Hybrid Energy Systems

Operational Learnings

Dr David Butler
Ray Massie

Operational learnings

…sharing our operational and maintenance learnings in taking hybrid renewable energy projects from concept, design and construction to what is now years of operation.

Topics

- System performance over time and as situations change
- Measurement of long term performance outcomes
- Importance of helping suppliers help themselves

What characterises hybrid energy systems?

- Medium-high levels of renewable energy (RE) generation
- RE generation brings significant variability and contingency complications
- ‘Enablers’ are required: wide range of potential solutions
- Reliably and cost of energy risks
- Long term implications

Commissioned power systems

	King Island	Flinders Island	Rottnest Island	Coober Pedy
Power system owner	Hydro Tasmania	Hydro Tasmania	Rottnest Island Authority	Energy Developments Limited
Date commissioned	2014	Nov 2017	Jul 2017	Jul 2017
Design RE contribution (long term)	65%	60%	45%	70%
Design RE penetration (short term) ***Zero diesel performance***	to 100% *25% of time, 77hr record*	to 100% *56% of time, 93hr record*	to 95%	to 100% *46% of time, 44hr record*
Load (peak)	2.5 MW	1.3 MW	1.1 MW	3.0 MW
Diesel generation	6.0 MW	3.0 MW	2.0 MW	5.0 MW
Solar generation	0.1 MW + 0.7 MW distributed	0.2 MW controlled + 0.4 MW distributed	0.6 MW controlled	1.0 MW controlled
Wind generation	2.5 MW controlled	1.2 MW controlled	0.6 MW controlled	4.0 MW controlled
Battery - power (peak) **- storage**	3 MW 1.6 MWh adv. lead acid	0.75 MW 0.30 kWh LTO	-	1.5 MW 0.5 MWh LTO
Diesel UPS	2.0 MVA	0.85 MVA	-	1.7 MVA
Dynamic resistor	1.5 MW	1.5 MW	0.5 MW	3.0 MW
Hybrid control system	Yes	Yes	Yes	Yes
Smart grid	Community DER WiMax/4G	-	Desalination DER	-
Biofuels	Pure biodiesel ready	-	-	-
Other	0.8 MWh VRB decommissioned. Low load diesel trial	Existing wind IPP	Low load diesel	Performance guarantee

(1) Performance in changing situation

King Island history

i. RE installed 1998 and 2003
ii. Large industrial closure 2012
iii. Ageing RE generation often unavailable
iv. Increasing load + roof top solar

