Santos

CONVERSION OF REMOTE CRUDE OIL PUMPS TO SOLAR & BATTERY PROJECT

PUBLIC REPORT

December 2021

This project received funding from the Australian Renewable Energy Agency (ARENA) as part of ARENA's Advancing Renewables Program.

Executive Summary

Project Title	Conversion of Remote Crude Oil Pumps to Solar & Battery Project
Project Number	2018/ARP177
Recipient Name	Santos Limited
Project Partners/ Participants/ Sub-contractors	JV Partners: Vamgas Pty Ltd, Delhi Petroleum Pty Ltd, Beach Energy (Operations) Limited, Alliance Petroleum Australia Pty Ltd, Reef Oil Pty Ltd, Santos Petroleum Pty Ltd, Santos (BOL) Pty Ltd, Bridge Oil Developments Pty Ltd, Santos (NARNL) Pty Ltd, Basin Oil Pty Ltd, Santos QNT Pty Ltd, Mawson Petroleum Pty Limited, Drillsearch energy Limited, Bounty Oil & Gas N.L, Australian Gasfields Limited, Bridgeport (Eromanga) Pty Ltd EPC Contractors: AGL Energy, APEX, Kaefer Integrated Services, CD Power
Project Commencement Date	14th December 2018
Project Completion Date	7th August 2021

Santos has completed the installation of 56 solar photovoltaic and battery energy storage systems on beam pumps in the Cooper Basin. These renewable energy systems replaced the pre-existing crude oil generators powering the wellsite pumps. ARENA partially funded the program on behalf of the Australian Government, contributing AU$4.2 million. The project was completed over two phases with the first phase involving an initial 22 wells in 2019. The second phase implemented the remaining 34 systems, with the final installation complete in August 2021.

The project encountered several challenges throughout its development. These included resourcing delays due to Covid-19 and the retreat of Ecoult from Australia. The latter resulted in all batteries completed in Phase 1 needing to be taken offline for remediation. Despite these challenges, all solar and battery systems have been installed successfully on all wells with a series of lessons learnt developed to improve implementation in future projects.

When the renewable energy systems were adequately sized, they were found to be more reliable than the pre-existing crude oil generators. However, several units were found to be undersized due to increased load requirements from the well. As a result, across the 56 pump conversions, the renewable energy systems were found to have lower availability than the original generators. The undersized units resulted in the crude oil generators having to be started to provide the required power. Currently the average system availability is 77%, with eight units currently offline for maintenance. When units currently offline for maintenance are excluded, the systems had an average availability rate of 90%, which is still lower than the project objective of 95%. A key recommendation for future projects would be to design the systems to be expansion ready with modular plug and play options to expand or contract the renewable energy capacity to match each stage in the well's life.

It was found that using renewable energy systems for the replacement of crude oil generators on beam pumps provided reliable energy if sized to meet the required load. It is recommended to use the lessons learnt through this project to better optimise future projects.

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1. Introduction

In an Australian-first for the oil industry, Santos successfully installed and commissioned 56 solar photovoltaic (PV) array and battery systems, allowing the beam pumps to operate without the use of fossil fuels. This project required close collaboration both within Santos and with external suppliers. It demonstrates Santos' commitment towards a lower carbon future, while cementing its position as a safe, reliable, low-cost operator. This project was aided by AU$4.2 million in funding from the Australian Renewable Energy Agency on behalf of the Australian Government.

The Solar Beam Pump project aimed to demonstrate the viability of replacing existing crude fuelled generation sets (gensets) with solar PV arrays and battery energy storage systems (BESS). Currently these gensets provide the electrical power to drive variable speed drives (VSDs) and electric motors for Santos's existing beam pump fleet.

There are approximately 220 beam pumps in the Cooper Basin that are not connected to overhead high voltage powerlines. These beam pumps currently consume around 140 barrels of crude fuel per day with a total power consumption of 1.4MWe.

