DIFFUSE ENERGY

AN ON PROGRAM CASE STUDY

DIFFUSE ENERGY CASE STUDY EXECUTIVE SUMMARY

Key findings

Diffuse Energy is a company that produces a small wind turbine called Hyland 920. The Hyland 920 consists of a diffuser (an aerodynamically shaped cylinder) that together with specially designed blades increases the mass flow of air passing across the blades, allowing more energy to be extracted from the wind.

This technology is well suited to remote locations and people who are 'off grid' and looking for a sustainable energy supply. The turbine has demonstrated savings of up to $150 per month through reduced diesel use for powering remote telecommunications sites. Trial sites have been established in two locations. These were affected by the 2019/20 bushfires and the trials are therefore yet to conclude.

The Hyland 902 wind turbine can be purchased outright or through an agreement under which Diffuse Energy supplies, installs and services the turbine. The first contracts for the supply of the technology are currently being negotiated.

Role played by the CSIRO ON program

— Participation in the ON program helped the team make the transition from academics to entrepreneurs. It encouraged an assessment of the commercial prospects of new research, helped to define the most prospective target markets, and developed the team's pitching skills.

— Participation in ON facilitated an introduction to Vertel (who eventually provided a trial site) and secured Diffuse Energy's ownership of the IP in the technology

— The net present value (NPV) of the benefits flowing from participation in the ON program is estimated to be $9.3 million (based on a 7 per cent real discount rate) and the benefit-cost ratio (BCR) is 10.7.

This case study uses the evaluation framework outlined in the CSIRO Impact Evaluation Guide. The results of applying that framework to the Diffuse Energy case study are summarised in Figure 1.

FIGURE 1 DIFFUSE ENERGY CASE STUDY – IMPACT FRAMEWORK

INPUTS	ACTIVITIES	OUTPUTS	OUTCOMES	IMPACTS
– Financial contributions of approx. $905,000 – In kind contributions of approx. $33,000	– Launching a business and website – Refining the turbine and control system – Establishing two trial sites	– Established a two-tier business model – Demonstrating the cost effectiveness of the technology for potential customers – Technology protected through a registered design and trade secret	– Secured investor funding – Approached by two potential companies for wholesale supply options – First mover advantage	– Improved stability of energy systems in remote and off-grid settings – Revenue – Employment opportunities – Reduction in operating costs and emissions due to less diesel consumption

SOURCE: ACIL ALLEN

1. Purpose and audience for case study

This case study describes the economic, environmental and social benefits arising from the Diffuse Energy project.

This evaluation is being undertaken to assess the positive impacts arising from the Diffuse Energy project's participation in the CSIRO's ON program. This case study can be read as a standalone document or aggregated with other case studies to substantiate the impact and value of the ON program as a whole, relative to the funds invested in these activities.

The information in this case study is provided for accountability, communication and continual improvement purposes. Audiences for this report may include Members of Parliament, Government Departments, the ON program, CSIRO and the general public.

CSIRO ON

The CSIRO ON program was established in 2015 as a four year program to help accelerate the impact of science research into market (the program ends in June 2020). The initiative was expanded through funding from NISA to service more broadly Australia's publicly funded researchers and their industry partners. The aim of the initiative is to more quickly translate great science and technology research into positive impact to help address some of the economic, environmental and social challenges facing the Australian and global community.

There are a number of elements to the program, including two facilitated programs, ON Prime and ON Accelerate. These two elements are designed to complement each other.

ON Prime is an open and collaborative program for existing science projects as well as new technologies and projects that are still in development. ON Prime helps research teams to ensure that they are working on the right problem, it provides frameworks to create and test assumptions about their idea and provide recommendations towards next steps. ON Prime can be considered as an entry level program, in effect it can be seen as a precursor to participation in the ON Accelerate program.

ON Accelerate is designed for teams that have made significant progress with their idea and their target market(s). This may be in the form of contracts for paid or unpaid trials, or at the most advanced stage, recurring sales with both new and existing customers. This implies that teams will have a working prototype of their product or service and have secured any appropriate intellectual property rights. It is expected that teams applying for ON Accelerate would have conducted significant engagement with their potential customers and be able to demonstrate what they learned throughout, including what the total addressable market is and what competition exists.

