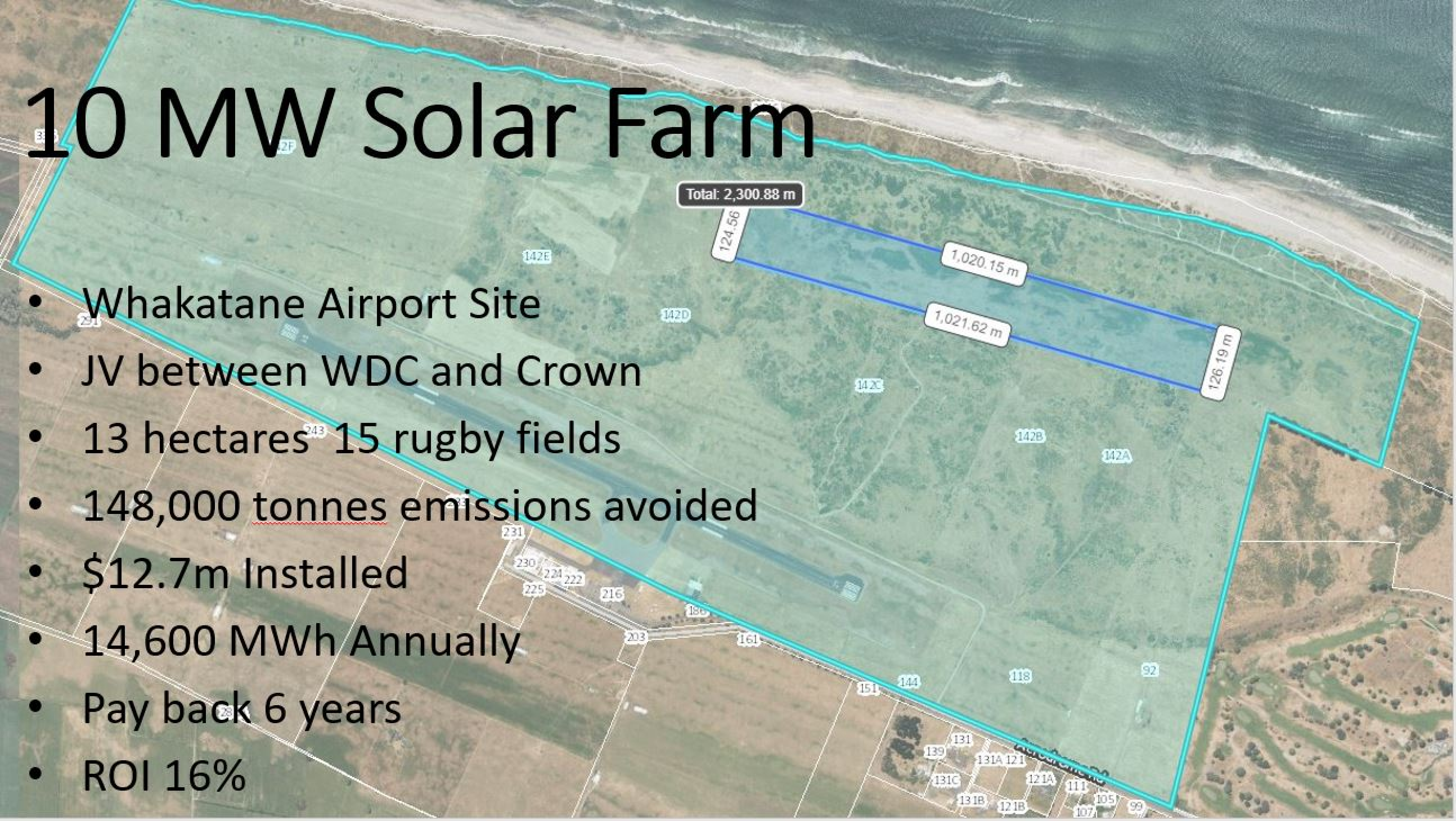
10 MW Solar Farm

- Whakatane Airport Site
- JV between WDC and Crown
- 13 hectares 15 rugby fields
- 148,000 tonnes emissions avoided
- $12.7m Installed
- 14,600 MWh Annually
- Pay back 6 years
- ROI 16%



Pre-Feasibility Study - Community Solar Farm for Whakatāne

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Executive Summary

This project pre-feasibility study addresses the provision of a community-based solar farm of 7 MW for Whakatāne township capable of supplying the electricity needs of about 2000 households. Whakatāne is an ideal location in New Zealand for the roll out such a solar farm project given that the district receives amongst the highest sunshine hours in the country.

This project would represent Whakatāne's contribution to the elimination of the 15% fossil fuel component of NZ's electricity generation, aligning with the zero carbon bill.

