AgenticGrid

Final
October 2026
agenticscale.ai

Disclaimer

This report presents research undertaken as a pilot to explore the potential use of artificial intelligence and related analytical tools in electricity network analysis and planning. The findings and case studies are illustrative only and do not replace Essential Energy's existing planning practices, policies, standards or investment governance processes. Results should therefore be used with appropriate caution and should not be relied upon in isolation for planning or investment decisions. References to particular locations or potential projects do not represent a commitment by Essential Energy to fund, develop or deliver those projects.

ESSENTIAL ENERGY PILOT · COMMERCIAL-IN-CONFIDENCE

Remote Microgrid and Reliability Assessment

Ivanhoe and Tibooburra, Far-West NSW

PREPARED FOR

Essential Energy

Assessment of battery and microgrid investments at Ivanhoe and Tibooburra for Essential Energy. Reliability value uses Essential Energy's Reliability Value Framework 2.0 and supplied fault, demand and cost data, discounted at Essential Energy's reliability WACC (3.86% real). Prepared by AgenticGrid, October 2026.

Contents

Document control 4

Executive summary 5

Introduction 8

Network and assets 9

Method 10

Assumptions and inputs 12

Results 13

Discussion 22

Conclusions and recommendations 23

Limitations 24

Items to confirm 25

References 26

Appendix A. Glossary 27

Appendix B. Sensitivity analysis 28

Appendix C. Diesel-free scenario 31

Appendix D. Battery-only case 32

Appendix E. Reliability method 33

Appendix F. Load forecasting 34

SECTION

Document control

Prepared for	Essential Energy
Prepared by	AgenticGrid (AgenticScale Pty Ltd)
Date	27 August 2026 (final, 8 October 2026)
Classification	Commercial-in-confidence

Stage	Date	Status	Notes
Microgrid sizing	22 Jul 2026	Working draft	Solar and battery sizing, energy security and the sensitivity suite, developed with Essential Energy
Reliability	15 Aug 2026	Working draft	Reliability valuation for both towns on Framework 2.0, with confirmed project costs and indicative trading
Operating model confirmed	17 Aug 2026	Draft for review	Tibooburra re-modelled as a solar and BESS microgrid replacing the recovered diesel; both towns discounted at the FY26 3.86% WACC; solar and BESS size optimised
Risk valuation	27 Aug 2026	Draft for review	Three-layer risk basis added: benchmark against the AER resilience values, Guaranteed Service Level exposure, and the residual risk stated in hours
RACE review response	15 Sep 2026	Draft for review	Addressed RACE reviewer comments: neutral-register language, BESS operating-model clarification (energy vs inverter power), replacement-capex sensitivity, citations and figure legibility
Review response (v4)	22 Sep 2026	Draft for review	Addressed follow-up review: BESS one-hour duration and round-trip losses made explicit, the Ivanhoe trading value framed as an optimistic upper bound, and promotional language reduced further
Final (v5)	8 Oct 2026	Final	Reviewer sign-off edits: a redundant confirmation sentence removed from Section 5.1, and the Figure 6 caption notes the truncated colour scale

Status note. Network topology, installed generation and twelve months of measured demand are confirmed by Essential Energy. The reliability fault records and the value calculations are Essential Energy's own (Framework 2.0, supplied by the senior planner). Project costs are Essential Energy's estimates. The market trading value is indicative and is being aligned with Essential Energy's wholesale price assumptions. Section 9 lists the items to settle for a final version. Confirming those values is a parameter update, not a re-analysis.

SECTION

Executive summary

Essential Energy asked a practical question at two of its most remote communities, Ivanhoe and Tibooburra: is a battery worth building, and if so at what size. This assessment answers that question two ways. It reproduces the sizing Essential Energy's own planners selected, and it quantifies in dollar terms the reliability the battery delivers, using Essential Energy's own framework and data. Both assessments are consistent with Essential Energy's planning outcomes and provide the evidence to inform the investment decision.

The headline for each town, with all values as net present value over 25 years at Essential Energy's 3.86% real reliability discount rate:

	Ivanhoe (4 MWh, no solar)	Tibooburra (solar + BESS microgrid)
Customers on the network	322	139
Value of unserved energy if nothing is done	$3.85 M	$5.0 M
Reliability value captured	$2.5 M	$5.0 M
Main value driver	Reliability, made positive by trading	Reliability (the microgrid replaces the diesel)
Market trading value	$3.2 M (4 MW export)	$0.4 M (1 MW export)
Total project cost	$5.6 M	$5.2 M (after a $1 M recovered-diesel credit)
Net position (Essential Energy's design)	**+$0.05 M** (upper case; trading optimistic, replacement and round-trip not yet netted, Sections 5.4, 5.9)	**+$0.25 M**
Value optimum (this study)	~6 MWh (4 MWh preferred, risk-adjusted)	500 kW / 2 MWh, about +$1.0 M

At Ivanhoe the case is reliability-led and marginally positive at the 4 MWh design once trading is included, and the 4 MWh sizing is consistent with the design Essential Energy's planners selected.

These are reliability-driven investments at the very edge of the network, where the case is finely balanced. Both are marginally positive at Essential Energy's designs once market trading is included. The assessment measures the reliability benefit, the cost and the trading on one consistent basis and optimises the design against them.

Four findings stand out.

First, both investments are driven by the same objective, reliability, but the engineering differs at each town. At Ivanhoe the diesel is retained; because it is an 11 kV unit sized to the balanced town, the 33 kV and rural customers on the other feeders are beyond its reach during an upstream outage, and the battery holds them up. The Ivanhoe case is positive once trading on its 4 MW export is included, though that trading value is an optimistic upper bound before the battery's one-hour duration and round-trip losses (Section 5.4). At Tibooburra the temporary diesel is removed and redeployed, and a solar and BESS microgrid supplies the whole town during outages, so the reliability benefit is larger; the case is carried by reliability rather than trading, because its export is capped at 1 MW.

Second, an assessment based on fuel savings alone does not capture the reliability value the battery provides. On a diesel-fuel-displacement basis alone the Ivanhoe battery returns a net present value of about –$4.6 M, because a battery with no solar displaces little fuel. Assessed on the reliability it delivers, using Essential Energy's Reliability Value Framework 2.0, the net position is positive. The value of unserved energy at Ivanhoe if nothing is done is about $6.06 M undiscounted over 25 years, or $3.85 M as a present value at the 3.86% rate (Essential Energy has confirmed the $6.06 M and the rate), and the 4 MWh battery captures a large part of it.

Third, the reliability valuation was rebuilt from Essential Energy's own fault records, customer mix and load rather than copied from its spreadsheet. It matched Essential Energy's workbook on 30 of 31 faults; on the one difference, an over-counted value on the longest fault, Essential Energy has since confirmed and corrected the workbook.

Fourth, this version makes the risk basis of the valuation explicit, in three layers. The duration bands in Essential Energy's Framework 2.0 are shown to sit, within about two percent, on the resilience multiples in the Australian Energy Regulator's September 2024 Value of Network Resilience decision, blended to each town's customer mix, so the dollars rest on the national instrument for prolonged outages (Section 5.10). Essential Energy's own exposure under the NSW Guaranteed Service Level scheme is priced from the same fault records (Section 5.11). And the risk that remains after each design, which carries the safety and reputational consequence no dollar figure captures, is stated in hours, together with the marginal cost of buying one more hour of coverage, so sizing beyond the value optimum becomes a priced risk-appetite decision rather than a judgment call (Section 5.12).

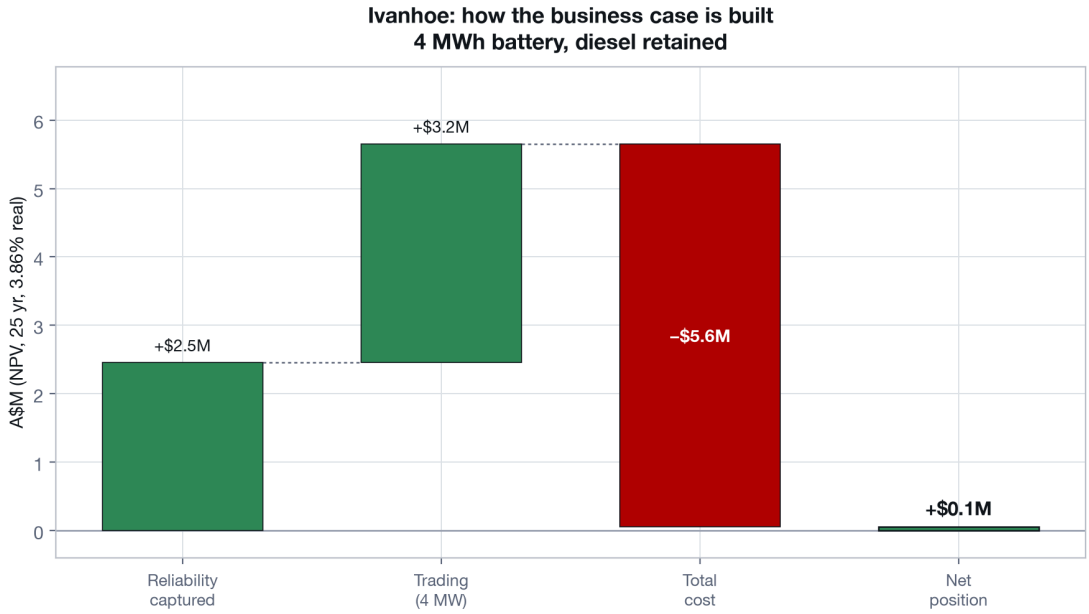


Figure 1. Ivanhoe, how the case is built at the 4 MWh design: reliability value captured plus market trading, less the total project cost, gives a small positive net position.