Recognising the successful 2018 pilot installation at the Hobbes-1 well site, solar PV and batteries were installed at an additional 56 oil wells across the Cooper Basin, both in South Australia and Queensland. These systems are designed to supply each site with 100 per cent renewable energy and is the next step to commercialise the technology through scale to reduce future project costs.

Benefits of converting from crude/diesel fuel power generation to solar and battery include:

+ Removal of fuel consumption, logistics and distribution
+ Reduction in maintenance costs as solar and battery are primarily static equipment
+ Reduction in risk associated with travel to remote environments
+ Increased availability and reliability of the power system

Santos has contracted CD Power, Kaefer, APEX and AGL Energy to deliver the conversion of oil well beam pumps to solar and battery power through EPC (Engineering, Procurement and Construction) contracts.

The purpose of this report is to share knowledge on how solar and battery power systems were implemented across the 56 wells. This will outline highlights, learnings and recommendations arising from the project.

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2. Project Summary

Solar and battery systems were installed on a total of 56 beam pumps across the Cooper Basin. The 100% renewable energy system replaced the original crude oil engines powering these wells. The projects aimed to achieve reliability levels greater than the pre-existing engines.

A trial installation was implemented on Hobbes 1 in October 2019 before the initiation of the ARENA project scope. The remaining 56 conversions were completed with the aid of ARENA funding. These were developed in two phases. The first phase was completed in 2019, with 22 beam pumps converted to renewable energy. Phase 1 was designed to trial multiple site solutions from multiple EPC contractors. During this phase AGL installed 17 systems, APEX installed 4 while Kaefer and CD Power installed 1 each. Following a Gate Event at the end of Phase 1, AGL was selected to implement the remaining 34 wells in Phase 2. This phase was completed in August 2021.

Key objectives of the project under the ARENA grant include:

- The installation of 56 renewable energy systems in the Cooper Basin, delivering 100% renewable energy and demonstrating at least 95% availability.
- Engage qualified EPC Contractor/s in a staged approach, initially converting 22 sites with multiple EPC Contractors and then proceeding to develop the preferred solution to the remaining sites with at least one EPC Contractor chosen from Phase 1.
- Demonstrate fuel savings of approximately 140 bbl/day and approximately $3 Million of operations and management cost savings across all 208 sites

Opportunities to extend learnings from these 56 wells are being considered for the remaining 151 wells in the final stage of the project. Options for centralised renewable energy generation are also being considered. Santos has already implemented these types of microgrids under separate projects at Charo and Tarbat.

Figure 1 – Solar Installation at Stimpee 1

3. Outcomes

Outcomes for each of the outputs outlined by ARENA were key considerations during each project stage. Where the targets were not fully met, important lessons learnt were developed which will aide in more effective outcomes in future projects. This project saw significant challenges including delays due to Covid-19, delivering multiple trial system designs simultaneously and the withdrawal of a key battery supplier. Despite these setbacks, all 56 renewable energy systems were delivered. AGL are currently investigating wells with higher genset usage for possible solutions. Different options such as relocating the solar and battery systems to lower load bearing beam pumps are being considered to increase the system availability.

3.1. Deployment of 100% Renewable Energy Systems

The oil well solar arrays are sized for the winter solar cycle when solar intensity is at its lowest. The battery system is then sized for a co-incident period of low solar intensity such as a rainy week. At most other times there is excess solar, which is primarily used to charge the main battery. This excess energy is also used to maintain optimum battery ambient temperature by running a thermostatically controlled air conditioning unit as well as powering communications which enable remote monitoring via the internet.

When the renewable energy systems are adequately sized, the systems were found to be more reliable than the pre-existing crude oil generators. Current average availability of the systems is 77%, with eight units currently offline for maintenance. Excluding these units currently offline for maintenance, the other units have a 90% availability rate, which is under the project target of 95%. As the initial maintenance issues with the new renewable energy systems are rectified, the availability should increase to at least 90% across all units.

A key learning was that approximately 20% of the battery systems were undersized for increased well loads. This resulted in the oil gensets needing to be powered on to supply additional power. These crude oil engines are not designed for frequent power ups and would sometimes fail on start up. If the battery was drained completely, the system would sometimes require a manual recovery. Due to the Cooper Basin's remoteness, any maintenance that was required resulted in extended downtime.

