PLANNING FOR GRID-SCALE SOLAR DEVELOPMENTS

Investigating potential impacts and community perceptions

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Planning for grid-scale solar developments in Central Otago: Investigating potential impacts and community perceptions

A research report submitted in fulfilment of the requirements for PLAN435/535 – Planning Case Study 2023

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Executive Summary

The world is experiencing a significant shift towards renewable energy sources, with solar energy emerging as a prominent player in the global energy transition. As concerns intensify over climate change and the finite nature of fossil fuels, governments, businesses, and individuals are increasingly recognising the potential of solar power to address both environmental and economic challenges. The transition to renewable energy is reshaping the global energy landscape and paving the way for a 'cleaner', more sustainable future.

Aotearoa-New Zealand has a target aspiration of achieving 100 percent renewable electricity by 2030. The increasing exploration for grid-scale solar development sites therefore comes as no surprise. In particular, the Central Otago District is experiencing a growing interest from private developers in the potential of grid-scale solar developments, due to favourable environmental conditions and expansive rural landscape. This presents new challenges for the Central Otago District Council, and other councils around the country, in grasping how to manage the infrastructure and land-use implications of grid-scale solar developments.

Research aim and objectives: The aim of the present research is to understand the solar conditions and infrastructure required to support grid-scale solar developments, and the benefits of a move towards grid-scale solar renewable energy in the Central Otago context.

To achieve the aim the following Research Objectives were conceived:

1. To investigate examples of grid-sized solar energy developments in Aotearoa-New Zealand and overseas;
2. To understand what environmental conditions, infrastructure and physical resources are needed to make a grid-scale solar energy development viable in Central Otago;
3. To consider the benefits and costs of grid-scale solar developments;
4. To consider the impact of a grid-sized solar energy development on a small rural community.

Methods: A mixed-method approach was employed to undertake the research. Both qualitative and quantitative methods were used, involving primary and secondary data collection. Primary methods included key informant interviews, photo-elicitation, GIS mapping, and survey

questionnaires, which were supported by secondary methods that encompassed a literature review and policy summary. The literature review illustrated relevant research on examples of grid-scale solar developments and identified research gaps. Policy summary familiarised the researchers with relevant policies associated with renewable energy generation and land-use change, and identified gaps specific to Central Otago's emerging solar sector. Key informant interviews involved planning practitioners, solar experts, landowners, and local residents to understand how solar farms are developed and people's perceptions of their impacts. The survey questionnaire gathered data on people's understanding, and degree of acceptance towards grid-scale solar developments in Central Otago.

Results and Discussion: The findings from the primary research were coded and five key themes were determined: site selection and infrastructure factors, potential impacts, community perceptions, landscape importance, and council and planning processes. Alongside that, GIS mapping and photo-elicitation results provided insights about suitable site locations.

***Objective 1*:** The literature review and policy summary examined case-studies of solar developments in both Aotearoa-New Zealand and overseas.

Objective 2: Findings from the research suggest that many areas of Central Otago meet the environmental conditions recommended for grid-scale solar farm development. The district is considered suitable because of sufficient solar radiance, minimal shade from topography, and limited impact from cloud coverage. Also, land with low productivity and the absence of viable alternative uses is ideal for solar farms, while challenges are posed by national policy restrictions for developing highly productive land. In relation to physical resources and infrastructure, transportation and connection to the national grid are crucial infrastructure requirements. Factors like proximity to substations, power line installation, and considerations of cost, visual impact, and rural character play pivotal roles. In addition, it should be noted that accessible connections to the national grid enhance feasibility of solar farm projects.

