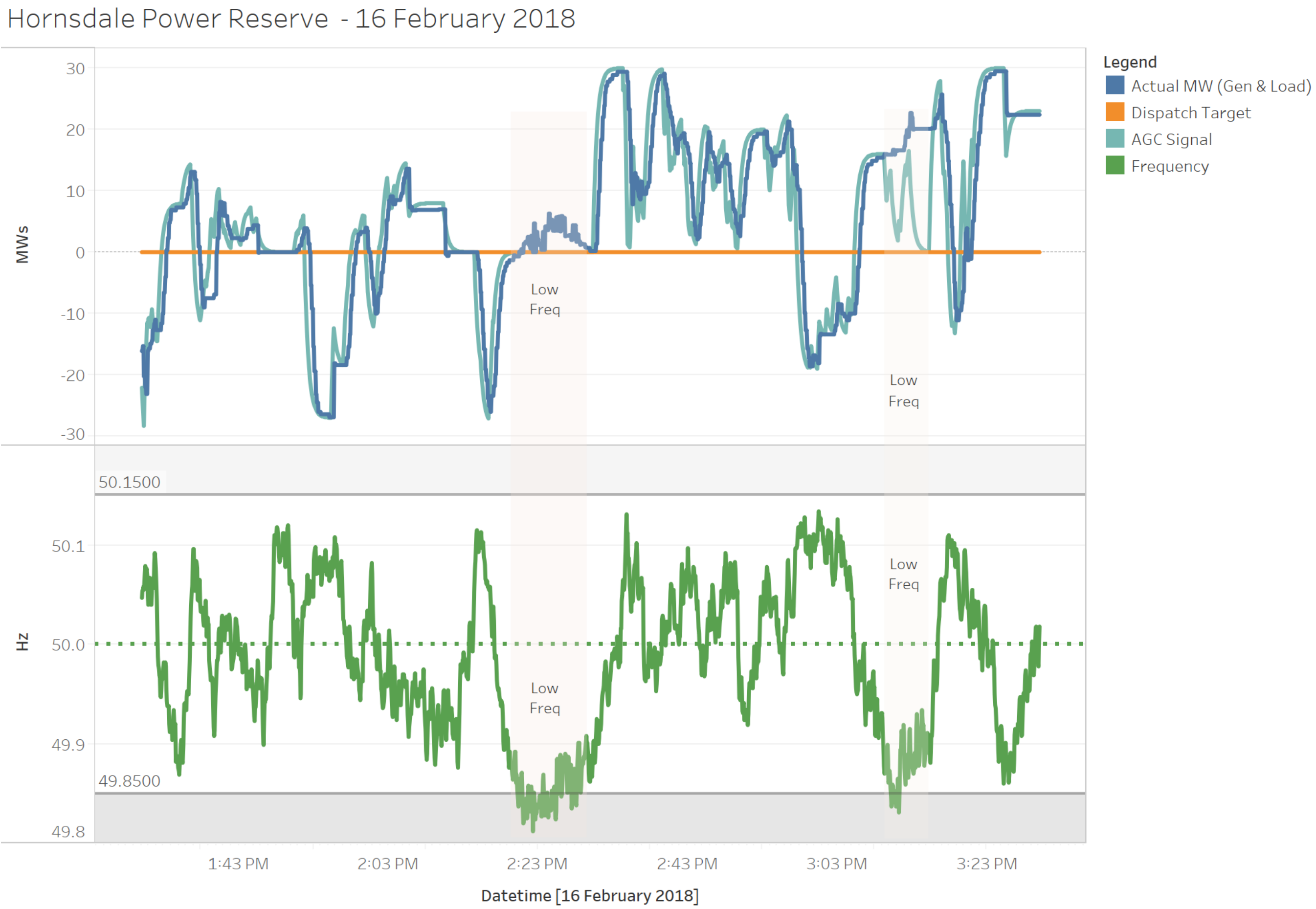
CONSTRAINTS ON BATTERY IMPLEMENTATION

- NO NEM RULE CHANGES POSSIBLE IN THE PROPOSED IMPLEMENTATION TIMEFRAME
- THE EXISTING AEMO NEM INFORMATION SYSTEM INFRASTRUCTURE MUST BE USED
- THE BATTERY NEEDS TO PARTICIPATE IN BOTH ENERGY & ANCILLARY SERVICE MARKETS
- RAPID SOFTWARE DEVELOPMENT METHODOLOGIES REQUIRED TO ALLOW FOR DEVELOPMENT OF SYSTEMS TO ALLOW AUTOMATED SUBMISSION OF OFFERS, OVERSIGHT & MANUAL MARKET INTERVENTION COMPLIANCE