A major object of this project is to provide affordable locally-generated electricity at lower than current retail prices especially to more financially challenged households.

Given the current ready availability of off-the-shelf solar PV components, locally fabricated timber structures, and minimal requirement for civil works, this project can easily be delivered by local suppliers. Combined with a suitable site identified within an existing Council Controlled Trading Organisation, the project is considered "shovel-ready". Because the customers will be within a 20 km radius of generation, existing smart metering and smart grid technology will trail-blaze the transition of New Zealand's legacy centralized electricity generation system to a community-owned modern distributed renewable electricity model.

The estimated cost of a project of this size exceeds $10 million NZD and the payback time is of the order of 10 years. Construction could be achieved within a 6-12-month time frame. Given that council land is being proposed, the need for approvals could be fast-tracked.

Example of a community solar farm. Source: https://www.clearwaycommunitysolar.com/how-community-solar-works/

1. INTRODUCTION

1.1. NZ Green-House Gas Emissions

New Zealand's green-house gas (GHG) emissions broken down by sector are shown in Figure 1. The lion's share, or about 49% of GHG emissions, result from agricultural production (Figure 1a) while the energy piece of the pie accounts for about 39%. This 39%, of the emissions pie can further be broken down by sector (Figure 1b) and it can be seen that electricity generation and transport account for about 16% and 44% respectively. Electrification of the transport sector could in principle reduce the transport component by half if all vehicles on NZ roads could be converted to battery electric vehicles (BEV) utilizing clean (zero-carbon) electricity.

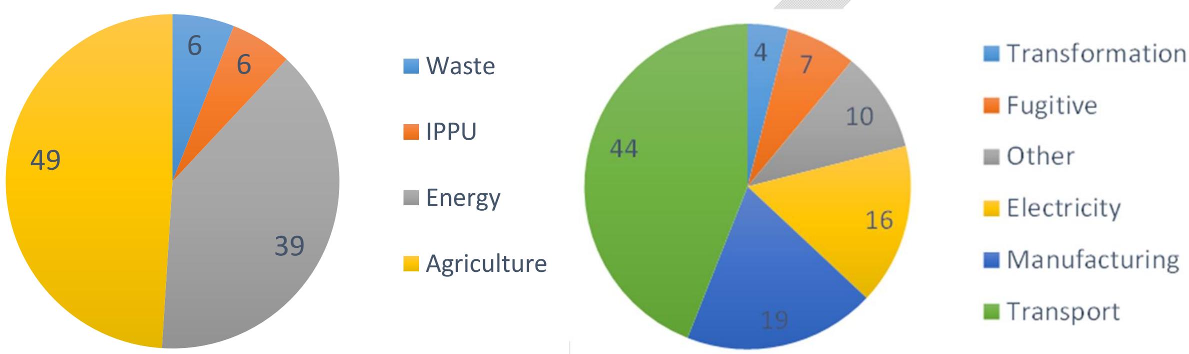


Figure 1. (a) New Zealand's GHG emissions by sector in 2013, **(b)** breakdown of energy sector emissions (data from [6, 7]). IPPU – Industrial processes and product use.

1.2. New Zealand Energy Sector by Source

Electricity generation in NZ is dominated by hydro and geothermal sources (Figure 2). These are generally considered renewable and therefore should have relatively small carbon footprint. Thermal base-load power generation using coal and gas as fuels are inherently 'dirty', and together constitute about 15% of electricity generation in NZ. Renewables such as solar and wind constitute a relatively minor but increasing portion of our generation. Although our grid is relatively clean, and given that we have good base-load sources (hydro & geothermal), removing the 15% contribution from coal and gas and replacing with renewables such as solar and wind, could be particularly advantageous in reducing emissions associated with energy generation.

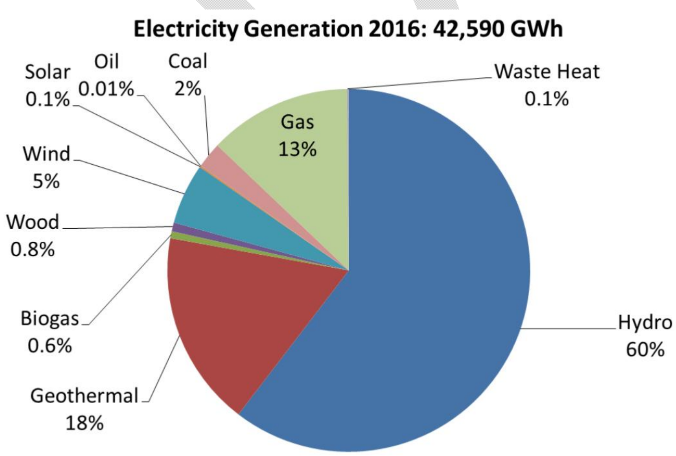


Figure 2. Electricity generation in New Zealand by source in 2016.