For ON Accelerate, shortlisted applicants are invited to participate in a two-day Selection Bootcamp event where teams will be provided with training and coaching simulating the accelerator experience. At the conclusion of the selection bootcamp, the teams will pitch to a panel of external judges for a spot in the Accelerator. Projects that are at Investment Readiness Level (IRL) Stage 3 can apply directly for ON Accelerate without going through Prime or Bootcamp.

Following a team's passage through the ON Prime or ON Accelerate program they are eligible to apply for ON Runway support. That funding is designed to help teams to further progress their project. The support provided can be spent on a range of services, for example, regulatory certification, marketing, bookkeeping or investor agreements.

The program is expected to exceed its targets for participation. It is predicted that it will have reached 515 teams with over 1,850 people by the time it concludes on 30 June 2020.

2. Background

Diffuse Energy is a company that produces small wind turbines. It was founded by three colleagues from the University of Newcastle (UN). The CEO, Joss Kesby, had researched wind technologies as a PhD student at the UN, while his colleagues Samuel Evans and James Bradley, assisted with building and testing prototypes to verify the results of Joss's modelling. Joss, Samuel and James participated in ON Prime in Sept 2017 and ON Accelerate in February 2018.

Currently, Diffuse Energy produces a wind turbine called the Hyland 920. It consists of a diffuser (an aerodynamically shaped cylinder) that, together with specially designed blades, increases the mass flow of air passing across the blades, allowing more energy to be extracted from the wind. The Hyland 920 has been designed in accordance with international small wind turbine design standard IEC 61400.2-2013 and computer aided engineering software has been used to verify the wind turbine components. Wind loading has been calculated as per AS1170.2 for Category D wind speed with a return rate of 50 years. Composites used in construction have a minimum rated UV exposure life of 20 years.

The Hyland includes a maximum power point tracking (MPPT) controller that optimises the amount of power extracted for a given wind speed. For wind speeds beyond 18 m/s (65 kmh) the controller is designed to reduce the rotor speed to limit the power output to 1 kW and prevent the damage of electrical systems. The turbine is also safer as the blades are enclosed within the diffuser.

The turbine is quieter due to the minimisation of the tip vortices, which in turn means there is less of the wind's energy lost in the wake. When assessing noise levels of existing wind turbines certified by the Small Wind Certification Council (SWCC) average noise levels are reported at 45 dB(A) for an open-blade horizontal-axis design. Noise of this level is deemed within the range of "quiet radio music" by Safe Work Australia.

3. Impact pathway

3.1 Project inputs

The total cost for the Diffuse Energy project was about $938,500, of which approximately $33,000 was in-kind contributions from the University of Newcastle in the form of access to facilities and support for conference attendance (see Table 1).

TABLE 1 SUPPORT FOR THE DIFFUSE ENERGY PROJECT

Contributor / type of support	2017 ($)	2018 ($)	2019 ($)	2020 ($)
Cash				
Shearwater Growth Equity				400,000
ON program	11,438	246,400	74,191	15,000
Jobs for NSW grant		25,000		
Friends and family			145,000	
In-kind				
University of Newcastle		15,000	17,920	
Total	**$11, 438**	**$286,400**	**$237,111**	**$415,000**

3.2 Project activities

Key activities to date include modelling and testing the impacts of cowl designs on turbine performance and organising the manufacture of the components. The cowl is moulded plastic (similar to that used for bins and kayaks) and the fan blades are carbon fibre. The researchers have also designed and built the control systems for the turbine as there was no 'off the shelf' product available that was suitable for use with the remote telecommunications towers that Diffuse Energy have selected as their first target market for the technology. The objective is to make the system as close to 'plug and play' as possible. The first commercial versions were available in early 2020.

The researchers have established two trial sites. One is with Vertel, which operates 1400 telecommunications towers in remote locations across Australia. Diffuse Energy installed a turbine on a tower west of Coffs Harbour. It operated for several months but in early December during the 2019/20 bush fires it was hit during a water bombing run and a component snapped. The broken part will be replaced and the testing program resumed as soon as possible.

The other is with NBNCo, which has 7,000 remote towers that are not connected to the grid. This involved installing a turbine for their technical provider in Wodonga, however the towers were burnt in the 2019/20 fires. The intention is to restart the project in first half of 2020.

The researchers have also started an independent business, developed a business plan, launched a website and undertaken a brand refresh. They have also developed a relationship with an investor (Shearwater Growth Equity (SGE)).

