Summary: Phase 1 - Solar Sector Scan

1.1 Utility-Scale Solar Photovoltaics

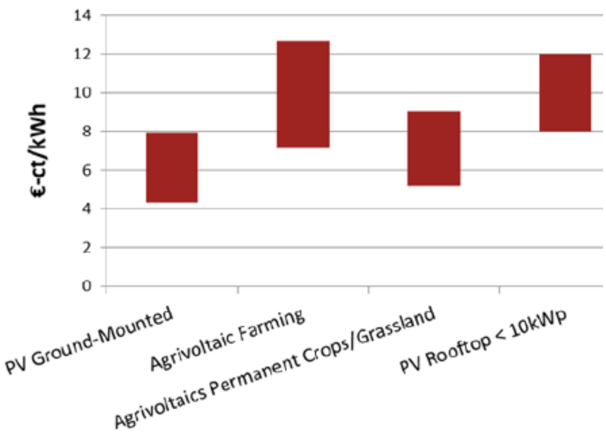
Utility-Scale Solar Photovoltaics is a particularly interesting model to consider given that it's identified & ranked by Project Drawdown as number 8 out of the 80 solutions to climate change **(Drawdown ranks solutions by Total Atmospheric CO2e Reduction [GT]).**

1.2 Distributed Generation & Rooftop Solar

About 95% of distributed generation is from renewable sources such as wind, geothermal and hydro, and 'behind the meter' generation such as rooftop solar. These forms of decentralised generation play a role in reducing the amount of electricity that would otherwise have to be transmitted by the grid. This is particularly valuable when it can offset periods of peak demand when the grid is limited in some way (for example if a line fails during a storm). (NZ's Interim Climate Change Committee Report: Accelerated Electrification - Evidence, analysis and recommendations - April 2019)

For the above reasons, rooftop solar is a particularly interesting model given that it's part of a distributed generation model which is identified & ranked by Project Drawdown as number 10 out of the 80 solutions to climate change **(Drawdown ranks solutions by Total Atmospheric CO2e Reduction [GT]).**

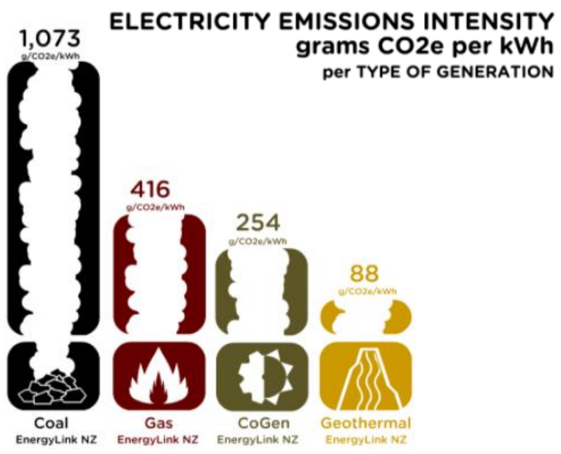
1.3 Agrivoltaics



- ***Figure: Estimated average Levelized Cost of Electricity (LCOE) for ground mounted photovoltaic systems and agrivoltaics, Fraunhofer ISE - Agrivoltaics Guidelines for Germany – October 2020***
- **Benefits of Agrivoltaics could/may include:**
  - **land use efficiency,**
  - **water savings,**
  - **higher crop yields (particularly in arid regions),**
  - **improve solar pv generation/efficiency (cooler panels due to crops),**
  - **relevant to: dairy, grazing, apples, berries, grapes, other crops, etc,**
  - **building resilient systems & protection from rain, hail, frost, etc,**
  - **increase in per hectare returns for farmers &/or generators**
- Recognising that heading into the future we need to 'rewild the planet' and better utilise land, agrivoltaics provides a platform for the dual use of land.
- **Lodestone appears to be the only utility scale solar farm in NZ going down the Agrivoltaics route making them the pioneers in this space in NZ.**
- It is likely that Lodestone will build their solar arrays and that horticulturists &/or agriculturists will have an opportunity to lease the land off Lodestone and adapt their farming methods to best utilise/leverage Lodestone's solar infrastructure. **Acknowledging that solar pv is going to play an increasingly important part of NZ's electricity generation profile, this could present an opportunity for NZ farmers/growers to innovate using agrivoltaics to improve farming/growing practises &/or improve per hectare returns.**