1.3. Description of NZ Renewable Energy Sector and the Players

As part of this PFS we have been in consultation with Brendan Winitana, Chair of Sustainable Energy Association of New Zealand (SEANZ). This entity advocates for renewable energy at all levels driving distributed generation of solar PV, batteries and all related technology and the business models that result from and including P2P (Peer-to-Peer), virtual power plants, PV output aggregation, community energy besides the norm of solar on roofs and storage/batteries behind and in front of the meter.

At the present time there are various models in play in NZ that are provided by a range of vendors/suppliers (not necessarily electricity retailers of which there are 41 in NZ). These traditional suppliers are working towards delivering a new energy future based on Distributed Energy Resources (DER). This is in contrast to the old expensive archaic centralized generation, move electricity up and down the country model. A distributed model enables system resilience, lower cost electricity supply to lower decile households providing energy equity. It is expected that in time these distributed renewable energy models will undercut offerings from current retailers that utilize centralized generation (*e.g.* Trustpower). The traditional retailers will be looking to find a niche in this new system. Trustpower have done a good job and it is working NZ wide for them with the 'solar buddies' initiative. The new distributed renewable model is still in its infancy in NZ and abroad there are many other countries that are significantly ahead of us (*e.g.* Denmark, Germany …).

The new model requires the co-operation and collaboration of a local lines company (*e.g.* Horizon Energy) just as the present proposal requires. This may be easier said than done. Of the 29 lines companies in NZ, only six at this time are working towards a new model. Horizon are not being driven by regulation and given their legacy ownership structure, are not resourced to enter the new future yet.

The current regulatory environment is well behind and in catch-up mode. Regulation of lines companies, retailers and participants under the Electricity Act (and the Financial Markets Act) is always well behind.

The regulator (Electricity Authority) will eventually have to adopt new regulations that accommodate modern models that will deliver more distributed energy via solar, wind, batteries, IoT, sensors, energy management systems. Allow innovation to create new models to support the consumer and prosumer directly. It is expected that this will provide the push-and-pull drive for building a secondary electricity market to supply lower cost electricity. That is, one not connected to the current model.

The energy transition (Figure 3) is therefore well underway in many other jurisdictions including Hawaii, New York, California, Denmark, Japan, Germany, Portugal, Spain, UK, provinces in China, Malaysia, parts of Australia. However, it is expected that the transition will take time; perhaps a decade.

The Minister of Energy, Hon. Dr Megan Woods, appears to be driving the transition here with a view to reducing energy poverty and hardship in NZ and decarbonization of the system. She has and continues to make the moves to accomplish this at consumer level (winter energy payments) and regulation as she is responsible for the above.