Objective 3: Environmental and economic costs and benefits were discussed on a ward scale, in relation to the lifecycle of grid-scale solar developments. During the construction phase, such projects present a mix of costs and benefits. From an economic standpoint, solar developments can provide employment opportunities, secondary economic gain for local communities, potential for further local development and investment, and upskilling of local workforce as part of a Community Benefit Agreement. However, there are notable environmental risks related to land fragmentation, habitat loss, soil decline, erosion, and the production of dust. In the operational phase, solar developments are characterised by positive economic impacts such as potential tourism, infrastructure upgrades, and economic diversification for landowners. There may be employment opportunities, but the number of Full-Time Equivalent positions may be specific to a particular development. During this phase the main environmental concerns include land fragmentation, water stress, and habitat loss. Furthermore, the potential for agrivoltaic systems to enhance environmental and economic outcomes is highlighted. The decommissioning phase raises uncertainties and knowledge gaps. Waste from panels and batteries were the major environmental issues discussed. The economic considerations include the costs of decommissioning and the responsibility for restoring previous land conditions. Therefore, it is important to plan for decommissioning from the inception of a solar development, and circular economy principles can help maintain value throughout the lifecycle. This report emphasises the need for extended producer responsibility and further consideration of decommissioning processes during the design phases.

Objective 4: The impact on rural communities was discussed in relation to Naseby, a small settlement in Central Otago. Various social impacts are identified regarding the different phases of a solar farm project. These impacts are categorised into eight key spheres: way of life, culture, community, political systems, environment, health, personal and property rights, and fears and aspirations. The most common effects anticipated throughout the construction, operation, and decommission phases are related to way of life, local culture, and community. Conversely, impacts on health, personal rights, fears, and aspirations are less prevalent. To understand the acceptance and approval of the Naseby Solar Farm, the researchers applied a Social License continuum that identified factors that contribute to project legitimacy, credibility, and trust. Furthermore, a Traffic Light Framework is used to evaluate costs, benefits, and *'game-changing'* factors in relation to social license for solar farm development in Naseby. The Social License framework integrates community uncertainty and perceptions about environmental effects, economic impacts, community engagement, and compatibility with individual and community worldviews. Importantly, this report acknowledged limitations in assessing cultural impacts, illustrating the need for stand-alone Cultural Impact Assessment and long-term relationship building with Indigenous communities.

Recommendations: The following recommendations have been devised from the analysis of the research outputs.

Recommendation One: Enable and manage solar developments through a policy framework.

The aim of this recommendation is to create a clear and consistent framework that facilitates the effective management and implementation of solar developments within the region. This framework should address the specific considerations and requirements for solar projects, such as land use, Environmental Impact Assessments, and community engagement.

Recommendation Two: Facilitate cross-industry opportunities for education.

The effect of this recommendation ensures communities can make informed decisions and actively engage in discussions related to solar development in Central Otago.

Recommendation Three: Promote partnership with mana whenua and transparency with the wider community.

This recommendation suggests that the CODC fosters transparency and open communication with local communities to ensure awareness and understanding of all potential future developments. Partnership with mana whenua, and involving them in decision-making processes, is imperative in respecting expectations and aspirations of local iwi.

Acknowledgments

Firstly, to the Central Otago District Council for outlining such an interesting a current issue for us to explore within the context of Central Otago. Thank you to Ann, Rebecca, and Paula for your help with recruitment and your guidance throughout the process. We would like to say a special thank you to those that gave their time to speak with us as well as joining us for dinner during field week and attending the presentation of our findings in Dunedin.

Secondly to all of our participants who gave their time either to complete our survey on the streets of Clyde, Alexandra, and Naseby, and those who allowed us into their homes and offices and shared their stories and perspectives through interviews. Without these people this research would be meaningless.

We would also like to say a big thank you to the Master of Planning staff who contributed to the PLAN435/535 paper, namely Professor Michelle Thompson-Fawcett and Jay Sinclair for coordinating the paper, providing ongoing support and advice, and managing to get us to Central Otago for field week. Also, thanks to Robyn and Liz for administrative support, Chris Garden the GIS whizz, and Cassino Doyle for accompanying us on field week and providing expertise and laughs.