1.4 Carbon Footprint of Solar in NZ

Comparison of NZ retailer Ecotricity's renewable generation mix to NZ thermal CO2 emissions



NZ Thermal Generation Emissions vs Ecotricity Construction Emissions
(Data Source: Energy Link NZ 12 months emissions 2020)

Table 3: Product carbon footprint summary by lifecycle activity for solar

Post Audit Totals		
Upstream	0.038	$kgCO_2e$/kWh
Core	0.013	$kgCO_2e$/ kWh
Downstream[2]	0	$kgCO_2e$/ kWh
Total inventory:	**0.0503**	**$kgCO_2e$/ kWh**

Ecotricity CO2 Emissions data source from Toitu

50.3 gCO2e per kWh (for domestic solar product)	7.1 gCO2e per kWh	6.6 gCO2e per kWh
Ecotricity Solar	**Ecotricity Wind**	**Ecotricity Hydro**

Key Findings from EPECentre Report: Emissions Accounting for Trust Horizon's Proposed Rooftop PV Installation

- ***PV systems using multi-silicon panels were found to have emissions in the order of 48 gCO2-e/kWh over the system's lifetime.*** *This is approximately a third smaller embedded emissions compared to mono-silicon panels (71 gCO2-e/kWh) for the 3 kWp reference system.*
- ***As the PV installation size increases, a gradual decrease in embedded emissions per kW peak is expected.***
- ***In the future, PV embedded emissions are expected to decrease as cleaner energy is used in their manufacture.***
- ***Additionally new technology is on the horizon with lower energy requirements such as perovskite-based solar cells that could provide a further pathway to PV sources with lower embedded emissions.***
- *PV's ability to offset carbon emissions in New Zealand with an already high renewable proportion is open to debate. It is the view taken here however, that PV generation should be offset against marginal generation, the last and typically most expensive generation to be despatched.*
- ***Lifecycle PV emissions are an order of magnitude lower than the operational emissions of natural gas ~ 427 gCO2-e/kWh.***
- *PV installations were able to offset their embedded emissions in three to four years and had the potential to offset 13-14 tonnes of CO2-e/kWp over their thirty-year lifetime.*

1.5 Levelized Cost of Electricity (LCOE): Solar vs Other Utility Scale Generation

Figure: [Levelised Cost of Energy Comparison – Historic Utility Scale Generation Comparison – (Lazard Investment Bank)]