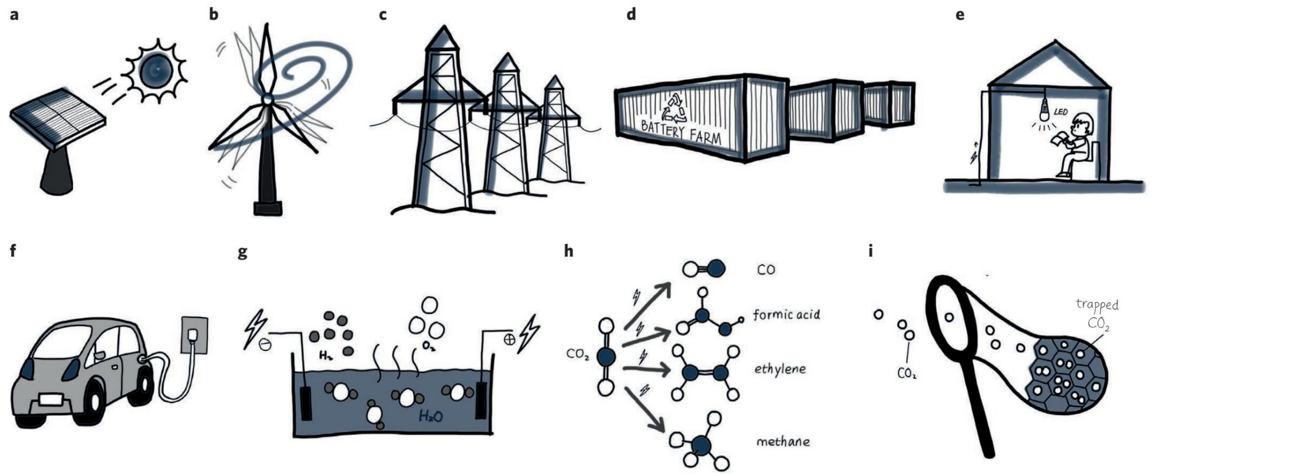


Figure 3. Our renewable energy future. **a**–**i**, Advances in materials science and engineering are increasing the efficiency of electricity generation from clean renewable energy sources - solar panels (**a**) and wind turbines (**b**), for instance - as well as electricity distribution (**c**) and storage (**d**). Improved energy management in buildings (**e**) and widespread diffusion of electric vehicles (**f**) are decreasing our carbon footprint. Better catalysts and photoelectrochemical devices allow a more efficient generation of hydrogen and oxygen (**g**), and CO_2 conversion to fuels and chemicals (**h**). Carbon-capture materials (**i**) will decrease the amount of CO_2 released in the atmosphere. **Source:** Chu *et al.*, The path towards sustainable energy. *Nature Materials* **2016,** *16,* 16. DOI: 10.1038/NMAT4834. Author, Steven Chu, is a Nobel Prizing winning physicist and former US Energy Secretary.

1.4. Development of Solar PV in Whakatāne District

We live in a district with the highest average sunshine hours in New Zealand, in the range 1700-2600 hours. This is relatively ideal in terms of harnessing solar energy. Of the renewable energy alternatives, solar PV has a relatively higher energy density than say wind energy and therefore makes a good deal of sense given our location.

To have a meaningful effect on emissions in our district, one alternative would be to expand solar generation by equipping many roof tops with solar panels. However, given the relatively high depravation rates in our district, many households would not be able to afford this option, even with generous government subsidies. An alternative approach that is gaining traction in many advanced countries is the so-called 'Community Solar' option. The idea of community solar has taken off in recent years as more homeowners have realized that they can go solar without putting solar panels on the roofs of their homes. Community solar can benefit from economy of scale. Typically, to install a 3 kWp rooftop solar system costs $2600/kWp compared to a 2MW farm that can be installed for $1600/kWp. A community solar project - sometimes referred to as a 'solar garden' or 'roofless solar' - is a solar power plant whose electricity is shared by a number of households. In most cases, a community solar array is a large ground mounted installation that spans one or hectares.
See examples at: https://recsolar.com/all-case-studies/clean-energy-collective-portfolio/

The 5 MW (AC) community solar farm example shown in Figure 4 was built by REC Solar in five months including substation. The energy from the project is being purchased by Hawaiian Electric Company (HECO) on a 20-year PPA, contributing to Hawaii's goal of 100% clean energy by 2045.

The cited Hawaiian project shows that such installations can be built and grid-connected in very short time frames. Such a time-frame would match well the post COVID-19 recovery phase.

Figure 4. 5 MW AC Alhoa community solar project, Hawaii. Source: https://recsolar.com/all-case-studies/clean-energy-collective-portfolio/

2. PROPOSAL

2.1. Description

We propose to initially develop a 7 MW solar farm to be located on the outskirts of Whakatāne township. Such a solar park would be expected to power about 2000, two-person households, assuming ideal irradiance conditions. There are about 8000 homes in Whakatāne township.

While a detailed analysis of potential locations has not yet been conducted, one obvious possibility is to use council land. A potentially suitable location would be the council land adjacent to the airport. Since this is council land, it is expected that approvals would not be an issue.

Covering 5 hectares (6 rugby fields) there is good security, ample room for expansion, on sandy soil unsuitable for other economic land uses.

Figure 5. Potential location of 7 MW solar farm.

2.2. Operating on a break even return

7 MW Proposal	
Panel Peak Power (Wp)	410
Rated Peak Power (kWp)	7,000
Number Panels	17,073
Number Inverters (50kW)	135
Daily Average Production (kWh)	26,250
Annual Production (kWh)	9,581,250
Wholesale Cost Electricity ($/kWh)	$ 0.04
Generation Cost	$ 383,250
LCOE per Lazard (NZ$ per kWh)	$ 1,500.00
Installed Cost	$ 10,500,000
Pay Back (years)	27
ROI	3.7%
Annual CO_2 avoided (tonnes)	98,068
Number Households	2256

To operate the farm and sell at a very conservative nominal wholesale rate of 4 c/kWh (near what Meridian charges NZAS Tiwai Point), the plant would be paid off in 27 years.