3.2. Fuel & Maintenance Savings

The installation of renewable energy systems has the benefit of displacing fuel use and reducing maintenance costs. These savings are summarised in Table 1. Values for the 208 well scenario are projected from current averages. To meet the 140 bbl/day target, wells with higher load requirements would have to be converted.

Table 1 - Fuel and Maintenance Savings

Saving	Scenario	Value
Fuel Saving (bbl/day)	57 wells (100% availability)	28.4
	208 well (100% availability)	103.5
	57 wells (90% availability)	25.5
	208 well (90% availability)	93.2

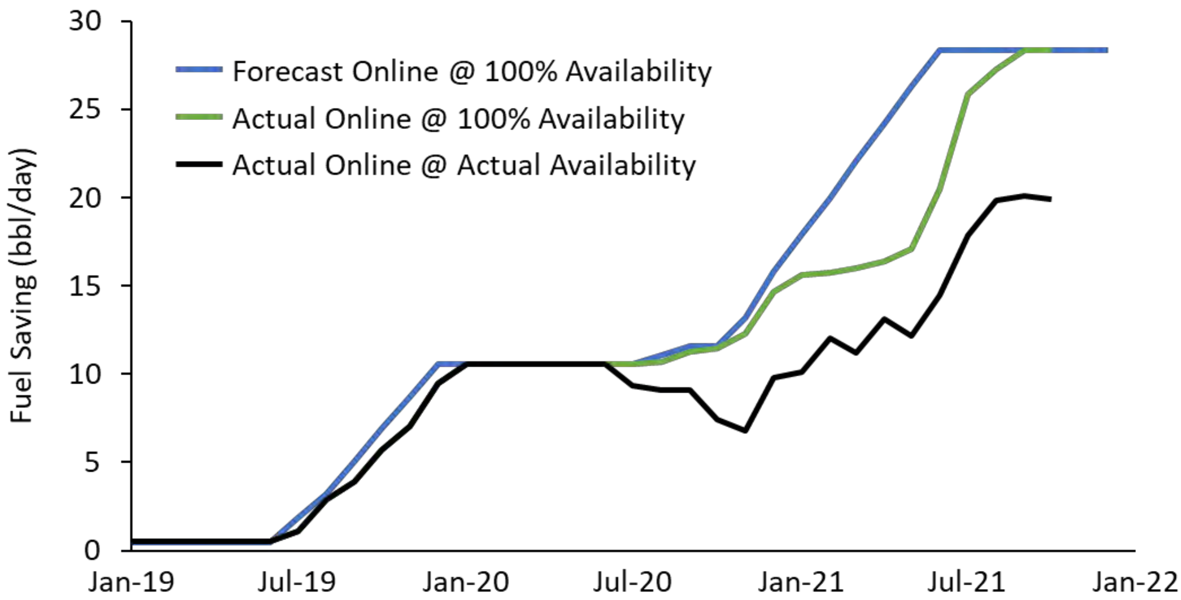

Figure 2 - Forecast Vs. Actual Fuel Reduction

3.3. Lessons Learnt

Along with the lessons outlined in the table below, there were several efficiency improvements seen throughout the project. These included logistics, work method, materials management, permitting and commissioning being refined as the project developed. Overall, it was found that that the solar and battery units were reliable when sized to meet the load requirements and were simple to install from a project perspective.