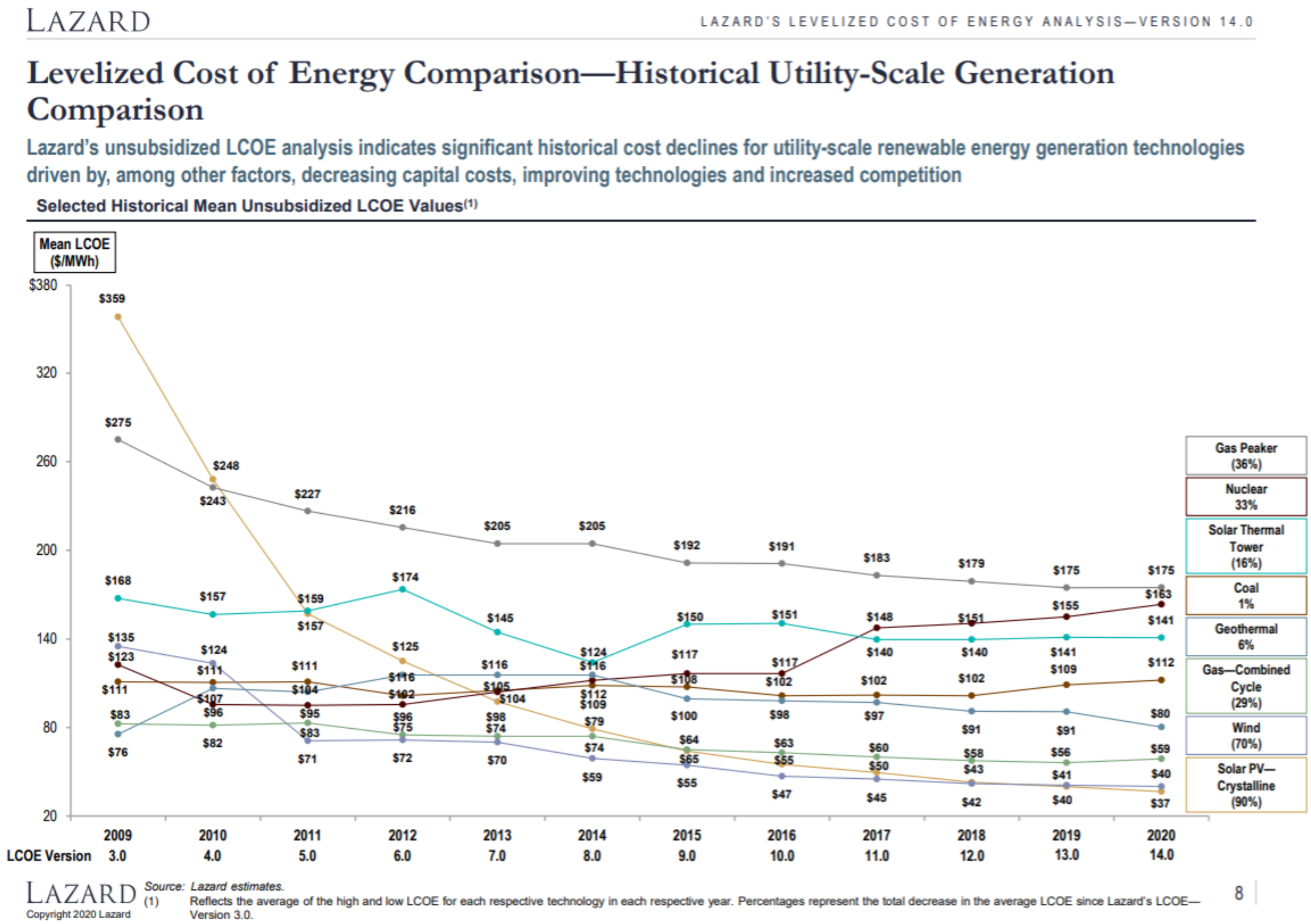


Table: [IRENA Total installed Cost, capacity factor and levelized cost of electricity trends by technology, 2010 and 2020]

Table H1 Total installed cost, capacity factor and levelised cost of electricity trends by technology, 2010 and 2020

	Total installed costs (2020 USD/kW)			Capacity factor (%)			Levelised cost of electricity (2020 USD/kWh)		
	2010	2020	Percent change	2010	2020	Percent change	2010	2020	Percent change
Bioenergy	2 619	2 543	-3%	72	70	-2%	0.076	0.076	0%
Geothermal	2 620	4 468	71%	87	83	-5%	0.049	0.071	45%
Hydropower	1 269	1 870	47%	44	46	4%	0.038	0.044	18%
Solar PV	4 731	883	-81%	14	16	17%	0.381	0.057	-85%
CSP	9 095	4 581	-50%	30	42	40%	0.340	0.108	-68%
Onshore wind	1 971	1 355	-31%	27	36	31%	0.089	0.039	-56%
Offshore wind	4 706	3 185	-32%	38	40	6%	0.162	0.084	-48%