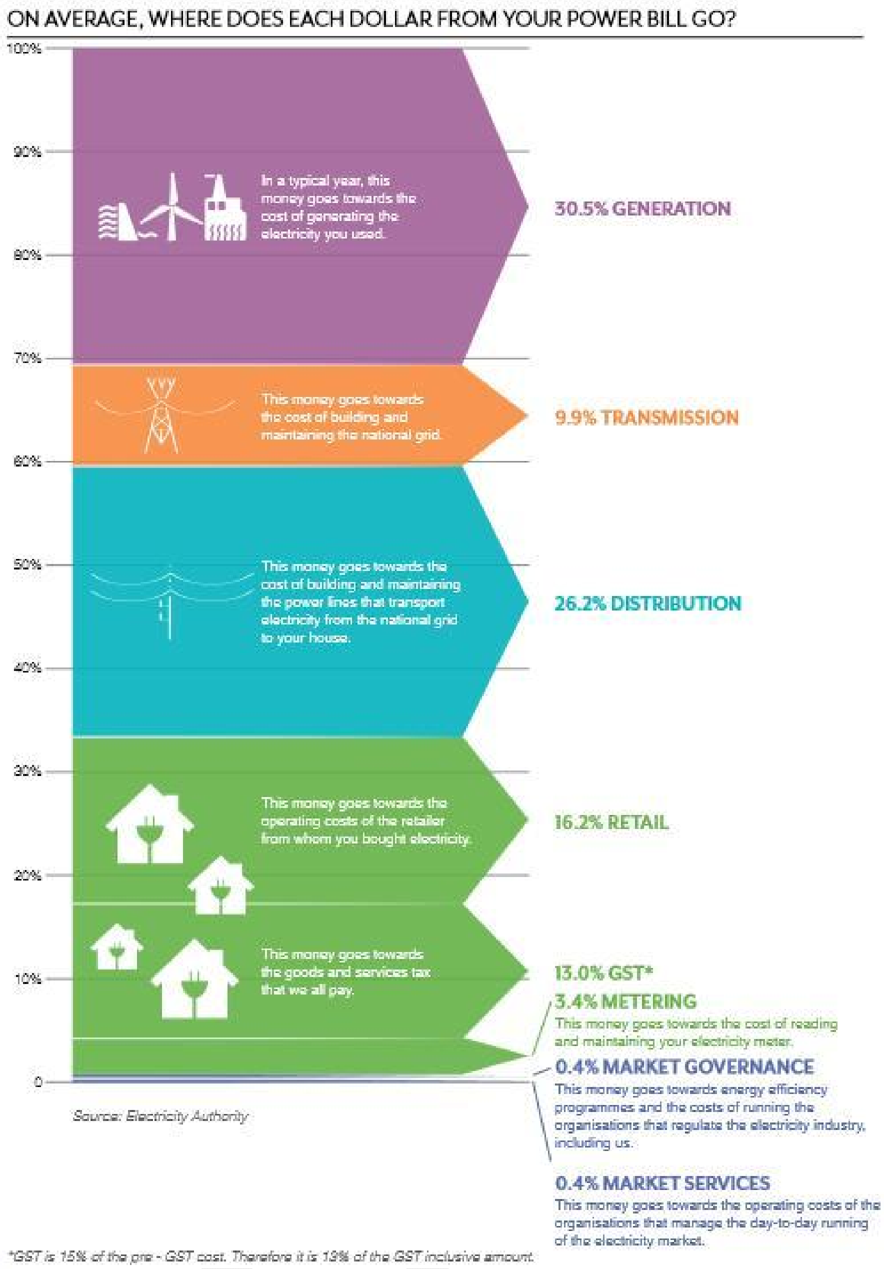
Warranty on panels is usually 25 years although the life of the farm could easily exceed 30 years.
If cost of money is at 1.5% interest, 3.7% allows for other unknowns (force majeure events….)

Inverters have a 10-year warranty so it is conceivable that some would require replacement before end of life. Rates, land rental, maintenance, insurances would be included in the "wholesale" rate.

Maintenance is expected to be relatively low and might include 6 monthly panel cleans, electrician checking for panel failures (one panel in a string failing, will fail the whole string). Monitoring will alert operators (alarm). Fuel – nil.

2.3 Returns on Investment operating as a Gentailer

If the Farm were to operate as a Gentailer using typical retail rate of 27 c/kWh, and expenses are per EA chart, then expect pay back in 8.8 years. ROI 11.3%. This suggests that the 7MW Proposal model in 2.2 above is about right and commercially viable.



Gentailer Price incl.GST	
Cost of Generation ($/kWh)	$ 0.08
Transmission Cost ($/kWh)	$ 0.03
Distribution	$ 0.07
Retail Fees ($/kWh)	$ 0.04
Taxes	$ 0.05
Profit Rate part of Generation + Retail Costs	
Total Selling Price ($/kWh)	$ 0.27
Annual Income	$ 2,586,938

Annual Expenditure	$ 1,396,946
Annual Income less expenditure	**$ 1,189,991**
Installed Cost	$ 10,500,000
Pay Back (years)	8.8
ROI	11.3%

Because this project is designed to sell electricity to our community for which the median income is below the national average, in the order of $25,000 per annum, the rates of return are not expected to be as good.