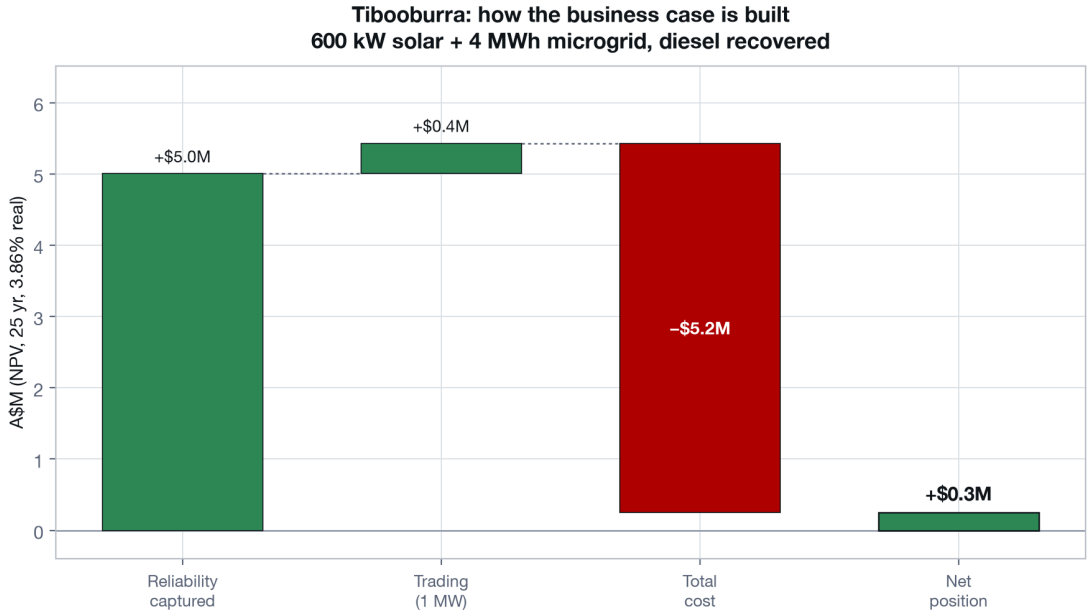


Figure 2. Tibooburra, how the case is built at the 600 kW / 4 MWh microgrid: the reliability value the microgrid captures, plus a small trading value, less the project cost after the recovered-diesel credit.

The reliability results, the sizing and the trading are in Section 5. The microgrid sizing sensitivity that Essential Energy has reviewed before is in Appendix B, and the reliability method for both towns is in Appendix E.

The same method is repeatable for other network planning decisions on Essential Energy's own data (Section 6).

SECTION 1

Introduction

1.1 Background

Ivanhoe (supplied from Hillston) and Tibooburra (supplied from Mt Gipps over about 292 km of 33 kV line) are remote communities at the extremity of the Essential Energy network. Essential Energy has installed a diesel generator at each town and is planning a battery, with solar at Tibooburra, to improve reliability, enable islanded operation and reduce diesel use. This report assesses those investments.

1.2 Objectives

For each town the assessment sets out to:

1. size the battery, and the solar where relevant, against the installed generator;
2. value the reliability the battery delivers, using Essential Energy's Reliability Value Framework 2.0;
3. quantify the cost-benefit against continued diesel operation, including an indicative market trading value; and
4. do so quickly and repeatably, so the same assessment extends to the next town and the next decision.

1.3 Developing the approach with Essential Energy

This work has been developed step by step with Essential Energy's planning specialists. The first stage sized the solar and battery on the diesel fuel displaced. Working through it with Essential Energy's senior planner and the planning team, it became clear that at a town where the diesel covers the balanced load, fuel displacement misses the battery's main job, which is holding up the 33 kV and rural customers the diesel cannot reach during an upstream outage. The approach was then extended to value that reliability directly, on Essential Energy's own Reliability Value Framework 2.0 and data, and to bring in Essential Energy's confirmed project costs and an indicative market trading value, so that both towns now carry a worked result.

1.4 Scope

The assessment covers each town's battery and microgrid economics: sizing, the value of reliability, diesel and emissions displacement, an indicative trading value, and multi-day energy security. It does not cover protection design, grid-forming control design, or procurement.

SECTION 2

Network and assets

Confirmed by Essential Energy

2.1 Network topology

	Ivanhoe	Tibooburra
Grid supply	Hillston 132 kV	Mt Gipps, about 292 km of 33 kV line
Supply point	Single zone substation, five feeders (three SWER)	No zone substation, single feeder MTG4B1
Customers	322 (244 residential, 38 commercial, 40 agriculture)	139 (78 residential, 43 commercial, 18 agriculture)

2.2 Installed generation

	Ivanhoe	Tibooburra
Generator	Atlas Copco QIS1015	VPOWER PPU880
Rating	810 kW	640 kW
Fuel at 100% / 50% load	197 / 102 L/h	161 / 85 L/h

At Ivanhoe the diesel generator is retained and treated as fixed capacity. At Tibooburra the temporary diesel is removed and redeployed to another resilience investment (a $1 M credit to this project, understood as the redeployment value of the recovered generator, to confirm with Essential Energy); it is not run to offset fuel. A solar and BESS microgrid then supplies the town during outages, so the assessment sizes both the solar and the BESS. Section 5.7 tests the alternative of retaining the diesel.

2.3 Measured demand

Twelve months of measured half-hourly load were supplied for each town.

	Ivanhoe	Tibooburra
Peak demand	472 kW	442 kW
Mean demand	184 kW	107 kW
Demand forecast	Flat	Flat (Essential Energy, Aug 2026)

SECTION 3

Method

3.1 Two towns, two operating models

Both towns are grid-connected and rely on local assets only during upstream outages, so the value is reliability. The engineering differs.

- **Ivanhoe.** The diesel is retained. It is an 11 kV unit sized to the balanced town, so during an outage it covers that load, while the 33 kV and rural (SWER) customers on the other feeders are electrically beyond it. The battery holds up those customers until its energy is exhausted. Only the battery is sized.
- **Tibooburra.** The temporary diesel is recovered, and a solar and BESS microgrid supplies the whole town during outages. The BESS carries the load and the solar recharges it, so the microgrid can ride through multi-day outages. Both the solar and the BESS are sized.

In both cases the reliability value is measured on Essential Energy's Reliability Value Framework 2.0. Market trading on the same asset adds value in normal operation. Section 5 sets out the combined position and, for Tibooburra, the solar and BESS size optimisation.

3.2 Reliability value

The value of energy not supplied uses the Australian Energy Regulator's duration-banded Value of Customer Reliability, in dollars per MWh, blended to each town's customer mix, across three elapsed-outage bands: 0 to 12 hours, 12 to 24 hours (the dearest, the resilience premium), and beyond 24 hours. At Ivanhoe each fault's valued duration is capped at the longest ordinary (non-major-event) fault, consistent with Essential Energy's treatment; at Tibooburra Essential Energy's workbook values the full duration of every fault, and this assessment matches that. The historical record is scaled to the 25-year study. The local supply serves the load at risk from the start of each outage until its energy is exhausted, capturing the early hours first and leaving the tail unserved. Appendix E gives the detail for both towns.

3.3 Costs and discounting

Reliability values are discounted at Essential Energy's reliability-investment WACC of 3.86% real over 25 years. This is Essential Energy's FY26 pre-tax real regulated cost of capital, the rate it applies to reliability investment, and it is used for both towns' reliability numbers. Project costs are Essential Energy's own estimates (Section 4). The microgrid diesel-displacement figures in Appendix B and Appendix C come from the earlier microgrid sizing stage, on the microgrid-stage cost-benefit convention (15 years, 5.5% real commercial discount rate). The two rates differ: discounting the reliability stream at 5.5% instead of 3.86% would reduce the reliability net present values. Aligning the two cost bases is an open item (Section 9).

3.4 An independent calculation

The reliability valuation is computed independently, from first principles on the Australian Energy Regulator's published Value of Customer Reliability, the same basis as Framework 2.0, over Essential Energy's raw inputs: the fault records, the measured demand, the customer mix and the network. It uses Essential Energy's data, not Essential Energy's spreadsheet. Run fault by fault at Ivanhoe, the engine matched Essential Energy's own workbook on 30 of 31 faults and differed on one, a single over-counted cell on the longest fault, which Essential Energy has since confirmed and corrected.