In addition they have planned a program of presentations and exhibitions for 2020 including: Sydney Climate Action Summit Expo, Smart Energy Conference, Australian Energy Week, Comms Connect, National Cleantech Conference and All Energy Australia. Finally, they are providing mentoring services to Redback Systems (a participant in ON Accelerate in 2020).

Role of the ON program

Participation in the ON program assisted the team with the transition from academics to entrepreneurs and business owners. In particular, it helped the team to explore the commercialisation potential of the results of Joss's research as a student at the University of Newcastle team. Without this, the team believes that poor decisions would have been made and investments lost, and that the team would have remained at the university. Joss noted that ON was "*instrumental in getting us to where we are now.*"

The ON program also helped the team to improve their pitching skills. Through the pitch training the team met Vertel (one of two companies that they would eventually establish a trial with). They also got a better understanding of the yacht market (their original target market). That is worth $50 million globally, which would be too small to attract the level of investment that they needed to develop the technology.

3.3 Project outputs

Diffuse Energy has identified the potential for the turbine to be supplied to three markets: off grid telecommunications systems as a compliment to existing small scale energy systems; remote locations with power supply difficulties, such as the mining and agriculture sectors; remote living (tiny homes, caravans and yachts) looking for a sustainable energy supply. They estimate the scale of the first market to be some 20,000 towers. Diffuse Energy is undertaking work that seeks to develop the markets for its technology.

The two trials (with Vertel and NBNCo) have yet to be concluded, however they have already demonstrated that the technology can reduce diesel costs for remote communications towers. This is a significant consideration for people looking for alternative ways to generate power in regions that are off-grid or in areas where the grid is unreliable. This is particularly attractive for people or firms living or operating in remote areas as diesel generators can be costly to run and maintain. There can also be challenges in servicing equipment in remote areas.

Diffuse Energy has also developed a subscription model for their technology. This aims to provide customers with their technology with no up-front costs or ongoing commitments and keeps arrangements as simple as possible. The trials have shown that users can save $100-$150 per month compared to relying entirely on diesel by installing a Diffuse Energy turbine.[1] Another benefit is improved energy resilience. Many telecom tower sites during the recent bushfires either went down because they couldn't be refuelled or could only be refuelled by helicopter. Either option is expensive for the telco and they are looking for alternate energy forms to improve the resilience of their systems.

Securing financial support from SGE. SGE has expressed interest in making a further investment if Diffuse Energy can get around 20 turbines installed on telecoms towers.

Publications

There have been no publications about this technology in order to protect commercial-in-confidence information.

Innovation / commercialisation

The Intellectual Property (IP) in the wind turbine technology is held entirely by Diffuse Energy. The ON program helped the team to negotiate this arrangement with the University.

The optimisation model is a trade secret and the shape of the cowl is a registered design; the physical shape of the diffuser is crucial to the aerodynamics, which is in turn important for optimising the efficiency of the turbine.

Diffuse Energy estimate that they have at least a two year 'first mover' advantage. They note that a United States competitor is marketing a similar turbine, but it is 300cm in diameter and this is too big for Australian telecommunications towers (the Hyland 920 is 90cm in diameter).

Role of ON program

Participation in ON assisted the team to transition their assessment of the potential for the technology from that of researchers and academics to entrepreneurs with business motivations. This involved learning to deal with uncertainty and limited information. In the absence of the ON program it is unlikely that the research team would have commercialised the technology.

[1] Savings arise from reduced need for fuel, avoided delivery costs and lower generator maintenance costs. There are also reduced battery costs by reducing depth of discharge and extended generator life due to reduced runtime.

3.4 Project Outcomes

While it is still too early for Diffuse Energy to have demonstrated any significant growth, they have managed to secure an investor. Shearwater Growth Equity will provide a $400,000 initial investment in return for a 12% equity in the firm.

Two companies have approached Diffuse Energy to discuss adoption of the Hyland 920 turbine:

— GreenPlate: this company manufactures solar powered BBQs for public places (parks and playgrounds) and are interested in a small wind turbine for powering these. Diffuse Energy could provide these under a wholesale arrangement.
— Tinyhomes: this company provide eco-designer tiny homes and are interested in incorporating a wind turbine into their package so that owners don't need to rely on a utility company for their power.

Role of the ON program

The services provide by Runway included access to book-keeping and financial services provided by a third party.

3.5 Adoption

As at February 2020, Diffuse Energy has no customers. However, as noted above, two companies have expressed interest in purchasing the wind turbine, most likely under wholesale arrangements.