2.4. Returns operating as a Community Investment

Charging electricity at 13 c/kWh (versus current 27 c/kWh) would represent significant savings to consumers and would offer an 8.8 year payback time. Well inside the 30 year expected plant life. This price would also be sufficient to discourage electricity wastage.

Community Price incl.GST	
Cost of Generation ($/kWh)	$ 0.04
Transmission Cost ($/kWh)	$ -
Distribution ($/kWh)	$ 0.01
Retail Fees ($/kWh)	$ 0.024
Taxes	$ 0.03
Profit Rate ($/kWh)	$ 0.033
Total Selling Price ($/kWh)	**$ 0.13**
Annual Income	$ 1,259,934
Annual Expenditure	$ 560,503
Annual Income less expenditure	**$ 699,431**
Installed Cost	$ 10,500,000
Pay Back (years)	15.0
ROI	6.7%

Note, a key feature of this model is the nil Transmission Charge paid to TransPower because the proposed location does not require electricity to pass through the TransPower Grid. Electricity from the farm is routed directly to consumers via the local Lines Company. For those services a Distribution Charge commensurate with assets used is allowed for. This model is not normal and will involve modernizing of the outdated Transmission Pricing Methodology (TPM) currently administered by the Electricity Authority (EA). Refer discussion below, 3.2 The Regulations.

2.5. Use of Smart Meters and Energy Management System (EMS)

Transmission charges will be dependent on real time smart meters tracking energy flow to customers based on distance transmitted over lines company assets. Obviously, the greater the distance through lines company assets (low voltage lines and transformers), the greater the charge. Makeup energy (when the Farm is not generating) purchased from the Matahina Hydro will pass through numerous transformers and a variety of

MV and LV lines thus attracting a higher transmission rate. Hence the imperative to prioritise customers closest to the Farm.

As number of customers grow and range is extended the opportunity exists to build another farm near the new distant customers to allow them to benefit from the new transmission model.

2.6. Funding Models

There are a multitude of potential funding options and for the moment we provide only a few suggests in this document.

1. Council provides land and the bulk of the financing via a debt facility. Power is sold back to the grid at 10 c/kWh and proceeds distributed back to council and rate payers.
2. Co-funding by council and ratepayers.
3. Total private funding. In this respect, Vector Powersmart has indicated an interest.
4. Public-private partnership.

https://news.energysage.com/solar-farms-start-one/

2.7. Intermittency of Solar PV Generation

Where the CCTO operates as a Gentailer there will be an obligation to supply electricity at times when the sun is not shining, the Farm is not generating.
This will necessitate purchasing from an alternative source to supply customers. Local hydro and geothermal are available which will keep transmission costs low.

2.8. Seasonality of Solar PV Generation

Generation in summer will be about thrice that can be achieved in winter.

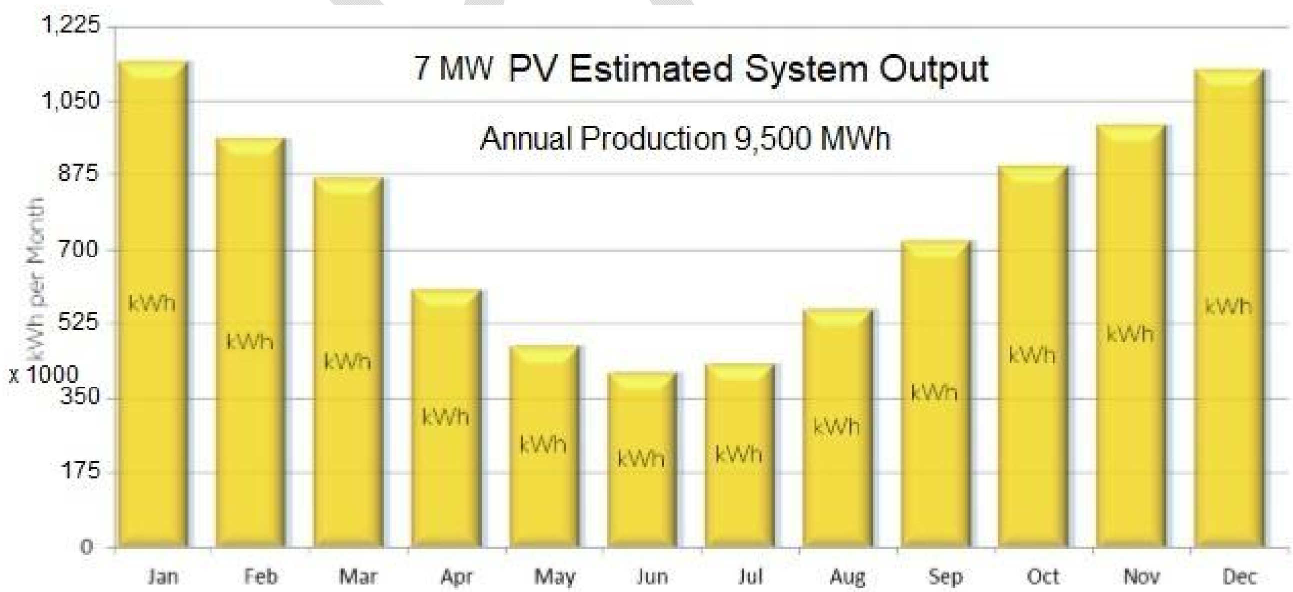


Figure 6. Expected electricity generation profile based on one of the author's standard roof-top solar installation.