3.5 Three layers of value and risk

Reliability investment turns on the cost of an outage, and that cost has more than one kind of owner. Customers lose supply; the network carries payment, response and reputational consequences of its own; and some consequences, safety above all, have no defensible price. Blending these into a single dollar figure either flattens the rare long event into an average or invites double counting, since the customer losses are already inside the Value of Customer Reliability. This assessment therefore keeps three layers separate:

1. **Priced, on the regulator's instruments.** The expected value of unserved energy, on the duration-banded Framework 2.0 basis of Section 3.2, benchmarked against the Australian Energy Regulator's Value of Network Resilience decision for prolonged outages (Section 5.10).
2. **Priced, as Essential Energy's own exposure.** The Guaranteed Service Level payments the fault record exposes Essential Energy to, computed from the same fault data (Section 5.11). Emergency response, generator hire and community relief costs sit in this layer and are Essential Energy inputs still to be added.
3. **Stated, not priced.** The risk each design leaves behind, expressed in hours of customer interruption, the longest remaining event, and the marginal cost of one more hour of coverage (Section 5.12). Safety and reputational consequence live here, treated as a sizing constraint for the risk owner rather than a dollar line.

The three layers answer different questions: layer one whether the investment is worth making, layer two what doing nothing costs Essential Energy directly, and layer three how much unpriced risk each option accepts, at what price to remove.

SECTION 4

Assumptions and inputs

Parameter	Value	Basis	Status
Reliability discount rate	3.86% real, 25 yr	Essential Energy reliability WACC (senior planner)	Confirmed
Value of Customer Reliability	AER duration bands, blended to town mix	Framework 2.0 workbooks	Confirmed by Essential Energy
Ivanhoe fault record	31 faults over 12.5 yr	Framework 2.0 (Essential Energy)	Confirmed
Tibooburra fault record	88 faults over 12.5 yr	Framework 2.0 (Essential Energy)	Confirmed
Ivanhoe battery cost	$325k/MWh incremental, $1.3 M for 4 MWh	Essential Energy (senior planner)	Confirmed estimate
Ivanhoe establishment cost	about $4.3 M (extends the zone substation)	Essential Energy (senior planner)	Confirmed estimate
Tibooburra project cost	$5.2 M ($3.8 M establishment + $1.3 M BESS + $1.1 M solar, less a $1 M recovered-diesel credit)	Essential Energy (senior planner)	Confirmed estimate
Solar cost	not applicable	$1.8 M/MW installed ($1.1 M for 600 kW)	Essential Energy (senior planner)
Tibooburra export limit	1 MW (small upstream transformer)	Essential Energy (senior planner)	Confirmed
Trading capacity value	$60k/MW/yr benchmark	Essential Energy (senior planner)	Indicative, to model
Delivered diesel price	A$2.00/L	Regional benchmark	Assumption, to confirm

SECTION 5

Results

5.1 Ivanhoe: reliability value by battery size

The value of unserved energy if nothing is done sets the ceiling on what a battery can capture. At Ivanhoe that ceiling is $6.06 M undiscounted over 25 years (in real, constant dollars), or $3.85 M as a present value. The larger the battery, the more of that value it captures, with diminishing returns as the longest outages exceed what any practical battery can cover.

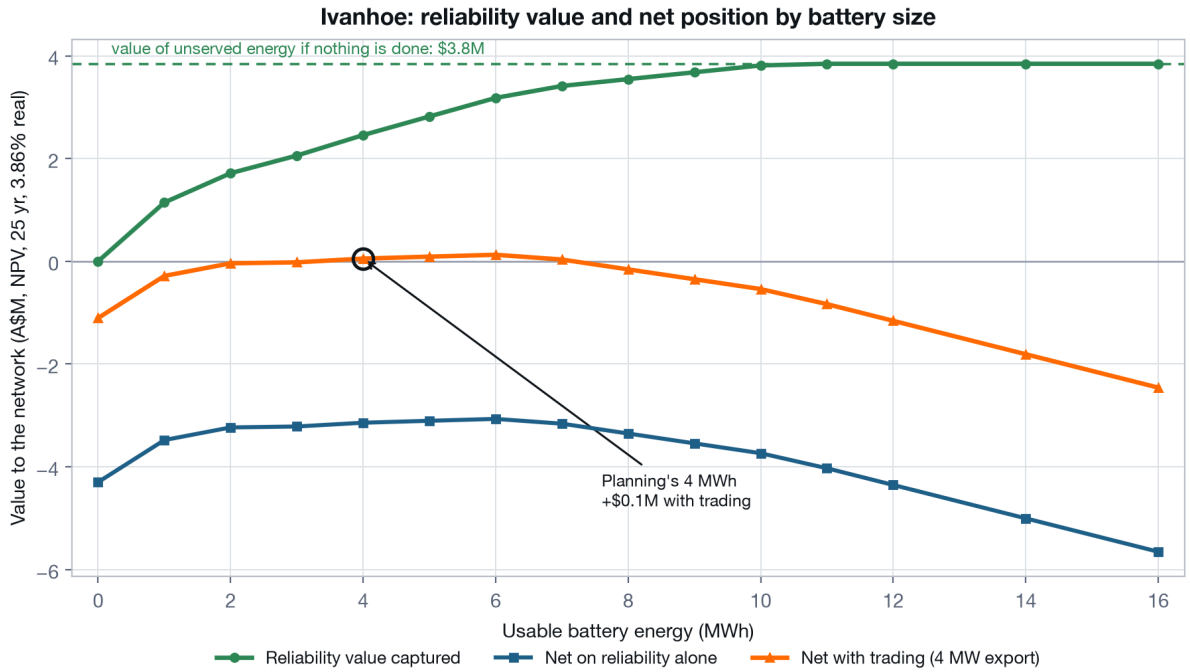


Figure 3. Ivanhoe. Reliability value captured rises towards the do-nothing ceiling. Net on reliability alone is negative at the full project cost. Adding trading on the 4 MW export lifts the net above zero, and Planning's 4 MWh sits close to the best size.

At Ivanhoe the 4 MWh battery captures $2.5 M of reliability value. On the full project cost of $5.6 M the battery does not pay on reliability alone, which is expected at the very edge of the network. Trading on the 4 MW export adds $3.2 M, and the combined position is a small positive, about +$0.05 M. The best combined size is around 6 MWh, so Planning's 4 MWh is well placed and leaves headroom for load growth and battery ageing.

5.2 Ivanhoe: sizing at 4 MWh

At Ivanhoe the 4 MWh battery is close to the best combined size, cuts unserved energy to a fraction of the do-nothing case, and leaves headroom for growth and ageing. Sizing for zero unserved energy would take about 10 MWh, a resilience choice the reliability value alone does not pay for.

The value-maximising size at Ivanhoe is closer to 6 MWh, yet 4 MWh remains the preferred design. The step from 4 MWh to 6 MWh buys only about $0.75 M more reliability value for about $0.65 M more battery capital, and lifts the combined net by only about $0.1 M. That incremental return does not justify the extra capital, so the smaller battery is the better risk-adjusted outcome. The analysis is consistent with Essential Energy's 4 MWh choice rather than pushing to the mathematically highest-value size.

5.3 The combined business case

Bringing the pieces together at each town's planned design:

	Ivanhoe (4 MWh)	Tibooburra (600 kW, 4 MWh)
Reliability value captured	+$2.5 M	+$5.0 M
Market trading	+$3.2 M (4 MW)	+$0.4 M (1 MW)
Total project cost	−$5.6 M	−$5.2 M
Net position	**+$0.05 M**	**+$0.25 M**

In both cases the reliability value is the primary driver, and the market trading value brings the combined net position above zero. Ivanhoe keeps its diesel and adds a battery; Tibooburra recovers its diesel and builds a solar and BESS microgrid that captures a much larger reliability benefit ($5.0 M) because it supplies the whole town during outages, against a project cost of $5.2 M after the $1 M recovered-diesel credit. Both are finely balanced, which is why the Tibooburra design is optimised (Section 5.5). Figures 1 and 2 show these stacks.

5.4 Trading is set by export capacity

Market trading on the same battery is an additional revenue stream, and its value is set by how much the site can export. The figure here is indicative, on the capacity basis explained below; a firm value would come from the market-based assessment in Recommendation 3.

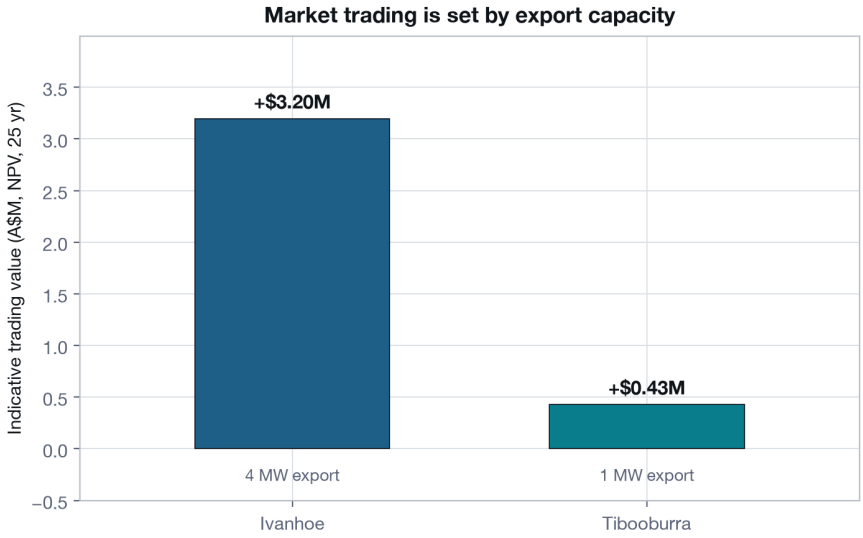


Figure 5. Trading value follows export capacity. Ivanhoe's 4 MW export supports about A$3.2 M; Tibooburra's 1 MW limit, set by a small upstream transformer, supports about A$0.4 M.