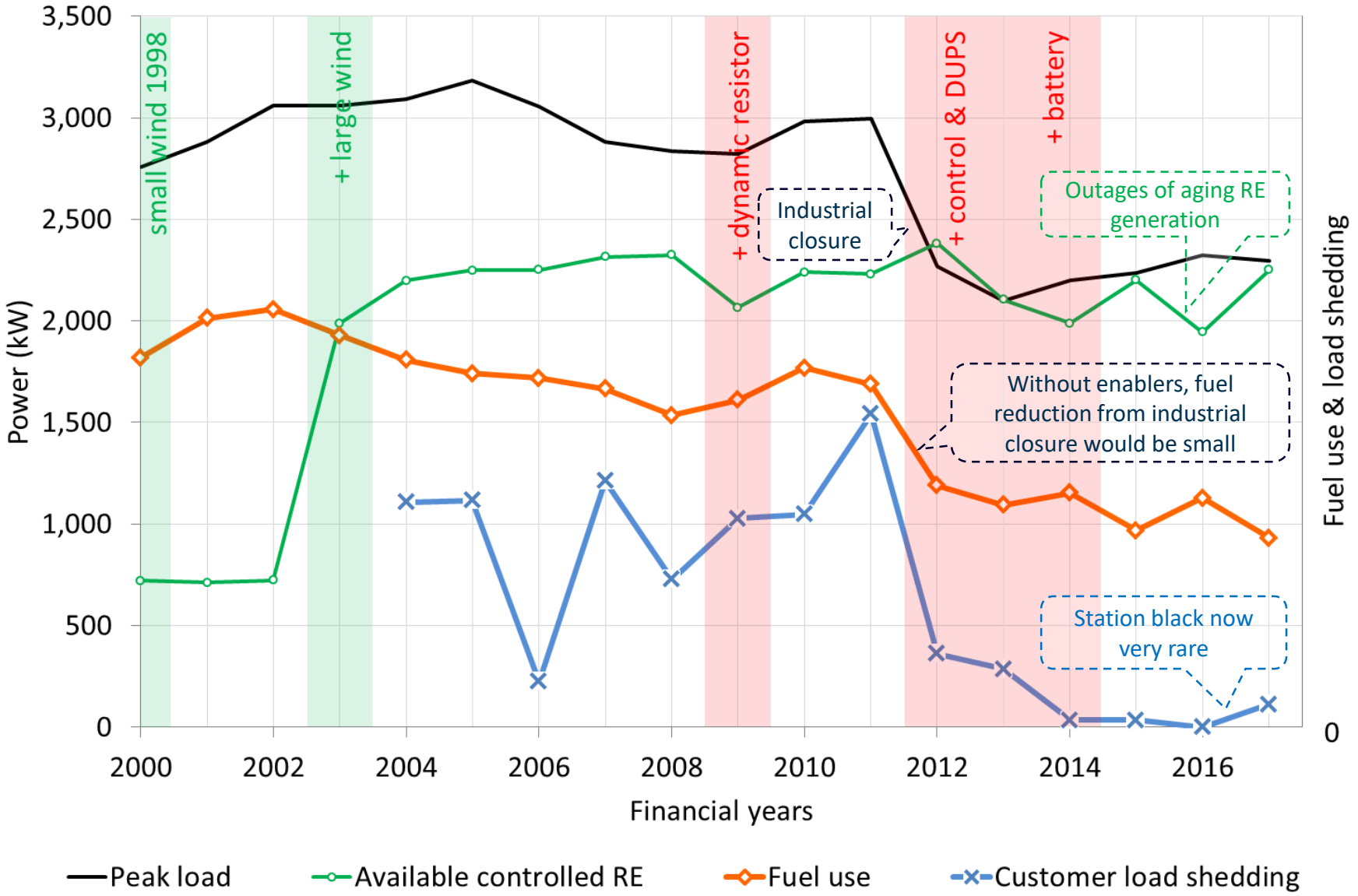
Consequence

- Planned RE expansion stopped due to industrial closure
- Controlled RE generation is reducing
- RE and load more variable