Role of the ON program

Participation in the ON program helped the team to understand the potential market for the technology, and to move beyond a focus on the yachting market to examine the technology's broader potential and develop two product offerings, described above, that could facilitate adoption.

3.6 Impacts

Distributed power generation and ways to reduce reliance on the grid are increasingly important issues for energy users in Australia and these are increasingly attracting public interest. Diffuse Energy's small wind turbine technology is a renewable technology that supports a shift towards more environmentally sustainable energy generation, particularly for the remote telecommunications market.

Infrastructure and services in rural locations such as hospitals and fire brigades will continue to use diesel generators for back-up power, however Diffuse Energy's product can reduce the run time and reliance on these and can be remotely monitored. For communities in remote areas it is common for there to be reliability issues with equipment, such as remote monitoring systems not working, or equipment components not interacting properly.

Finally, to the extent that Diffuse Energy's technology is used as a substitute for diesel, the resultant reduction in diesel use would help to reduce the emissions footprint associated with operating the towers.

Role of the ON program

ON has played a key role in the commercialisation of an experimental technology that may have a significant impact on conventional energy needs in remote regions. Early indications are that the technology will reduce the cost of the energy supplies used by providers of essential services in remote areas. The opportunity provided by the ON program to develop a business model and trial the service offering with potential customers is invaluable experience for an emerging business.

4. Clarifying the Impacts

Diffuse Energy's turbine materials have a design life of 20 years and an estimated lifetime of 10 years. They cost $2,050 to produce (this includes manufacture, freight, and returns).

The Diffuse Energy business plan has two offerings: a recurring revenue and a wholesale model. Each is described below.

Recurring revenue model: this option is for people that cannot connect to the grid (ie., the towers) or use solar panels and batteries, and rely on diesel generators. Diffuse Energy charges customers $197 (ex GST) per month, with no up-front fees and no lock in contracts. Customers are sent a wind turbine that they install on their telecommunications tower. If anything breaks, a new turbine is sent to them to install (or individual component, depending on what has broken) and the broken wind turbine is returned.

For Diffuse Energy the monthly fee pays for the turbine within 11 months, and the rest of the installed life of the turbine is gross profit. Diffuse Energy estimate the recurring revenue model to be the highest margin mechanism for marketing the wind turbine. However, as the up-front capital costs to build and send the turbines are substantial, the wholesale model was developed to help to fund the implementation of the recurring revenue model.

ACIL Allen has conservatively estimated that Diffuse Energy's (recurring revenue) market will grow by around one per cent a year and that they will supply 5 per cent of the 20,000 remote area telecommunications towers by 2025. It is assumed that they will continue to grow at around two per cent a year out to 2030 after which their market share will remain constant.

Wholesale model: this option is tailored to companies who want to add wind energy to their product offerings. For these customers the RRP for the turbine and the system controller is $3,265 (ex GST). This provides a gross profit margin of 42 percent (at current build cost) and the wholesalers a margin of 16 percent. It also provides a margin on accessories that are required for turbine installation, such as electrical cabling and plugs.

ACIL Allen has assumed that Diffuse Energy will sell 50 turbines a year for the next 5 years and then 100 turbines a year for the next ten years.

With regard to the potential environmental benefits of Diffuse Energy's technology ACIL Allen has assumed that each turbine sold will save 45 litres of diesel fuel every month. This amounts to an estimated reduction in diesel demand of some 540 litres a year for each turbine sold. Combusting a litre of diesel fuel produces around 2.7 kg of CO_2.[2] Thus each installed turbine could prevent almost 1.5 tonne of CO_2 being emitted. What value you assign to that abatement will depend on the price of carbon. The average price paid by the Emissions Reduction Fund (ERF) in 2018 was around $14 per tonne of avoided emissions.[3] This would imply that the abatement from installing a single turbine is worth around $21 a year.

4.1 Counterfactual

In the absence of the ON program the results of the research by the team at the University of Newcastle are unlikely to have been commercialised. Furthermore, the opportunities to trial the technology would not have materialised and the approach from two potential wholesale customers would not have occurred.

4.2 Attribution

The benefits to flow from commercialisation of the wind turbine technology can be fully attributed to the ON program.

5. Evaluating the Impacts

5.1 Cost-Benefit Analysis

Benefits

The key benefits included in the analysis are the reduction in CO_2 emissions and reduced "leakage" from the economy due to reduced diesel consumption[4]. The total benefits from a reduction in diesel fuel usage due to the technology between 2020/21 and 2030/31 with participation in the ON program are shown in **Figure 3**.