Energy is reserved for reliability only to cover the load at risk during upstream outages, which is a small fraction of the time, so most of the battery's capacity is free to trade. The values here use a $60k/MW/year benchmark: a capacity-availability value per MW of inverter export capacity, an Essential Energy benchmark, not an energy margin of dollars per MWh multiplied by hours traded.

Two features of the asset qualify this value, and are stated plainly here. The Ivanhoe asset is 4 MWh of energy on a 4 MW (4 MVA) inverter, so it is a 1C battery: at full 4 MW output it runs for only about an hour before it is empty, and round-trip losses of about 10 to 15 percent reduce the energy it returns each cycle. The $60k/MW/year benchmark rewards the 4 MW rating without netting either the one-hour duration or the round-trip loss, so it is an optimistic, indicative upper bound, not a firm value. A market that prices duration and efficiency, which the price-trace model in Recommendation 3 would apply, would value a one-hour battery below this benchmark. Because the Ivanhoe case leans on this value, it is tested across a range below, and the low end is the more realistic reading once duration and losses are counted.

Trading assumption	Trading value (NPV)	Ivanhoe combined net
Low, about $40k/MW/yr	+$2.0 M	−$1.2 M
Expected, $60k/MW/yr	+$3.2 M	+$0.05 M
High, about $90k/MW/yr	+$5.0 M	+$1.9 M

The Ivanhoe result turns positive only once trading reaches about $59k/MW/year, just below the $60k expected benchmark, so it is finely balanced on this single assumption. Once the one-hour duration and round-trip losses are counted, the effective capacity value would sit lower, toward the low case above, where the Ivanhoe combined net is about −$1.2 M. A market-based assessment against Essential Energy's own price forecast (Recommendation 3) is needed to settle it, so the Ivanhoe recommendation should be read as conditional on that assessment. Tibooburra is not sensitive to this: its export is capped at 1 MW, so trading is small in every case, and its result rests on reliability.

5.5 Tibooburra: optimising the microgrid

At Tibooburra the study optimises the solar and BESS size together, which is what Essential Energy asked for. Larger solar lets the microgrid ride through longer and cloudier outages; larger BESS bridges the nights and low-solar spells. Each is traded off against its cost ($1.8 M/MW of solar, $325k/MWh of BESS) and the reliability value it captures.

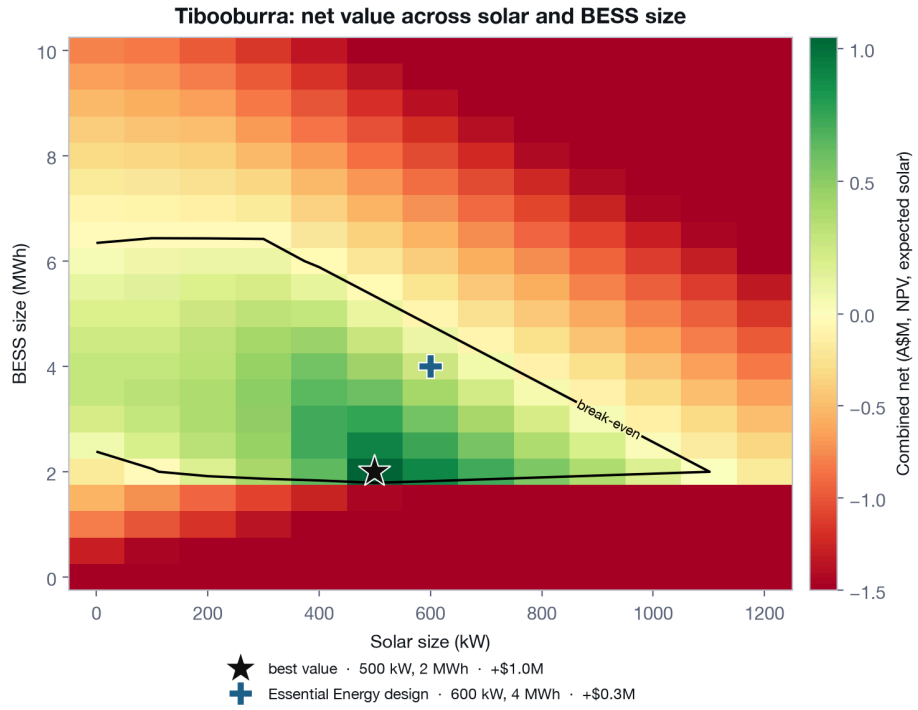


Figure 6. Tibooburra. Combined net value across solar and BESS size, on expected solar. The best-value design is about 500 kW / 2 MWh; Essential Energy's 600 kW / 4 MWh sits just above it, buying more resilience to a low-solar spell for a modest cost. The colour scale is truncated to improve visibility, so cells at the dark-red end are not all equal in value.

Essential Energy's 600 kW / 4 MWh microgrid captures $5.0 M of reliability value on expected solar, for a combined net of about +$0.25 M. The best-value size on this basis is smaller, about 500 kW / 2 MWh, at about +$1.0 M, because the BESS captures nearly all the reliability value and additional solar and BESS mostly add cost. The larger 4 MWh BESS is more resilient to a cloudy multi-day outage (Section 5.6), so the choice is a value against resilience trade-off, which the analysis makes explicit.

5.6 Tibooburra: low-solar sensitivity

The microgrid depends on the solar recharging the BESS through an outage, so the binding case is a multi-day outage during a cloudy spell. On a low-solar assumption, solar at about 40% of its average during the outage, the 600 kW / 4 MWh design's reliability capture falls from $5.0 M to about $4.5 M and its combined net to about –$0.3 M, while the smaller 500 kW / 2 MWh design falls further because it has less stored energy to fall back on. This is why Essential Energy's larger BESS is a reasonable choice despite the smaller design testing better on expected solar. A full dispatch model against the measured solar record would firm this and is a natural next step.

5.7 Tibooburra: retaining the diesel (an option to weigh)

Essential Energy asked whether retaining the existing temporary diesel as a permanent firming and backup asset improves the outcome, rather than recovering it. The answer turns on one point: a retained diesel (640 kW, larger than the town's 442 kW peak) can supply the whole town through any outage on its own, so it delivers the full reliability value ($5.0 M) by itself. The battery then no longer has to carry a multi-day outage, so it can be much smaller, sized for fast response and trading rather than autonomy, and the solar sizes for fuel displacement and trading. This is the same structure as the Ivanhoe design: a battery alongside a firm diesel.

Scenario	Solar (kW)	BESS (MWh)	Diesel retained	Cost	Net NPV	Reliability
Current planning basis	600	4	No	$5.2 M	+$0.25 M	Full on expected solar
AgenticGrid diesel-free (optimised)	500	2	No	$4.35 M	+$1.0 M	Full on expected solar
Diesel retained (optimised)	~400	~1	Yes	~$4.4 M (indicative)	~+$1.1 M (indicative)	Full, robust to low solar

On these indicative figures, retaining the diesel is at least as economic as the diesel-free designs and materially more resilient, because the diesel removes the low-solar risk the diesel-free microgrid carries (Section 5.6), and it lets the battery shrink from 4 MWh to about 1 MWh. The trade-offs are the ongoing diesel fuel, maintenance and emissions, keeping an ageing asset, and forgoing the $1 M recovery credit.

Answering the decision questions directly: retaining the diesel lets the battery be much smaller for the same reliability, because the diesel firms it; its greatest value is precisely during the prolonged low-solar events where the diesel-free microgrid is weakest. Whether it is the superior whole-of-business outcome depends on three inputs Essential Energy holds: the establishment cost with the diesel retained (likely lower, as the diesel provides grid-forming), the avoided diesel relocation and future replacement cost, and the intended diesel run profile. With those, the indicative figures above can be firmed. The purpose is not to advocate diesel use, but to test whether retaining the existing asset is a viable optimisation before it is relocated. The solar is shown capped at 600 kW; if land or connection limits the array below that, the optimisation would settle on a smaller solar size once the cap is confirmed.

5.8 Reliability reserve and benefit stacking

The combined case adds reliability and trading value together. That is only sound if the two services do not draw on the same capacity at the same time, so it is worth showing why they do not.

Reliability is called on only during upstream outages, about two to three times a year at Ivanhoe from 31 faults over 12.5 years. Trading happens in normal operation, the other 99.9 percent of the time, so the two rarely compete. The only overlap risk is an outage beginning while the battery is mid-trade at

low charge. That is managed with a reliability reserve: a minimum state of charge held back to cover the load at risk from the start of an outage until dispatch re-coordinates.

Because the load at risk is small relative to the battery (0.28 MW at Ivanhoe and 0.14 MW at Tibooburra, against a 4 MWh battery), the reserve is a modest share of capacity. Holding two hours of load at risk is about 14 percent of the battery at Ivanhoe and 7 percent at Tibooburra, leaving the large majority free to trade. The reliability value captured is therefore essentially unchanged, and the two benefits do not materially compete. A full co-optimised dispatch model would confirm the exact reserve and is a natural next step.

5.9 Battery degradation

Over a 25-year life a battery loses usable energy capacity. Energy fade affects the reliability energy most; the trading value is largely a capacity service on the inverter rating, which energy fade affects little. Asset replacement over 25 years is treated separately, below. The table shows the Ivanhoe combined net if the battery is maintained near nameplate, and if it is allowed to fade.