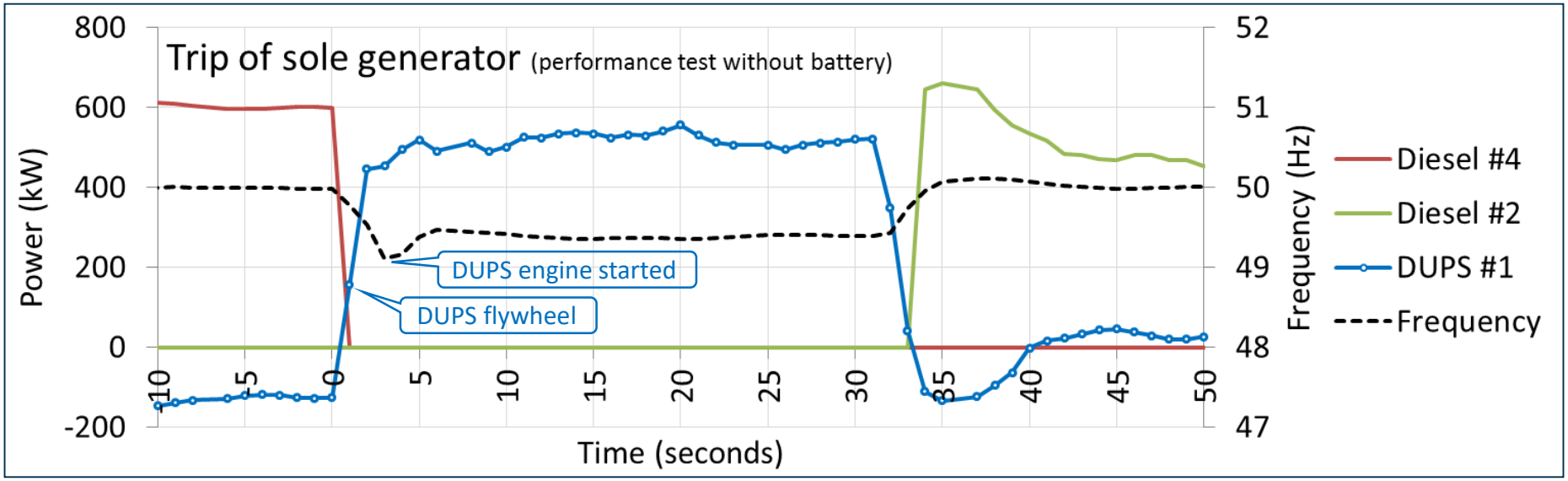
Saviours

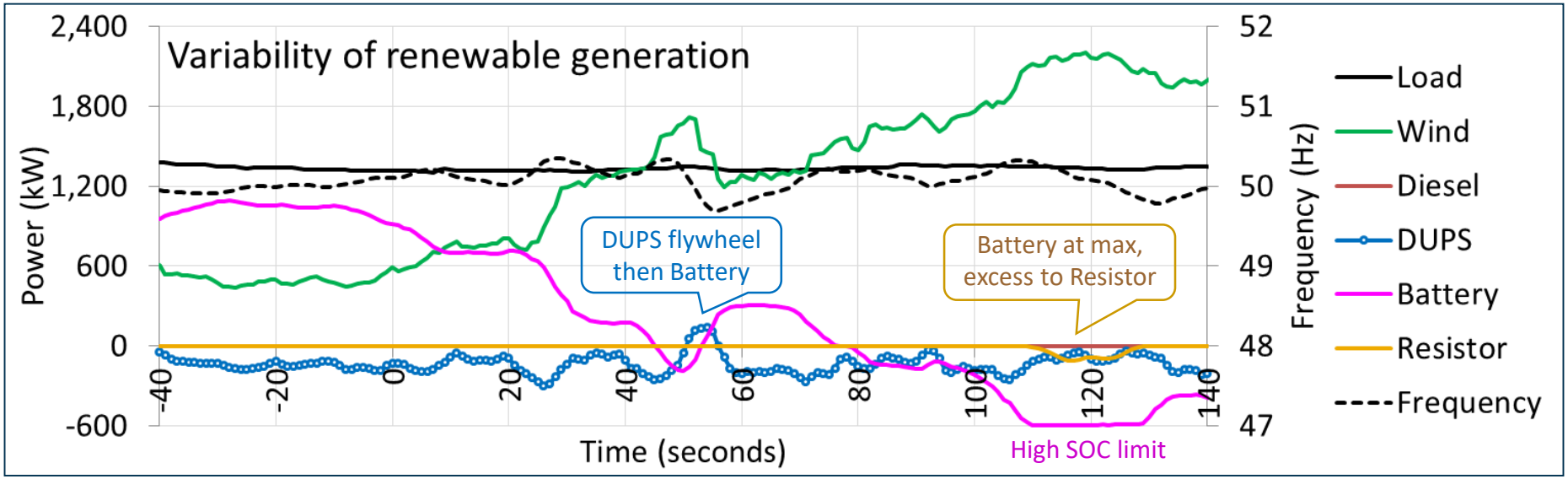
- Enablers accommodate large variability
- Enablers economic for large range of RE type and technology
- Massively improved generation reliability

King Island long term performance



Preventing blackouts





(2) Performance outcomes

Short term assessment

- Coober Pedy 6 month RE guarantee
- Model based, many variables
- 70% RE targets met