Winter in NZ is when demand is greatest for home heating. Unfortunately, this is when the Farm is least able to produce elecrtricity due to the sun's low zenith and shorter days. This is the bane of solar electricity generation and NZ is no different to any other nation. However, EBOP is fortunate to have six geothermal generators at Kawerau offering baseload electricity complemented by peak load from Matahina Hydro.

Another option to level out the load is to introduce wind turbines and batteries at some time in the future. Again, the CCTO model will depend on alternative sources to meet evening and cloudy winter days. This does invite a proposal for a second plant to be a geothermal (baseload) generator to balance customer's needs. Perhaps at Awakeri?

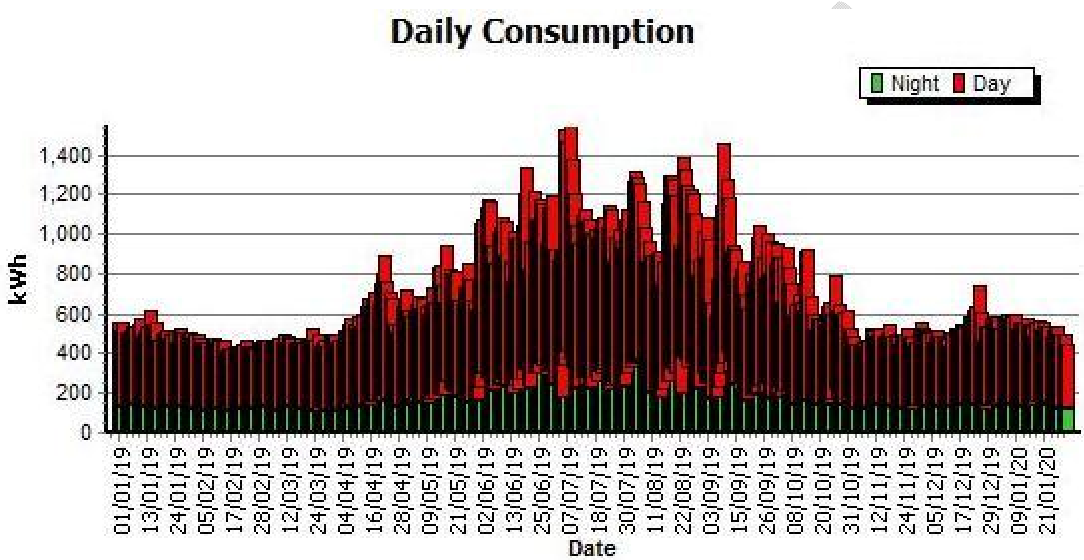


Figure 7. Consumption profile is the reverse of the Farm's Generation Profile.
Mid-winter daily consumption is 2.5 times summer consumption, 80% of it during daylight hours.

2.7. How many Customers can the Solar Farm Support?

Until AI (artificial intelligence) algorithms are applied to the smart meter data being accumulated by the Farm and it's customers, it is a "dark art" optimizing the number of customers a solar PV farm can support. To balance the variables of seasons and weather the CCTO model may need to acquire batteries and baseload generation.

3. The Council Controlled Trading Organisation (CCTO) Model

The aim is to use the existing Whakatāne Airport model with minor amendments to include the Farm on its site and expand its business model. Include trading as an Electricity Generator/Retailer similar to Trust Power. To own and operate the generation assets and have its own customers.

3.1 Smart Meters

Customer Smart Meters are integral to the distributed retail model. Phone apps to see in real time energy consumption and costs will be an important part of the system. Increasing customer knowledge of consumption and its costs is a means of reducing poverty. The ability to monitor appliances, peak loads (rates) and transmission charges and provide instant feedback is key to this educational component. Invoicing daily via Debit Card helps to emphasize the relationship of electrical device use and their operating costs. How much a washing mac

Hot water cylinders will be stripped of the primitive thermostatic ON/OFF control and shifted to the EMS to optimize consumption of solar production, load shifting and benefiting from off-peak rates.

3.2 The Regulations

"A generation company cannot own or have an interest in a distribution company and a distribution company cannot retail electricity or deal in electricity hedges. There are two exceptions to the regulations: generation companies can own the lines required to transport electricity from their power stations to the grid or local distribution network; and distribution companies can own a small amount of conventional generation capacity within their network but are not limited in the level of renewable generation capacity. There is no barrier to vertical integration from generation to retail."