Battery condition	Reliability value	Ivanhoe combined net
Maintained near 4 MWh (augmented)	+$2.5 M	+$0.05 M
Fades to about 80% by year 25, average near 90%	+$2.3 M	−$0.1 M
Fades to about 65% by year 25, average near 80%	+$2.1 M	−$0.3 M

The energy-fade effect alone is modest, because trading holds up and the reliability value is dominated by the cheaper early outage hours that even a degraded battery still covers. Augmentation, standard practice for a 25-year battery, holds the result at the maintained line for a small operating cost.

The more material 25-year effect is asset replacement. Both the battery (around years 10 to 15) and the inverter (around years 12 to 15) have service lives shorter than the study, and the figures above do not yet include the discounted cost of replacing them, priced in real terms at the lower unit costs expected by then. Together with the round-trip losses not yet netted (Section 8), and with the Ivanhoe net at only +$0.05 M, a replacement schedule could reduce the Ivanhoe case to marginal or negative. The precise effect depends on Essential Energy's replacement costs and schedule (Section 9), which is why the Ivanhoe recommendation is treated as finely balanced. Essential Energy engineering can settle the augmentation and replacement strategy.

5.10 Benchmarked against the AER resilience values

Layer one: the dollars rest on the national instrument

The Australian Energy Regulator's published Value of Customer Reliability (Reference 1) covers standard outages of up to 12 hours. Outages beyond 12 hours, which carry most of the value at both towns, are valued under the AER's Value of Network Resilience (September 2024, Reference 2): tiered multiples of the standard VCR, 2.0 times for 12 to 24 hours and 1.5 times beyond 24 hours for residential customers, and 1.5, 1.0 and 0.5 times for business customers across the 12-24, 24-72 and beyond-72-hour tiers.

Expressing Framework 2.0's duration bands as multiples of their own first-12-hour rate, and blending the AER tiers by each town's residential share of customers, the two agree within about two percent at both towns and in both bands. Framework 2.0's bands therefore sit within about two percent of the AER multiples blended to each town's mix.

	Ivanhoe	Tibooburra
Residential share of customers	244 of 322	78 of 139
Framework 2.0 band, 12 to 24 h	1.91x	1.81x
AER multiples blended to the mix	1.88x	1.78x
Framework 2.0 band, beyond 24 h	1.41x	1.31x
AER multiples blended to the mix	1.38x	1.28x

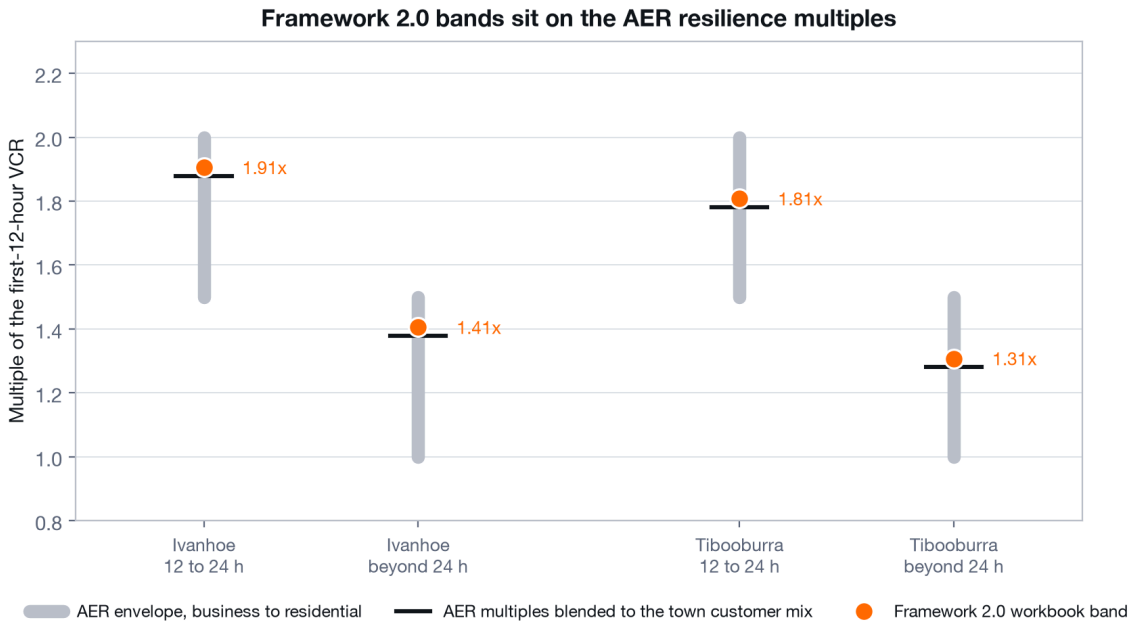


Figure 7. Each workbook band (orange) against the AER tier envelope (grey, business to residential) and the AER multiples blended to the town's customer mix (black). The workbook bands sit on the blend at both towns.

The AER decision also sets an upper bound of $3,500 per residential customer per prolonged outage, the least-cost of backup self-generation, beyond which a rational customer would self-supply. The worst valued event at Ivanhoe (51.7 hours, capped at 36.2) averages about $1,700 per customer, inside the bound, so Ivanhoe's capped convention is conservative against the AER instrument. Tibooburra's longest event (92.2 hours, valued in full per Essential Energy's workbook) averages about $4,400 per customer, above the bound; applying the bound to the residential share of the events that exceed it would trim the do-nothing value by roughly $0.26 M (undiscounted), about three percent. The two conventions therefore agree to within rounding, and the uncapped Tibooburra basis is, if anything, slightly generous to the do-nothing cost, which is noted in Section 9.

5.11 What doing nothing costs Essential Energy directly

Layer two: the network's own exposure

The value in Section 5.1 accrues to customers. Essential Energy also carries a direct, visible exposure under the NSW Guaranteed Service Level scheme: a customer who suffers 36 hours of interruptions, or 20 interruptions, in a financial year is entitled to a GSL1 payment ($122.88 in 2025-26), and 120 hours or 50 interruptions to a GSL2 payment ($415.47), one of each per customer per year, indexed annually.

Counting only single faults long enough to cross a threshold on their own, the fault records expose Essential Energy to four qualifying events at Ivanhoe and six at Tibooburra over the 25-year study:

	Ivanhoe	Tibooburra
Faults crossing 36 h, over 25 years	4	6
Exposure if nothing is done	$158k	$102k
Exposure at the planned design	$79k	nil on expected solar; $34k low solar

Three observations follow. The exposure is real but small against the customer-side value, about two percent of it: the scheme compensates only a fraction of the cost customers bear and is not a proxy for it. The figures are a floor, since faults that accumulate 36 hours across a year cannot be counted without dated fault records, and payments are claim-based. And the layer is incomplete by design: emergency response, generator hire, freight to the far west, community relief and complaint handling belong here and are Essential Energy inputs the framework has slots for (Section 9).

5.12 The risk that remains, stated in hours

Layer three: what the dollars do not capture

Safety and reputational consequence concentrate in the rare long outage, and no defensible dollar rate exists for them. Rather than force them into a price, the assessment states the risk each option leaves behind in physical units, and prices only the cost of removing it.

	Ivanhoe	Tibooburra
Customer interruption if nothing is done	20 h per year	51 h per year
Longest event on the record	52 h	92 h
Interruption remaining at the design	6.1 h per year	nil expected; 4.9 h per year low solar
Longest event remaining	38 h	nil expected; 44 h low solar
Cost of one more hour of coverage	about $92k	about $45k

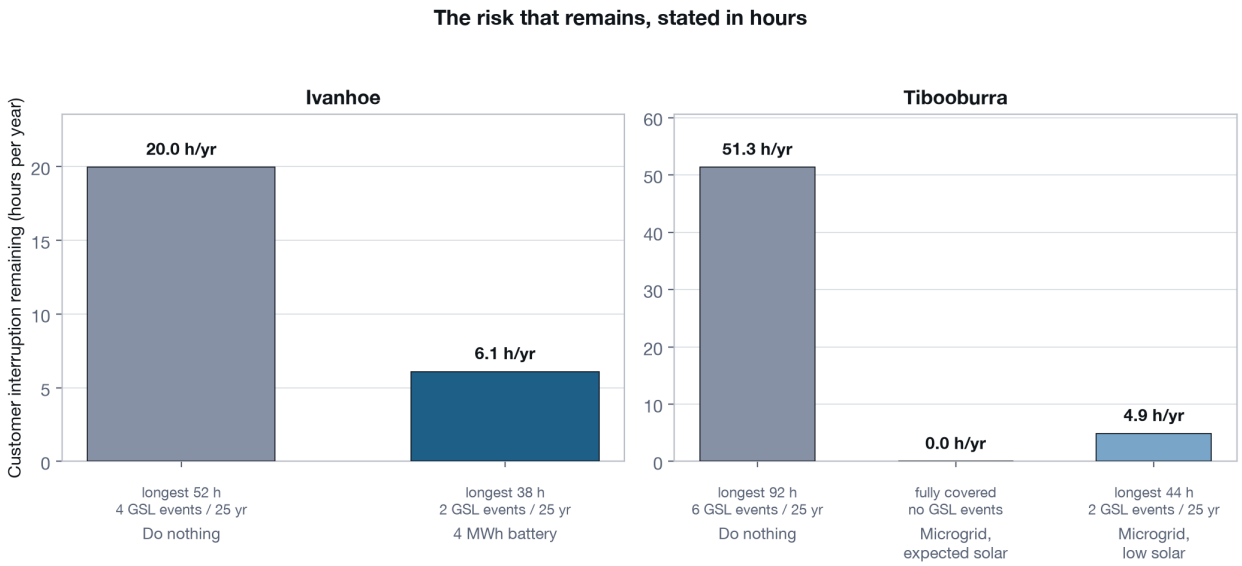


Figure 8. Customer interruption remaining under each option, with the longest remaining event and the Guaranteed Service Level events still incurred. The do-nothing bars are the risk position Essential Energy holds today.