Table 2 - Lessons Learnt Summary

Lesson	Consequence	Recommendation
Project		
Trial Size	Interactions with existing equipment was not fully understood before field rollout leading to larger maintenance requirements.	Trial new technology in smaller phases to understand the impact to existing equipment, allowing for adjustments to be made before full rollout.
Time Constraints	Time constraints due to grant timelines limited optimisation during Management of Change processes.	Ensure sufficient time to optimise designs during roll out using learnings during installation.
Installation Planning	Minimal local camp availability resulted in a reworked schedule.	Assess camp capacity requirements before installation.
	Wet weather delayed installation progress by restricting access. Heat was managed through breaks and utilising air-conditioned battery containers.	Ideally execute installations from April to October.
	Unstable road conditions resulted in damaged equipment. Units had to be disassembled/reassembled prior to transport, increasing transport time.	Transporting at very low speeds and detouring to bitumen roads when available was found to be more time effective.
Technical		
Load Requirements	Some units are now found to be undersized due to increased loads during well life maturity, resulting in having to switch to genset to meet load requirements. Gensets are not designed to start and stop in short timeframes and would sometimes fail on start up.	Design the systems to be expansion ready, with modular plug and play options to expand or contract the renewable energy capacity to match each stage in the well's life. Systems may be relocated to lower load intensive wells when no longer useful on current well.
	Cyclic loading during the beam pump operation was poorly understood during the first six installations, resulting in under sizing.	Ensure installation is sized to cope with both the peak demand (while lifting counterweight) and consistent load changes.
Multiple Designs	Multiple standard designs increased complexity around campaigning maintenance, design optimisation and source reliability issues.	After initial trials, minimise the number of standard designs by providing clear scope in the EPC contract.
Site Layout	Solar was orientated based on lease orientation and not for optimum solar. Resulted in 3-4% efficiency loss.	Orientate to optimum solar orientation if it can be done so while still fitting within pre-disturbed lease.
ABB Batteries	Battery design complexity resulted in several alarms triggering at once. This made it hard to determine the cause of battery faults.	A simpler design would improve maintenance times and root cause analyses.
Battery SoC	Batteries were not reaching 100% SoC (State of Charge).	Firmware upgrade was developed to rectify this and has been rolled out.
Contract		

Lesson	Consequence	Recommendation
Maintenance Requirements	Contract requires AGL to conduct all hardware maintenance to retain warrantee, delaying remediations due to site remoteness.	Ensure contract allows operator maintenance for non-complex faults to increase renewable system availability.
Spares list	Spares list was kept by AGL, restricting the ability to conduct simple repairs.	Include a spares list as a requirement in the contract to ensure they are documented during installation.

One of the key challenges for the implementation of the renewable energy systems was the Ecoult battery recall in August 2020. The battery was not designed to independently protect itself or the user from fire or electric shock when combined with certain equipment. This could be aggravated by overcharging and as a result all Phase 1 batteries installed in 2019 had to be taken offline for remediation. AGL's action was to install overvoltage and overtemperature protection through a series of remediation campaigns throughout 2020. AGL later bought Ecoult's Australian intellectual property, allowing AGL to report on the battery performance as well as support product warranty.

It was also found that in certain situations it would be more economical to power several closely located beam bumps by a single solar microgrid and BESS system. Santos has already implemented these types of microgrids under separate projects at Charo and Tarbat.

4. Future Developments

High capital costs associated with 24-hour renewable generation may be offset through developing mobile and multi-use power generation solutions. System modularisation would also allow the units to be used across varying lease designs or adhere to different power purchase agreements. The costs associated with fixing ground mounted solar arrays are also a significant proportion of the total costs. Developing rapid deployment techniques to mount solar panels provides an opportunity to reduce cost.

Battery costs remain high with battery storage options in the market today not well suited to the harsh conditions found in the remote power market or the transport conditions required to reach remote locations. Packaging methodologies need to move beyond the existing industry solution of building rooms to accommodate the system components to more integrated packages including not only power subsystems but also ambient temperature control, communications, security, vermin control, protection from radiation damage, data collection, mobility, and civil considerations.

The continued trajectory of declining battery costs, which is mirrored by PV costs, will aid with further development of this technology.

Central to addressing these challenges is continued knowledge and information sharing to drive awareness of the developing product set and awareness of the viability of renewables.

5. Conclusion

The project has proven that renewable micro-grids (comprising solar and battery) can deliver high availability power in continuous load applications in remote harsh environments. Santos is leveraging the implementation of the solar beam pump project, combined with the learnings taken away, by introducing renewables into other areas within its operations such as the completed Charo and Tarbat Microgrid.