1.6 Transpower Report "The Sun Rises on a Solar Energy Future" – Future of Solar in NZ & LCOE

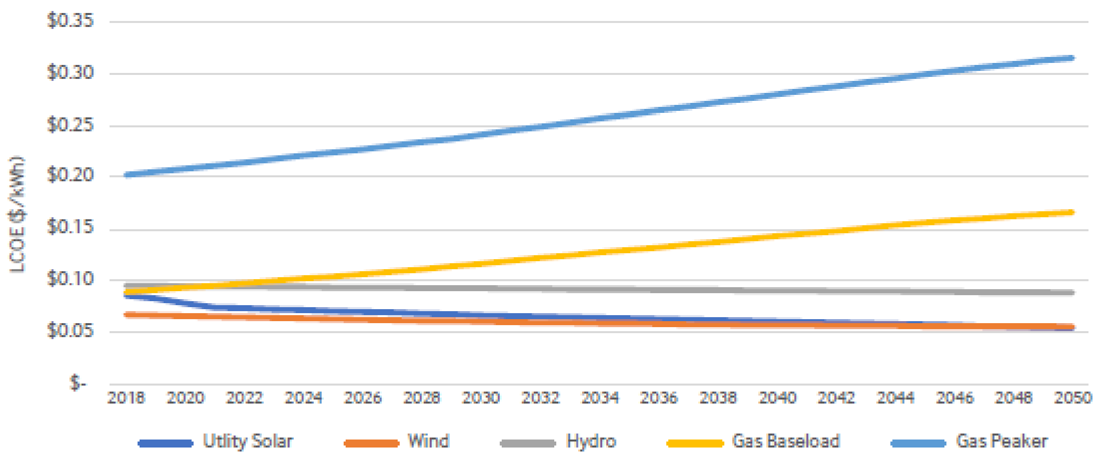
The case for solar in our energy future (key excerpts from the Transpower report)

In 2017, solar became the leading form of new utility energy generation in the world.

The United Nations reports that in 2017, 98GW of solar generation was installed globally, exceeding the 70GW of new fossil fuel generation built the same year by 40 per cent. This represents a significant global shift – the first time since the industrial revolution that a renewable form of energy has outstripped the construction of conventional fossil fuel-powered electricity generation. This shift is the result of a long-running trend of falling solar prices. Prices for solar installations have been helped at times and, in certain locations, by government subsidies but, stripping out all subsidies, utility solar is now on a pricing par with gas-fired peaking power stations. (It should be noted here that this is on a per unit of energy produced basis. However, this is not a direct like-for-like comparison as gas-fired peaking power stations produce power on demand, whereas solar produces variable energy output and varies by region.) Within the industry, looking at the real, underlying costs of energy sources is called a 'levelised cost of energy (LCOE)'.

Figure 1 below shows the levelised cost of energy for a range of electricity generation technologies1. With forecast carbon prices applied to gas-fired electricity generation, this graph shows that the cost of energy from gas-fired power stations will be double the price of energy from utility solar within a decade.

Figure 1: NZD cost of energy from different sources as technology and carbon prices evolve



The levelised cost of utility solar is expected to continue falling – by a further 24 per cent over the next 10 years, and by over 40 per cent by 2050. Based on what we currently know and believe, by 2050 utility solar is likely to be the world's cheapest form of energy – marginally cheaper than wind, which will also continue to fall in price.

The Massachusetts Institute of Technology has reported that the cost of photovoltaic solar cells has fallen by 99 per cent over the last 40 years. The installed cost per watt of solar energy has halved in Australia in the last six years.

The decreasing cost and steadily improving solar performance, as well as an increasing focus on sustainability and self-reliance, are now driving the mass adoption of distributed solar in homes and businesses, as well as grid and network connected solar farms.

Figure 6 : Levelised Cost of Energy compared to generation and retail prices ($/kWh)