Read this way, the do-nothing option is not a zero-cost baseline: it holds today's full risk position, 20 and 51 hours of customer interruption a year, worst events of 52 and 92 hours, and the associated exposure of Section 5.11, and that position worsens as the assets age. The Ivanhoe battery removes about seventy percent of the interrupted hours but still leaves a 38-hour worst event; covering it entirely would take roughly 10 MWh, and at about $92,000 per additional hour of coverage the reliability value alone does not pay for the tail. The Tibooburra microgrid clears the entire record on expected solar, and its exposure concentrates in the cloudy multi-day spell of Section 5.6.

The marginal cost of additional coverage lets the residual risk be weighed against its cost: whether a 38-hour worst event at Ivanhoe is acceptable is a judgment for the risk owner, and what it costs to shorten it is a stated price rather than a further re-run of the study. Where a hard requirement exists, for example an endurance target for a town during a heat event, it enters the sizing as a constraint, and the assessment reports the cost of meeting that constraint.

SECTION 6

Discussion

The two assessments illustrate the same finding in two different ways. At Ivanhoe the value is reliability, brought above zero by trading; at Tibooburra it is a solar and BESS microgrid replacing the diesel, valued on the reliability it delivers to the whole town. In both cases the assessment reproduces the design Essential Energy's planners selected, tests it for size, and quantifies the reliability value on Essential Energy's own framework and data. It is intended to support Essential Energy's planning, not to replace it.

A valuation based on fuel savings alone misses the reliability benefit: a battery that a fuel-only assessment would reject can be economic once the reliability it delivers to the customers beyond the diesel is included. The valuation reconciles fault by fault to Essential Energy's own workbook, so each figure is traceable to its source.

The same method, valuing a decision on Essential Energy's own data and frameworks and weighing the cost and value streams on one consistent basis, is repeatable for other network planning decisions. Whether to apply it more widely is a matter for Essential Energy.

SECTION 7

Conclusions and recommendations

1. **Ivanhoe (4 MWh): the sizing is sound, the economic case is conditional.** The 4 MWh battery is well sized for reliability. The case is reliability-led and marginally positive once trading is included, about +$0.05 M at the expected benchmark, but thin and conditional: the trading benchmark is an optimistic upper bound before the battery's one-hour duration and round-trip losses (Section 5.4), and battery and inverter replacement (Section 5.9) is not yet netted. The market-based trading assessment in recommendation 3 is needed to settle it, and could leave Ivanhoe marginal or negative.
2. **Tibooburra (solar + BESS microgrid): the assessment supports a reliability-led microgrid and quantifies the size trade-off.** Essential Energy's 600 kW / 4 MWh is about +$0.25 M on expected solar; a smaller 500 kW / 2 MWh tests better on value (about +$1.0 M), while the larger BESS is more resilient to a cloudy multi-day outage. These figures inform Essential Energy's size decision on that value against resilience trade-off.
3. **Confirm the trading value** by modelling it against Essential Energy's wholesale price assumptions, with the commercial team.
4. **Firm the Tibooburra solar modelling.** Confirm the microgrid's low-solar performance with a full dispatch model against the measured solar record, and settle the reliability reserve, with engineering.
5. **Adopt the three-layer risk basis, and supply the inputs that complete it.** The valuation now separates what is priced on the regulator's instruments, what Essential Energy is directly exposed to, and what remains unpriced and stated in hours (Sections 5.10 to 5.12). Four Essential Energy inputs would firm it: the customer count affected by upstream faults at Ivanhoe, dated fault records so cumulative Guaranteed Service Level years can be counted, the emergency response cost per long event, and an endurance target per town so the residual risk has an agreed acceptance line.

SECTION 8

Limitations

The reliability model treats the load at risk as constant during an outage, matching Essential Energy's framework; a time-varying outage load is a later refinement. The battery is assumed available for reliability at the start of each outage, which the reliability reserve in Section 5.8 supports. Battery degradation, and the mid-life replacement of the battery and inverter, are examined in Section 5.9. The market trading value is modelled as a capacity payment on the 4 MW inverter rating and does not net the battery's one-hour duration at full output or round-trip losses, so it is an optimistic upper bound (Section 5.4). At Ivanhoe, where the net position is thin, the trading de-rating and asset replacement together could reduce the case to marginal or negative, pending Essential Energy's replacement costs and the market-based trading assessment in Section 9. At Ivanhoe the single major-event fault is capped at the longest ordinary fault, matching Essential Energy's treatment; at Tibooburra the full duration of every fault is valued, matching Essential Energy's workbook. The Tibooburra microgrid's reliance on solar during outages is taken on an expected-value basis, with a low-solar sensitivity in Section 5.6.

The risk layers carry their own limits. The Guaranteed Service Level exposure counts only single faults long enough to cross a threshold on their own, because the fault records are undated; cumulative same-year triggers would raise it, and payments are claim-based, so the exposure is what would be paid if every affected customer claimed. The Ivanhoe exposure uses the whole-town customer count as an upper bound, since the customers at risk beyond the diesel are an Essential Energy input. The indicative trim from the AER's residential self-generation bound at Tibooburra approximates the residential share of each long event by the customer-share-blended tier weights. Safety and reputational consequence are deliberately not priced; they are represented by the residual risk profile in Section 5.12 for the risk owner to judge.

SECTION 9

Items to confirm

For the final version

- Model the trading value against Essential Energy's wholesale price assumptions (with the digital and commercial teams).
- Reconcile the microgrid cost basis (Appendix B and C) to Essential Energy's confirmed project costs, and confirm the delivered diesel price.
- Confirm the Tibooburra major-event convention (cap at the longest ordinary fault, as at Ivanhoe) or adopt the uncapped figure.
- Settle battery degradation, state of charge and end-of-life with Essential Energy engineering.
- Provide Essential Energy's battery and inverter replacement costs and schedule, so the 25-year replacement effect can be included (Section 5.9).
- Confirm the basis of the $1 M recovered-diesel credit at Tibooburra (understood as the redeployment or avoided-replacement value of the recovered generator).
- Confirm the customer count affected by upstream faults at Ivanhoe (the customers beyond the diesel), for the Guaranteed Service Level exposure.
- Provide dated fault records, so cumulative Guaranteed Service Level years and any major-event-day exclusions can be counted exactly.
- Add Essential Energy's emergency response cost per long event (generator hire, freight, crews, community relief) to the second layer.
- Set an endurance target per town (the longest outage each town should ride through), so the residual risk in Section 5.12 has an agreed acceptance line.

SECTION 10

References

1. Australian Energy Regulator, Values of Customer Reliability 2024, final report on VCR values (December 2024). https://www.aer.gov.au/industry/registers/resources/reviews/values-customer-reliability-2024
2. Australian Energy Regulator, Value of Network Resilience 2024, final decision (30 September 2024). https://www.aer.gov.au/industry/registers/resources/reviews/value-network-resilience-2024
3. Essential Energy, Guaranteed Service Level Scheme (2025-26 values).
4. Essential Energy, Reliability Value Framework 2.0 (Ivanhoe and Tibooburra workbooks, 2026), Essential Energy's internal commercial-in-confidence workbooks. The publicly available description of Essential Energy's appraisal method is the AER Essential Energy Appraisal Value Framework (October 2021, https://www.aer.gov.au/system/files/Essential%20Energy%20-%206.03.03%20Appraisal%20Value%20Framework%20-%20Oct21%20-%20Public.pdf); confirm with Essential Energy that Framework 2.0 is the current version of that method.
5. Essential Energy, measured half-hourly demand, network topology and installed generation (2025 to 2026).
6. AgenticGrid, microgrid sizing analysis for Ivanhoe and Tibooburra (July 2026).

APPENDIX A

Glossary

BESS battery energy storage system. **GSL** guaranteed service level, the NSW scheme under which customers with sustained interruptions are entitled to fixed payments. **NPV** net present value. **SWER** single wire earth return. **VCR** value of customer reliability. **VNR** value of network resilience, the AER's instrument for valuing outages beyond 12 hours. **WACC** weighted average cost of capital. **Load at risk** the 33 kV and rural load the battery must serve during an upstream outage. **Major-event day** a day excluded from the reliability standard, on which extended outages are not counted against reliability targets.