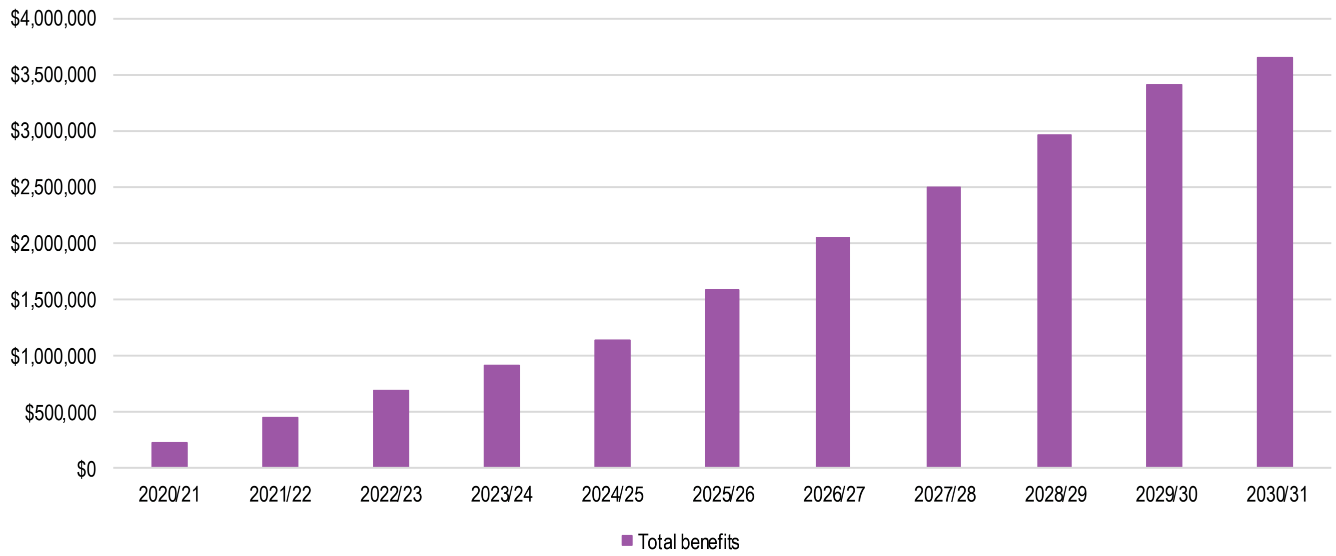
In the counterfactual ("without ON participation"), it is assumed that the product is not developed, and customers continue to use diesel until 2031.

The benefits of Diffuse Energy's technology have been calculated by projecting the uptake of units, and the value of the reduction in the use of diesel fuel used by customers. The key assumptions use are as follows:

— Diffuse Energy's market will grow to supply 17 per cent of the 20,000 remote area telecommunications towers by 2030, plus 50-100 wholesale sales per year (see section 4 for details).
— Benefits include a reduction in CO_2 emissions, and
— a reduction in diesel fuel usage and associated costs (which is largely an imported product) and the associated leakage from the Australian economy. The benefits are assumed to be $150 of avoided costs associated with using diesel per month for the 10-year life of the unit. Where 50 per cent of this benefit is included in the CBA which is the avoided "leakage" overseas from the purchase of diesel, and to account for other operating costs of the units not explicitly calculated.

[2] https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/1370.0~2010~Chapter~Fuel%20consumption%20and%20emissions%20(4.9.4)
[3] https://www.abc.net.au/news/2019-06-17/australian-emissions-reduction-fund-data-analysis/11164476
[4] Diesel and its inputs are largely imported

FIGURE 3 DIFFUSE ENERGY BENEFITS WITH PARTICIPATION IN THE ON PROGRAM, 2020/21 TO 2030/31 (2019/20 DOLLARS)



NOTE: Revenues without participation in the ON program are assumed to be zero. Note that the residual benefits after 2030/31 of installed units are included in the CBA but not shown in the figure.
SOURCE: ACIL ALLEN ESTIMATES BASED ON DIFFUSE INFORMATION

It is assumed that the benefits stream will cease after 2030/31 due to the introduction of similar products in the marketplace by other Australian companies.