Long term assessment

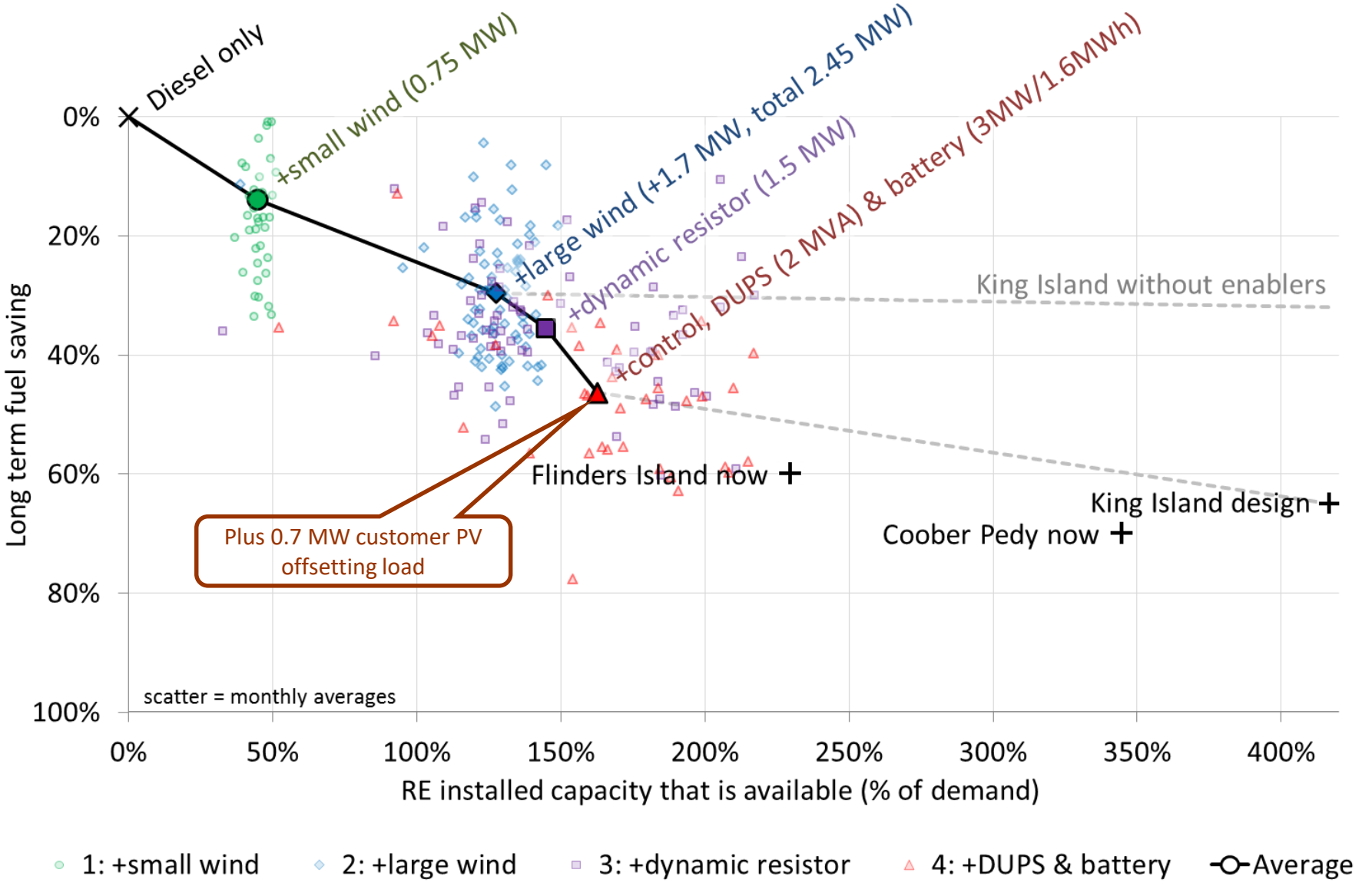
- Measurable
- Variable load, RE availability and resource
- Calibrates models used for other projects
- Operator experience: Could they use it?

King Island results

(next page)

- Trends show value of each project stage
- Monthly variability amplified at high RE:
  - Wind speed more significant
  - Aging RE not always available

King Island equipment outcomes



Operator video

https://www.youtube.com/watch?v=kcwnv-MBQ_M

0:49 to 2:00

Aronn Daw: Production Manager

Patrick Simmons: Lead Distribution

(3) Helping suppliers help themselves

Novel applications

- Unlikely to understand intended purpose
- Don’t know what they don’t know
- Want to address issues on site

Experience

- Often not aware of their weaknesses
- Best suppliers less interested in small or remote projects
- Responsibility split across subcontractors

Equipment

- Non-core functions can perform poorly
- ‘Easy’ may mean ‘haven’t considered’

Contract

- Tendered approach too aggressive

Example: Rottnest Island solar

Design requirement

- Fast set point control
- Often largest generator on system (600 kW)
- Reliable

Supplier needed support

- Control and protection fault rectification
- Revise operating principle to new limits
- Allowing extra time to complete works
- Providing a safe workplace

Learnings

- String inverters not currently suitable in critical applications
- Experienced personnel are important but rare in rapidly expanding market
- Design involvement and review is important at all stages

Example: King Island battery

Supply concerns

- In 2012 this was new tech. 4 of 5 tenderers since left market
- Good components with integration shortfalls
- Small team so limited skill base for unexpected challenges