APPENDIX B

Sensitivity analysis

Microgrid diesel displacement

This appendix carries the earlier fuel-displacement sizing sensitivity from an initial stage of this work, when the towns were modelled as diesel microgrids. It is superseded for Tibooburra by the reliability-based optimisation in Section 5.5 (the operating model is grid-connected with local supply during outages, not diesel displacement), and is retained here for the sensitivity method it illustrates. Reading the charts: the solid blue line is net present value on the left axis (higher is better); the dashed gold line is payback on the right axis (lower is better); the orange dotted line marks the reference design.

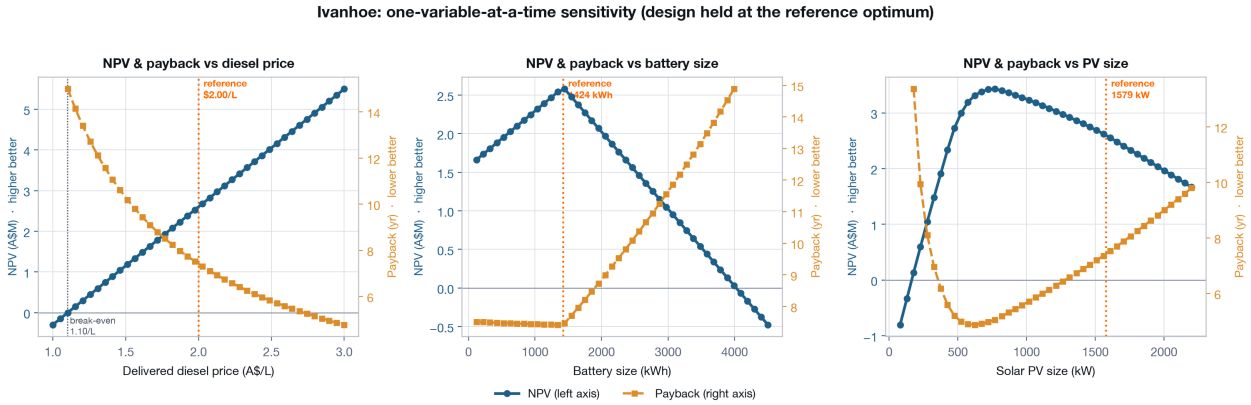


Figure B1. Ivanhoe. Net present value and payback of the microgrid against diesel price, battery size and solar size.

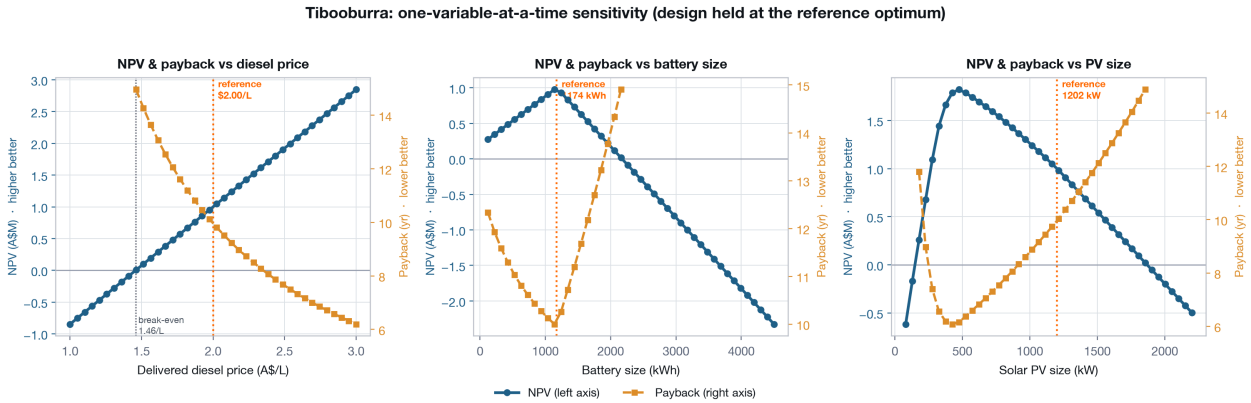


Figure B2. Tibooburra. Net present value and payback of the microgrid against diesel price, battery size and solar size.

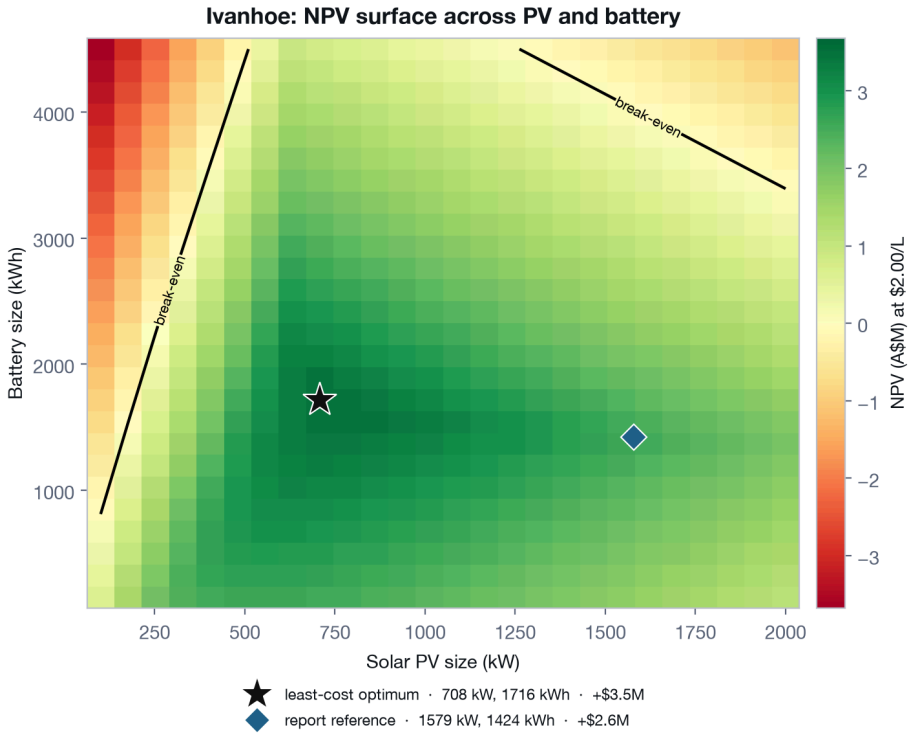


Figure B3. Ivanhoe. Microgrid net present value across solar and battery size, with the least-cost optimum and the reference design marked.

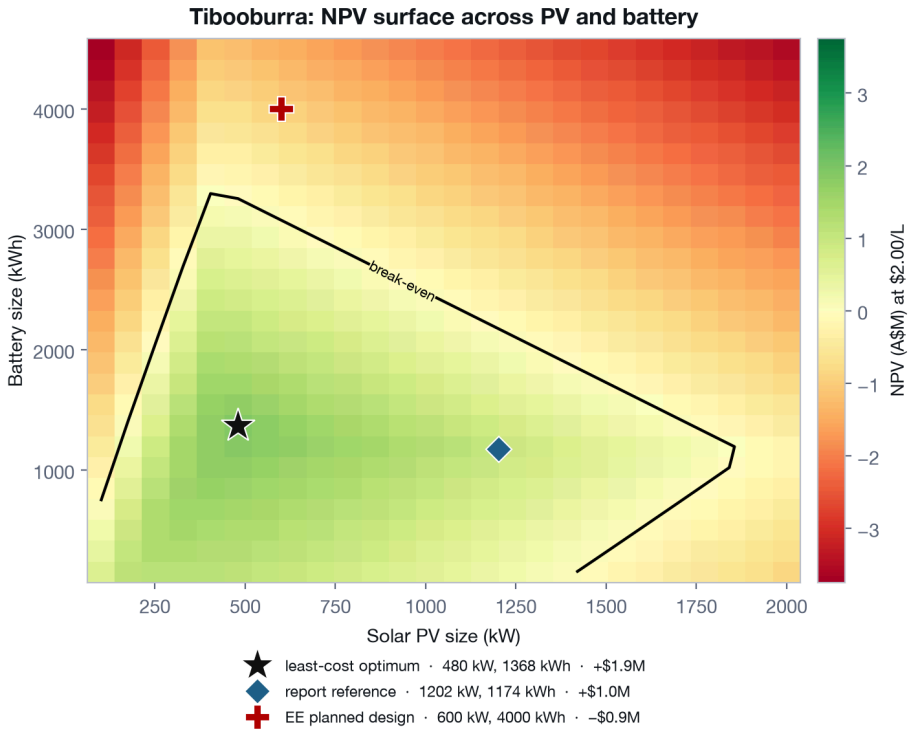


Figure B4. Tibooburra. Microgrid net present value across solar and battery size. Essential Energy's planned design and the least-cost optimum are marked.