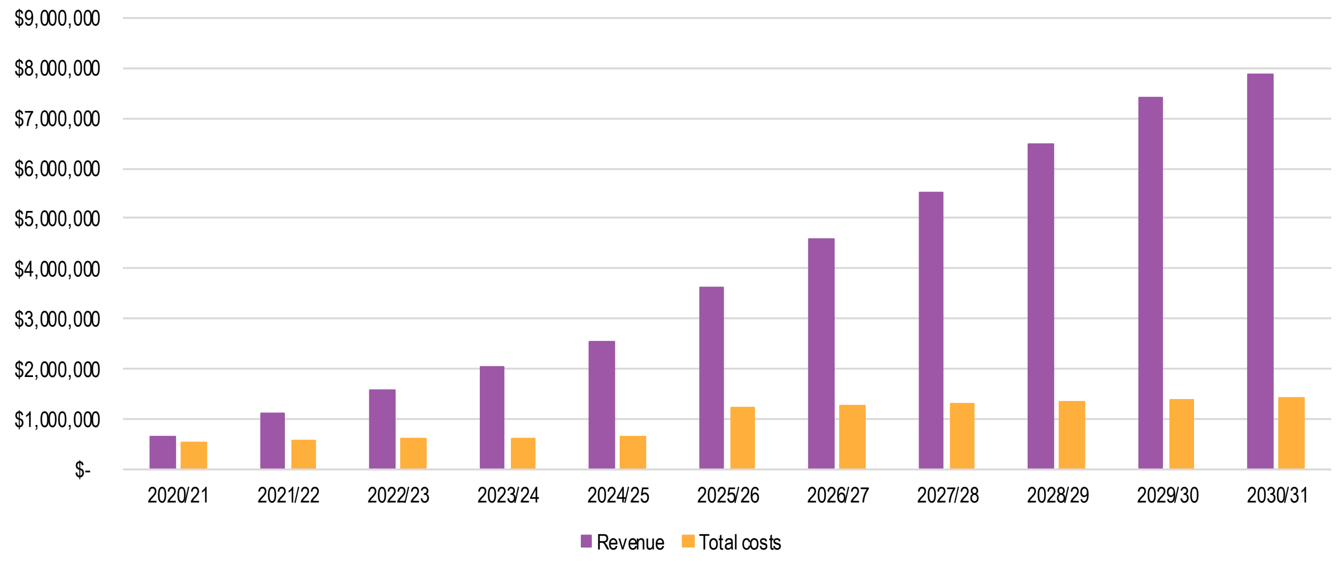
Diffuse revenues and costs

The revenues and production costs for Diffuse Energy were estimated using the assumptions outlined above. These assume the update rate outlined, a production cost of $2,050 and a sale price of $3,265. Note that the costs included in the analysis include ON related costs, other upfront cash and in-kind support, and the cost of production.

As can be seen in **Table 1** the ON-related costs of the Diffuse Energy project were just under $347,0295. Other upfront cash and in-kind support totalled $602,920. This results in a total upfront cost of $949,949. The counterfactual is that the product remained non-commercialised without any further work, as such all upfront cash and in-kind support are included as costs in the CBA and there is assumed to be very little or no activity in the counter factual.

The projected total operating costs of Diffuse Energy between 2020/21 and 2030/31 with participation in the ON program are shown in **Figure 4**. Note that the CBA assumes that production costs in the counterfactual (“without ON participation”) are assumed to be zero as it is assumed there was no commercialisation and no product produced and sold.

FIGURE 4 PROJECTED DIFFUSE ENERGY REVENUE AND COSTS WITH PARTICIPATION IN THE ON PROGRAM, 2020/21 TO 2030/31 (2019/20 DOLLARS)