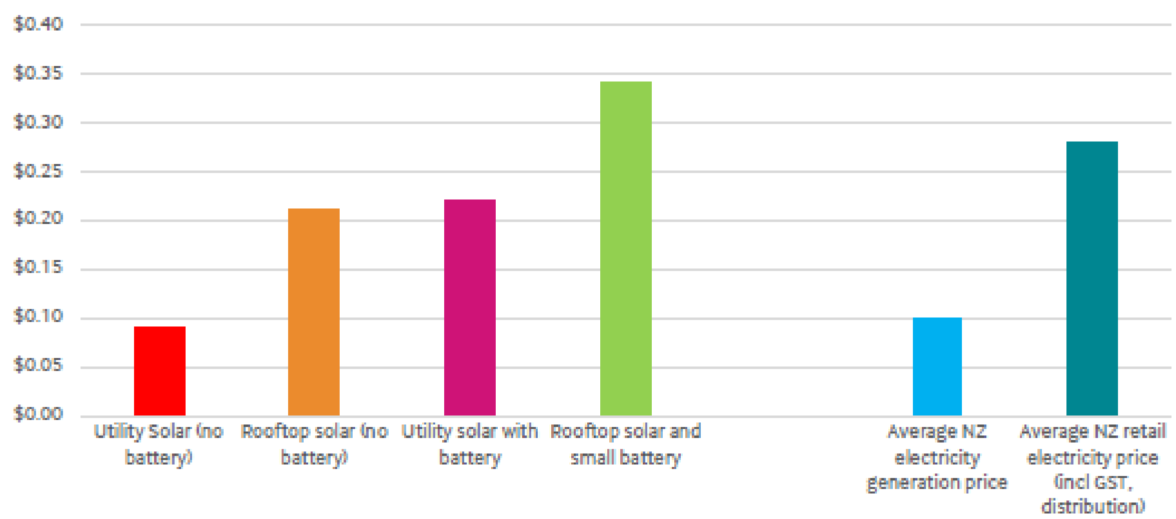


Figure 6 shows the average cost of energy produced. We compare utility and rooftop solar with and without batteries to the average New Zealand generation price and retail price. Note retail prices include the cost of distribution, transmission and retail. Without a battery, energy use must fit with times of generation. Average solar irradiation used for analysis. Generation price and retail price from Electricity Price Review First Report.

1.7 EECA - IRR analysis of Commercial-scale (rooftop) solar in New Zealand in 2021

PCL's view is that actual NZ capital costs are 20% lower than the figures presented by EECA therefore it is reasonable to assume the actual IRR will be 35% higher than EECA's IRR figures.

Table 10: Average internal rate of return by load type and location.

Load type	AK	HN	TR	NR	WN	NN	CC	DN	**Mean**
Big box retail	4.3%	4.8%	5.3%	2.2%	2.9%	5.0%	5.8%	0.6%	**3.9%**
Retail	5.8%	4.2%							**5.0%**
Grocery retail	5.0%	3.5%	6.5%	3.0%	2.6%	5.8%	3.2%	1.1%	**3.8%**
Food market	5.1%				2.6%		6.8%	1.7%	**4.0%**
Cool store				4.6%		5.6%			**5.1%**
Greenhouse		6.3%							**6.3%**
Corporate office	6.5%				3.1%				**4.8%**
Retail warehousing	4.8%						5.7%		**5.2%**
Warehousing	6.3%		3.3%	2.0%			4.7%		**4.1%**
Production	6.6%								**6.6%**
Manufacturing	8.4%				3.3%				**5.8%**
Education	6.8%								**6.8%**
Waste water treatment	5.2%								**5.2%**
Water supply	6.8%								**6.8%**
Dairy farm							4.4%		**4.4%**
Mean	**6.0%**	**4.7%**	**5.0%**	**3.0%**	**2.9%**	**5.5%**	**5.1%**	**1.1%**	**5.2%**

Applying the 35% increase to the NZ mean IRR of 5.2% results in an IRR of 7%, which appears consistent with 'industry chatter' of 7-8% IRR for commercial rooftop solar (or higher in some circumstances).

1.8 Solar Farms - List of largest NZ solar installations known by Purpose Capital (installed, under construction, & proposed):

Prior to 2021 there was no large/utility scale land based solar farms in NZ. Now there is a groundswell of projects "proposed" signalling that solar is commercially viable in a New Zealand context. It's quite possible there are many other projects in the pipeline that aren't listed below.