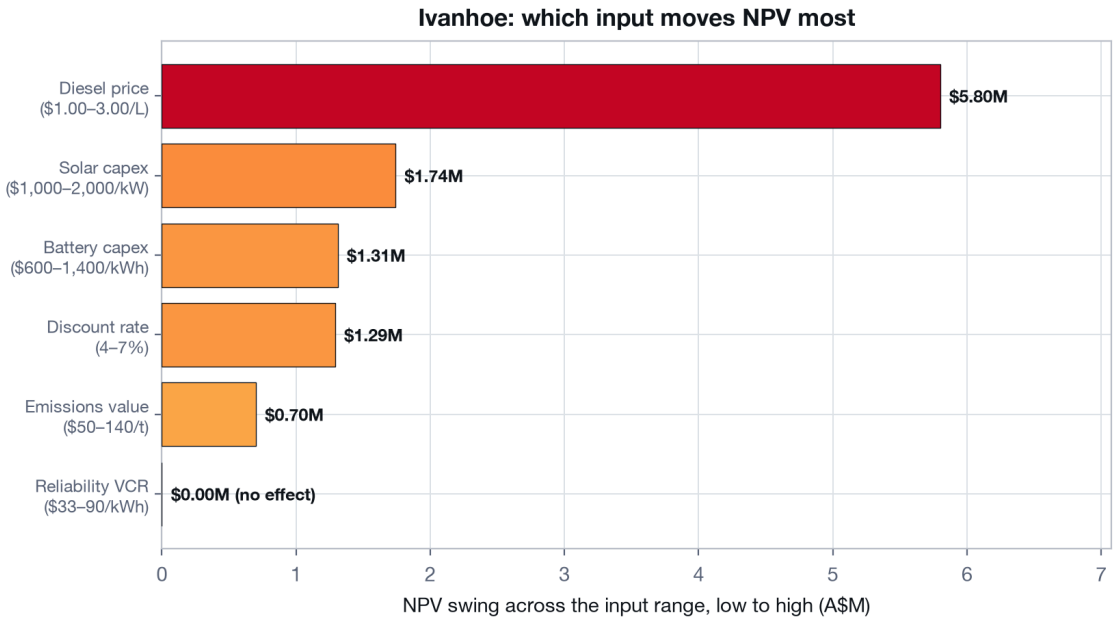


Figure B5. Ivanhoe. Which input moves the microgrid net present value most. On the fuel lens the reliability value has no effect; it is valued separately in Section 5.

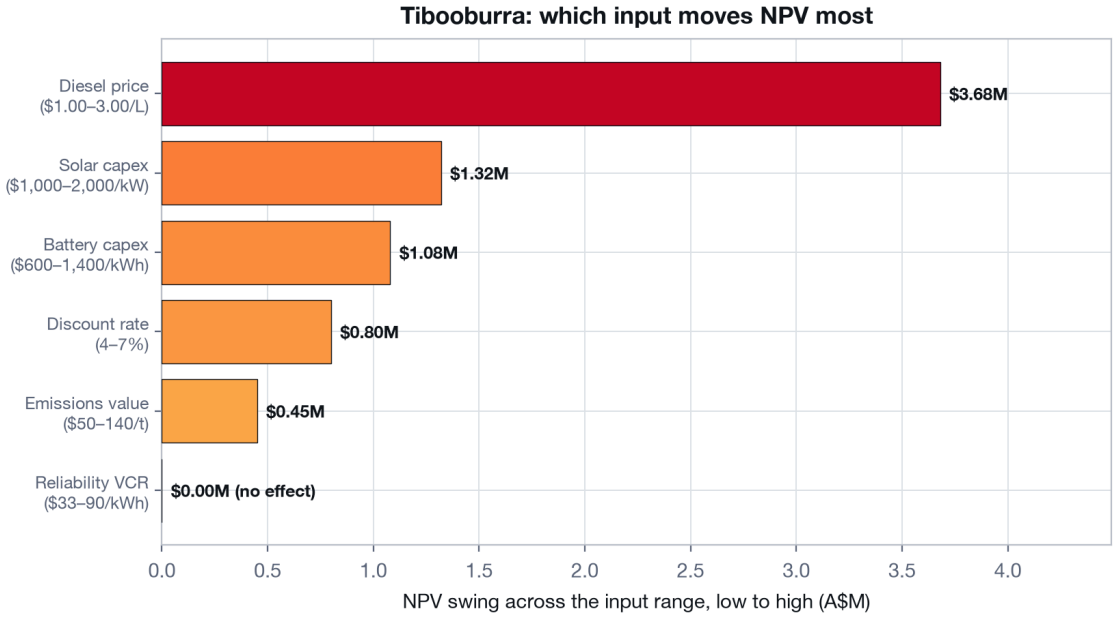


Figure B6. Tibooburra. Which input moves the microgrid net present value most.

APPENDIX C

Diesel-free scenario

The diesel-free configuration removes the generator and sizes solar and battery to carry the town through its worst low-solar week on battery alone. It is technically feasible at both towns but roughly doubles the capital, because the town must ride out a multi-day renewable drought without a generator. On the fuel-displacement basis it erases Tibooburra's business case and stretches Ivanhoe's payback. A small firm diesel, run only during those rare low-solar weeks, lets the solar and battery be sized for everyday economics rather than for the worst week.

APPENDIX D

Battery-only case

Ivanhoe reference, on the fuel lens

This figure shows why the fuel test alone rejects the Ivanhoe battery, and why the reliability lens is needed. With no solar to charge from, every added MWh is close to pure cost on the fuel basis, so Essential Energy's 4 MWh design sits well below zero. The same design is marginally positive, and conditional, once reliability and trading are counted (Sections 5.4, 5.9).

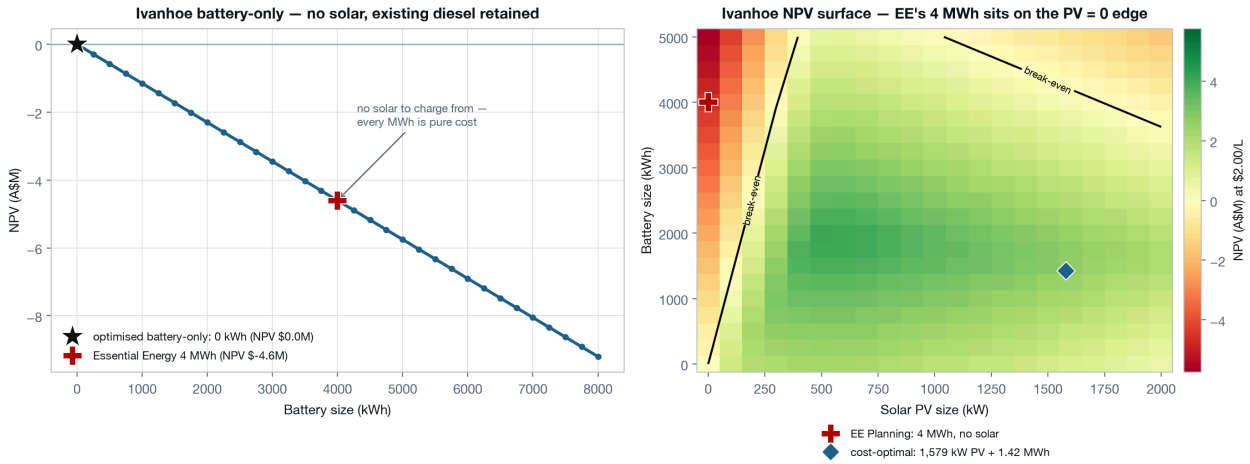


Figure D1. Ivanhoe on the fuel lens. With no solar, net present value falls with battery size, and Essential Energy's 4 MWh design sits at about −A$4.6 M. Counting reliability and trading reverses this (Section 5).

APPENDIX E

Reliability method

The value of unserved energy uses the Australian Energy Regulator's duration-banded Value of Customer Reliability, blended to each town's customer mix, in three elapsed-outage bands. The local supply, a battery at Ivanhoe and a solar and BESS microgrid at Tibooburra, serves the load at risk from the start of each outage until its energy is exhausted, capturing the cheaper early hours first.

	Ivanhoe	Tibooburra
Customers (res / com / ag)	322 (244 / 38 / 40)	139 (78 / 43 / 18)
VCR, 0 to 12 h ($/MWh)	37,400	36,500
VCR, 12 to 24 h ($/MWh)	71,200	65,900
VCR, beyond 24 h ($/MWh)	52,500	47,700
Load at risk (MW)	0.28 (SWER beyond the diesel)	0.14 (whole town, no diesel)
Faults over 12.5 yr	31	88
Valued-duration cap (h)	36.2 (longest ordinary fault)	none, full duration
Value of unserved energy, do nothing	$6.06 M undiscounted (real), $3.85 M NPV	$7.9 M undiscounted (real), $5.0 M NPV

At Ivanhoe the engine reproduced Essential Energy's workbook on 30 of 31 faults and identified a single over-counted cell on the longest fault, which Essential Energy confirmed and corrected, giving the $6.06 M figure. At Tibooburra the engine reproduces Essential Energy's 17 August workbook (88 faults, whole-town load, full durations) to $7.9 M undiscounted (real) and $5.0 M present value at the 3.86% WACC, matching Essential Energy's figure.

The three-layer risk basis around this method, the benchmark against the AER's Value of Network Resilience, the Guaranteed Service Level exposure and the residual risk profile, is set out in Sections 3.5 and 5.10 to 5.12 and computed from the same fault records.

APPENDIX F

Load forecasting

And the AER

Essential Energy advises a flat demand forecast for both towns. Where a structural forward projection is not relied on, sizing is confined to temperature-corrected and probability- of-exceedance methods on the measured demand, which is the basis used here. This does not change the sizing conclusions, since the designs are driven by reliability and diesel displacement rather than load growth.

This report presents findings prepared for Essential Energy using Essential Energy's Reliability Value Framework 2.0, measured data and cost estimates. Reliability values are discounted at Essential Energy's reliability WACC. The items in Section 9 remain to be settled for a final version.