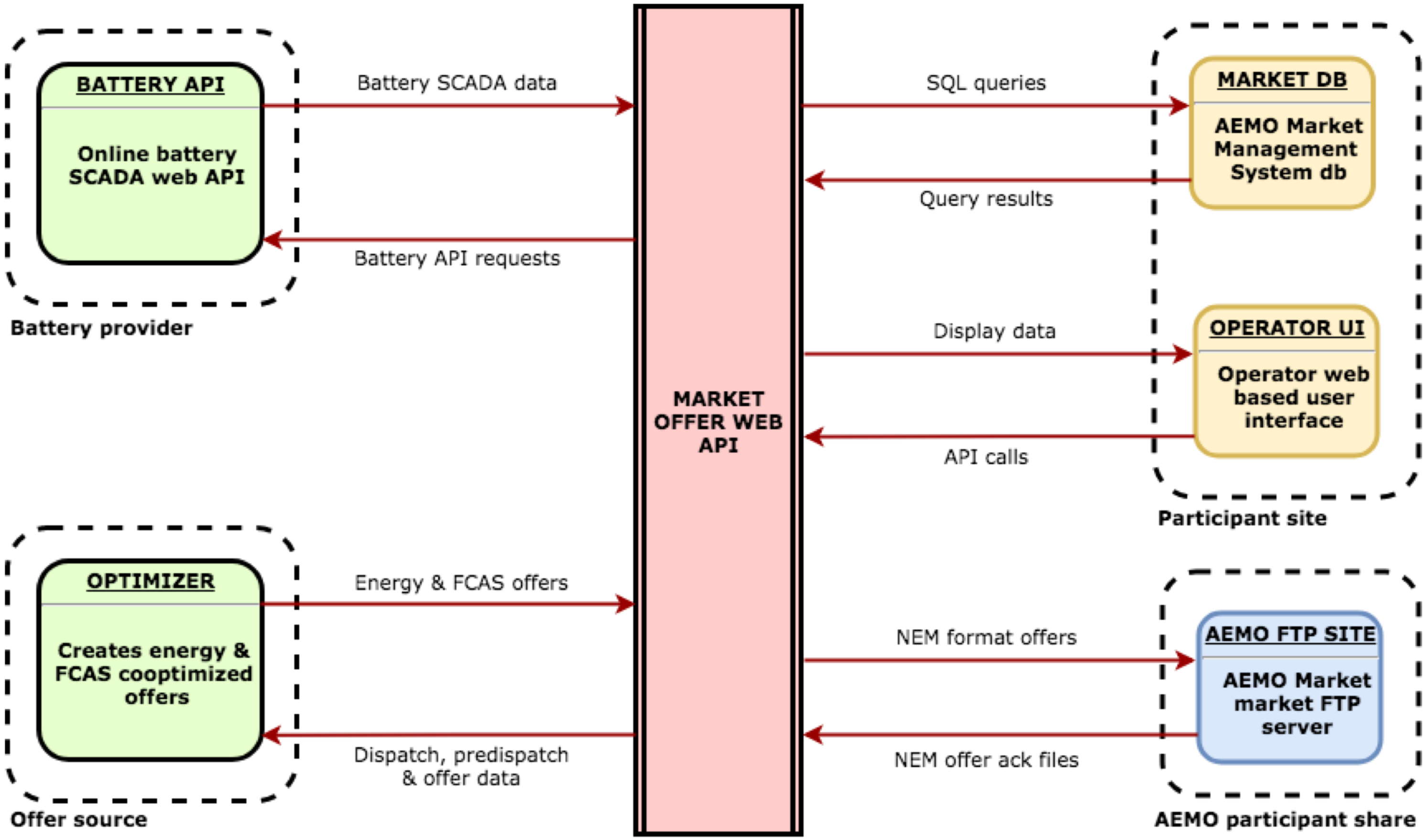
EXISTING MARKET RULES

- AEMO MARKET DISPATCH ENGINE DOES NOT HAVE A STORAGE CLASS OF GENERATOR AND NO NEGATIVE GENERATION – MUST BE OFFERED SEPARATELY AS GENERATOR AND A LOAD
- EIGHT ANCILLARY SERVICE MARKETS CO-OPTIMISED WITH ENERGY FROM THE MARKET PERSPECTIVE – RAISE & LOWER REGULATION AND 6S, 60S AND 5MIN CONTINGENCY SERVICES – NO FAST RESPONSE MARKET
- MARKETS ARE DISPATCHED EVERY 5 MINS BUT SETTTLED USING AVERAGED 30 MIN TRADING INTERVALS – INFLUENCES MARKET BEHAVIOUR OF PARTICIPANTS (TO BE CHANGED 2021)

GENERATION OF BATTERY WITH 0 MW DISPATCH TARGET



TRADING & OPERATIONS SYSTEM ARCHITECTURE



MARKET & BATTERY OUTCOMES SINCE 30 NOV 2017

- 8 HOURS OF LOCALLY SOURCED SA AGC SERVICES COST $3.5 MILLION LESS ON 14 JAN 2018 COMPARED TO 14 SEP 2017
- 25 AUG 2018 QLD & SA REGIONS ISLANDED AFTER LIGHTENING STRIKES ON INTERCONNECTORS – NO LOAD SHEDDING IN SA AND THE LIGHTS STAYED ON
- REVENUES OF $14 MILLION IN THE FIRST SIX MONTHS OF 2018
- $6 MILLION FROM FCAS – REDUCED SA FCAS COSTS BY $AUS 1.6 MILLION FOR NEOEN WIND FARMS (315 MW CAPACITY)
- 2% OF SA ENERGY CAPACITY BUT 11% FCAS GENERATION AND 10% FCAS LOAD CAPACITY IN SA

LESSONS TO BE LEARNED FROM THE PROJECT

- BATTERIES ARE AN ESSENTIAL PART OF THE FUTURE FOR GRID SYSTEMS WITH HIGH LEVELS OF RENEWABLE ENERGY
- BATTERIES NEED 24 X 7 OPERATIONS CENTRE MANAGEMENT TO BE COMPLIANT AND CAPITALIZE ON MARKET OPPORTUNITIES
- AUTOMATED OPTIMIZED OFFERS AT THE UNIT AND PORTFOLIO LEVEL WILL BECOME INCREASINGLY IMPORTANT
- MARKET RULES AND IT SYSTEMS CHANGE OVER TIMESCALES OF YEARS AND CAN NOT KEEP UP WITH TECHNOLOGY
- RENEWABLE BATTERY HYBRIDS TO CAPTURE SPILLED ENERGY MAKE SENSE BUT NEM RULES ONLY ALLOW THEM AS DISPATCHED PLANT

SUCCESSFUL MARKET INTEGRATION OF UTILITY-SCALE RENEWABLE STORAGE SOLUTIONS

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