Our situation

- Significant building & install costs
- Rigid schedule, high expectations
- Much labour to rectify

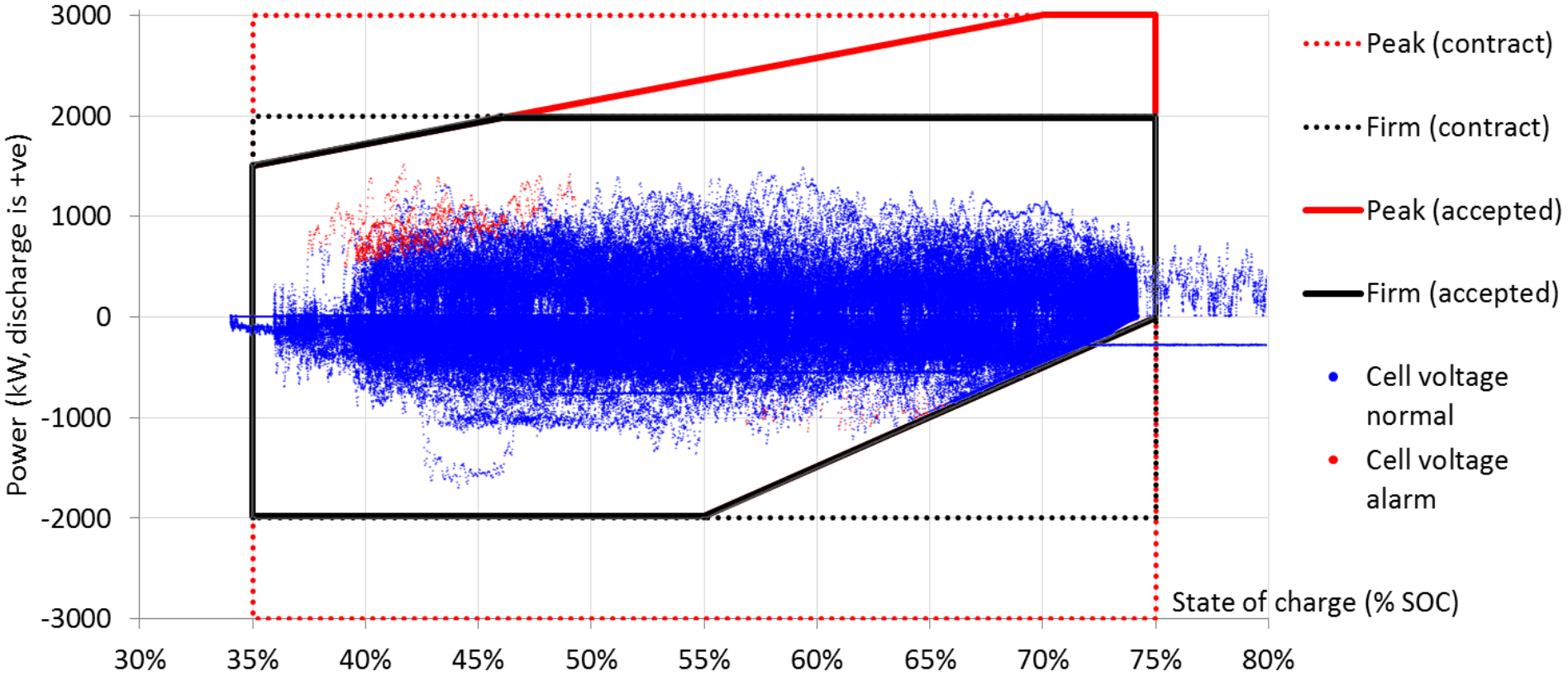
Learnings

(next page)

- Good contract and spec. is important
- Perilous to overlook control system
- Many failure modes with critical service impacts
- Collaborative approach saved project
- Our in-house skills were core

Example: King Island battery

Item	Contracted	Actual (Feb 2016)	Solution
Power capability	± 2 MW firm ± 3 MW max	Varies considerably with SOC and idle time	Improve battery control system. Revise operating principle. Accept new limits.
Discharge capacity	1.63 MWh	1.4 MWh	Accept new limit.
Reliability	99%, 200 days MTBF	82%, 6 days MTBF	Improve battery control system. Revise operating principle. New service level agreement.
Availability	95%	25%	



Hybrid Energy Systems

Operational Learnings