This model is not fit for purpose in the modern Distributed Energy Resource (DER) world.

3.3. Computer Analysis of Smart Meter Data

The current Transmission Pricing Methodology (TPM) requires decommissioning in favor of a real time balancing of energy flows around the country so charges /kWh reflect the cost to deliver over the transmission assets used. The cost to transmit a kWh from the Farm to a customer 1 km away should not be the same as a consumer in Auckland whose kWh has been sourced from Benmore.

3.4. Shovel Readiness

All of the technical components of this projects are readily available in New Zealand. There are many companies that undertake the various parts of the project.

For instance Vector Powersmart is one company that we are working on to better define costs and technology options. They have indicated a willingness to partner.
Another company that has expressed an interest is Revolve Energy.

3.5. Project Schedule

3.5.1. Design

By a NZ team with large solar PV installation experience. To include Scalability - future battery and more PV to support civil defense and resilience aspirations.

Local lines company to install new capacity from the Whakatane Airport site to the Hub - 10 km.

3.5.2. Critical Path

Covit-19 will impact on delivery of the large number of imported Solar PV components. Probably ex China which fortunately appears to be restarting.

3.5.3. Construction

Fabrication and placing of timber frames as soon as design completed. Local materials.

Install 17,000 PV panels mounted on frames, bolted to timber posts driven into sandy soil.
Modules raised 1.4 M above ground - Earthquake, flood and Tsunami resistant - targeting resilience to provide first response support after a major civil event.

Local electricians for wiring panels to Inverters (135 x 50kW) to Control Room. Specialist control and software engineers, some local. Defer to a highly skilled workforce associated with the nearby Pulp and Paper Industry for all disciplines involved in this relatively simple project.

3.5.4. Commissioning

A System Controls Engineer will be required for 6 months after start-up.

3.5.5. Maintenance

Washing of components as required due to salt laden environment. Smart monitoring to detect failures.
Warranty 25 years on panels, 10 years on Inverters. Nil moving parts.

4. Infrastructure Industry Reference Group - General Criteria

25 March 2020 "…. the Infrastructure Industry Reference Group to advise the Government on issues arising for the construction industry in NZ as a result of Covid-19".

"We are inviting industry participants, consultants, Local Bodies and other asset owners who have projects that fit the following criteria to provide us with a list for consideration."

4.1 …be truly ready for construction within a realistic 6 months

The bulk of the hardware involves fabrication of timber support frames in local workshops using local labor and nearby timber resources. Construction could start within weeks of module design. Prewiring and construction of Control Room can start early. A large diameter cable to the nearest Lines Company connection will need attention. Installation of lightweight PV panels dependent on overseas suppliers. There exists an Inverter manufacturer in Christchurch.

4.2 ...be of an infrastructure nature for the public benefit

The scientific case for anthropogenic climate change and the very real global existential threat posed by inaction makes projects of the type being proposed here of paramount importance to the world community of which NZ is a part.

Electricity is a fundamental requirement of a modern society and the infrastructure being proposed contributes to reducing NZ emissions and improves the resilience of the electrical system.

Moreover, the supply of cheaper renewable energy to a low decile community, plus close enough to back up the whole community in the event of a natural disaster isolating the community is of clear public benefit.

The authors believe that it is inevitable that NZ will eventually move toward a distributed electricity model and replace 15% of its 'dirty' electricity generation capacity with renewables. It is just a matter of time. The COVID-19 pandemic emergency and the subsequent recovery should be viewed as an opportunity to bring this inevitable clean energy transition forward.

4.3 ...is of a significant size, so that employment benefits for workers (either directly or as part of the NZ based supply chain) not less than $10m

At 7MW and costing $10.5m the proposed community solar farm has economy of scale to demonstrate the future of DER in NZ. Construction provides the most employment as the passive nature of solar PV and smart technology is set and forget. Taking the modular model to other isolated low decile communities Taneatua, Opotiki, Te Kaha and Northland could spawn growth of, to date, a much neglected Solar Industry.

4.4 … the project brings real value (in an economic or social sense) to NZ as a whole or the region in which it is located

Real value involves attacking energy poverty and therefore has both economic and social merit. That is, provided the true benefit of consuming electricity close to source is realized. Where actual transmission charges are applied.

Combined with other prosumers, the present project can become the foundation of community Virtual Power Plants (VPP). As the model is scaled up more economies can be gained when applied to communities presently at the end of long small diameter wires.

Extrapolating the Smart Grid (real time transmission charging) model to the whole of NZ will realize benefits of Smart Grid energy management and increased resilience.