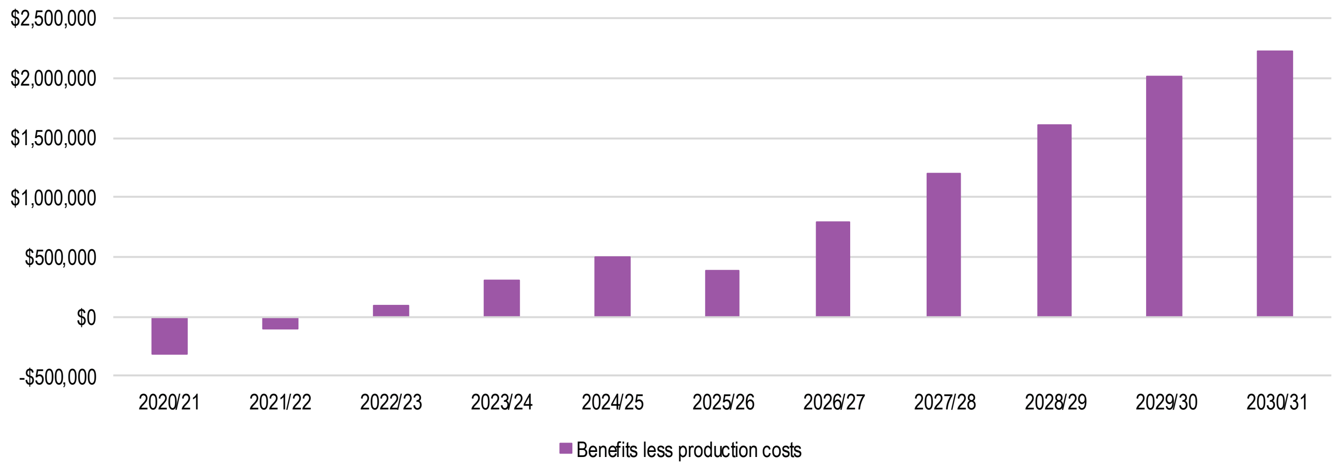


Note: the revenue estimated here is not used in the CBA.
SOURCE: ACIL ALLEN ESTIMATES BASED ON DIFFUSE INFORMATION

Assessment of benefits against costs

Taking into account the benefits and production costs, the net benefit added to the Australian economy by Diffuse Energy's technology (relative to the counterfactual where the ON program did not exist) is shown in **Figure 5**. The benefits initially are negative, as the cost to produce and install units are not outweighed by the annual benefits. However, as the number of installed units grow, the annual benefits increase and outweigh the new annual installation costs. Note that there is a dip in benefits in 2025/26 as this year is assumed to have a jump in the number of installations, hence larger cost that year.

FIGURE 5 BENEFITS VALUE ADDED TO AUSTRALIA BY DIFFUSE ENERGY, 2020/21 TO 2030/31. (2019/20 DOLLARS)



Note: Note this excludes the upfront ON costs, and other cash and in-kind support. Note that the residual benefits after 2030/31 of installed units are included in the CBA but not shown in the figure.
SOURCE: ACIL ALLEN ESTIMATES BASED ON DIFFUSE INFORMATION

The present value of upfront ON-related costs and other cash and in-kind support incurred by Diffuse Energy is $ $965,249 in 2019/20 dollars. The present value of benefits associated with participation in the ON program is estimated at $10.3 million in 2019/20 dollars under a 7 per cent real discount rate.

The net present value (NPV) of participation in the ON program is thus $9.3 million under the 7 per cent real discount rate, while the benefit-cost ratio (BCR) is 10.7. The NPV is calculated by subtracting the present value of costs from the present value of benefits, while the BCR is calculated by dividing the present value of benefits by the present value of costs.

Sensitivity analysis

If the projected sales of Diffuse Energy's technology (with participation in the ON program) between 2020/21 and 2030/31 are 20 per cent higher than those in the central case, the BCR will increase from 10.7 to 12.3. Conversely, if the projected uptake between 2018/19 and 2026/27 is 20 per cent lower than those in the central case, the BCR will decrease to 9.0.

If the projected benefits per installation of Diffuse Energy's turbine (that is avoided "leakage" and environmental benefits) are 20 per cent higher than those in the central case of the cost-benefit analysis, the BCR will increase from 10.7 to 14.0. Conversely, if the projected benefits per install are 20 per cent lower than those in the central case, the BCR will decrease to 7.3.

In the central case of the cost-benefit analysis, a 7 per cent real discount rate has been used. The BCR decreases to 16.1 under a 4 per cent real discount rate and increases to 7.2 under a 10 per cent real discount rate.

5.2 Potential future impacts

Two companies have approached Diffuse Energy to discuss adoption of the Hyland 920 turbine:

— GreenPlate: this company manufactures solar powered BBQs for public places (parks and playgrounds) and are interested in a small wind turbine for powering these. Diffuse Energy could provide these under a wholesale arrangement.

— Tinyhomes: this company provide eco-designer tiny homes and are interested in incorporating a wind turbine into their package so that owners don't need to rely on a utility company for their power.

The ON program's role

Participation in the ON program helped the Diffuse Energy team to understand the potential market for the technology. It has given the team the confidence to explore several other potential markets for their technology.