1. Lodestone (PROPOSED) $300m 400GWh
2. 1000MW Total Future Investments by Far North Solar Farm Ltd over the next 5-8 years (PROPOSED)
   FNSF have several large-scale solar projects planned in Northland, including a power station on the outskirts of Kaitaia with 20ha of panels and an ever bigger solar farm with a 30ha panel area near Dargaville.
3. 500MW total Genesis Energy solar farm planned in North Island (PROPOSED). 300kw solar farm in the Northern Waikato to deliver 550 GWh p.a.
   Genesis Energy plans to build enough solar energy farms over the next five years to meet a little under 2 per cent of the country's current electricity demand. The company said it was finalising a joint venture with overseas solar firms to generate about 750 gigawatt-hours of solar p.a. "Solar makes sense on a number of levels and we believe there is an economic opportunity to develop utility-scale solar projects in New Zealand,"- Genesis chief executive Marc England
4. 26 MW solar farm at the Marsden Point Oil Refinery, (PROJECT ON HOLD)
5. 16MW Pukenui Farm by Far North Solar Farm Ltd, $30m, 12ha of panels on 15ha of land (UNDER CONSTRUCTION)
6. 10MW solar farm at Hawke's Bay Airport and Centralines planned next to the runway, expected to be operational by the end of 2021 (PROPOSED)
7. 2.1MW Kapuni, owned by Todd Corporation, system by Sunergise (May 2021)
   "It definitely proves that there is a case for large-scale solar farms in New Zealand, and that they can be economic," Sunergise general manager Paul Makumbe said. Makumbe said the company was constantly looking for new solar energy sites around the country.
8. 2MW Kea Energy Marlborough Solar Farm, $2.5m-$3m (March 2021)
9. 1MW Floating Solar, Watercare's Rosedale wastewater treatment pond (2020)

* Note: c.200MW - Name of party omitted for confidentiality reasons, this party has MoUs in place for c.200MW of ground mounted solar systems in NZ.

** Note: 350 MW - HES Aotearoa, a joint venture between Hive Energy, Ethical Power Group and Solar South West, that they hope will lead to 350 MW of utility scale installations in NZ, their NZ Project Pipeline below however it's unknown whether there is overlap with any of the solar farms mentioned above.

Country	Project Name	Technology	Location	Capacity (MW)
New Zealand	HES 1		Auckland	60
	HES 2		Manawatu	90
	HES 3		Timaru	32
	HES 4		Waikato	15
	HES 5		Ashburton	50
	HES 6		Selwyn	88

1.9 Commercial Rooftop Solar - List of largest NZ solar installations known by Purpose Capital (installed, under construction, & proposed):

1. 1.166MW Foodstuffs North Island Distribution Centre (FNI to install NZ's largest rooftop installation at April 2020), system by Reid Technology, 6,000m^2 of panels estimated to generate 1.5GWh p.a. & the building is 75,000m^2 (Jan 2020)
2. 524kW Laminex Hamilton rooftop solar array (Sept 2020)
3. 422KW Mainfreight Auckland Depot (NZ's largest rooftop installation at April 2020), system by Reid Technology, Mainfreight building is 20,000m^2 (2020)
4. 411KW Yealands Wines, Blenheim rooftop solar installation, 10% of day time baseloads. (2016)
5. 315KW A&G Price, Thames, rooftop solar installation (Nov 2019)
6. 240KW Tarewa Shopping Centre Whangarei, rooftop solar installation (2014)
7. 170KW Mainfreight Hamilton Depot (NZ's 2nd largest rooftop installation at the time), system by SolarKing, Mainfreight building is 18,400m^2 (2015)
8. 153KW Misco Joinery, Christchurch. The largest commercial solar installation in Canterbury at time of install. Estimated 16.1% return on investment. 65% of total electricity needs (May 2019)
9. 150KW Energyworks (Engineering company in New Plymouth), system by Sunergise (May 2021)

It is apparent from the installations mentioned above, most of which occurred during 2019-2021, that Rooftop solar is commercially viable in a New Zealand context. Foodstuffs, when commenting on their NI Distribution Centre have said that initially it was a bit of a cost-neutral, socially responsible move, but soaring commercial power costs over the last few months have made that decision look great in hindsight.

1.10 Conclusion

Common rhetoric in NZ is that solar is unviable & an uneconomical means of electricity generation, however the decade from 2010 to 2020 saw the cost of solar decrease by 85%, putting it on a par with wind as having the lowest LCOE over both renewable and non-renewable forms of generation. It is predicted that the cost of solar will continue to decline over the next 10 to 20 years. At ~50 *gCO2-e/kWh,* solar does have a lower carbon footprint than many other forms of generation, however it's acknowledged that from a full lifecycle 'cradle to grave' perspective, there is room for continuous improvements: in the manufacturing of the panels, and how the panels are handled at the end of their life.

PC concludes 'the future looks bright for solar in NZ'. Based upon the phase 1 solar sector scan, as well as an initial review of the recently received Lodestone IM, PC has requested approval to enter DD on the Lodestone opportunity.