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List of Abbreviations

CIA – Cultural Impact Assessment

CODC – Central Otago District Council

COP26 – United Nations Climate Change Conference 2021

CSP – Concentrated Solar Power

EECA – Energy Efficiency and Conservation Authority

EIA – Environmental Impact Assessment

GHG – Greenhouse Gas

GIS – Geographical Information Systems

HPL – Highly Productive Land

IA – Impact Assessment

KI – Key Informant

MBIE – Ministry of Business, Innovation and Employment

MW – Megawatts

MfE – Ministry for the Environment

NES-ETA – National Environmental Standards for Electricity Transmission Activities 2009

NIWA – National Institute of Water and Atmospheric Research

NPS-ET – National Policy Statement on Electricity Transmission 2008

NPS-FM – National Policy Statement for Freshwater Management 2020

NPS-REG – National Policy Statement for Renewable Electricity Generation 2011

NRMP - Kāi Tahu Ki Otago Natural Resource Management Plan 2005

ORC – Otago Regional Council

PORPS 2021 – Proposed Otago Regional Policy Statement 2021

PV – Photovoltaic Systems

REG – Renewable Energy Generation

RMA – Resource Management Act 1991

RPS – Partially Operative Otago Regional Policy Statement 2019

SDGs – Sustainable Development Goals

SIA – Social Impact Assessment

SLO – Social License to Operate

SR – Survey Respondent

Kupu Māori – Glossary of te reo Māori vocabulary

The report-writers adopt the Kāi Tahu dialect for the kupu Māori that appear in this report, except for names of organisations.

(te) Ao Māori	The Māori world, Māori worldview
Hapū	Tribe, subtribe, kinship group; the primary political unit in Māori society, comprising whānau descending from a common ancestor
Iwi	Tribe, extended kinship group
Kāi Tahu, Kāi Tahu whānui	The iwi (extended kinship group) descended from the tūpuna Tahu Pōtiki
Kaitiakitaka	Stewardship, guardianship (approximation)
Mahika kai	Traditional food-gathering.
Mana whenua	Indigenous people holding and exercising customary authority over an area, passed down through whakapapa, and in accordance with tikaka.
Māniatoto	The correct Kāi Tahu spelling for Maniototo Ward.
Murihiku	The traditional Kāi Tahu name for the area now referred to as Southland.
(kā) Papatipu rūnaka	Hapū council based on traditional area of authority. Kā papatipu rūnaka are recognised in Te Rūnanga o Ngāi Tahu Act 1996.
Tākata whenua	Indigenous people; people of the land
Takiwā	Region, territory of tribal authority
Taoka	Treasure
Te Waipounamu	South Island of Aotearoa-New Zealand
Tikaka Māori	Māori custom, law, and traditions

1.0 Introduction

"Solar energy helps keep household power bills lower, and delivers economic and environmental benefits across the region and nationally."

– Rt Hon Chris Hipkins, 14 April 2023

In April 2023, Prime Minister Chris Hipkins announced that a series of large-scale solar energy projects were to proceed through the Fast-Track Consenting Process. Six months earlier, the International Energy Agency (2022) had declared solar-photovoltaic electricity to be the world's most affordable, with manufacturing and supply costs at their lowest in history. Since the ratification of the Paris Agreement (2015), governments have sought to accelerate their transition to renewable energy generation (REG). For Aotearoa-New Zealand, renewable energies such as hydropower and geothermal have featured in the landscape since the twentieth century, with the market dominated by state-owned or mixed-ownership utility providers like Meridian Energy. Yet nationally, renewable energy supply has not kept pace with demand, as nearly two-thirds of broader energy use still relies on fossil fuels (MBIE, 2022a). Hydropower represents 60 percent of the country's renewable capacity and has caused prominent landscape changes in Te Waipounamu (Trixl & Lloyd, 2022). Along with the emergence of wind-power, large-scale renewable energy developments introduce complex planning issues associated with siting, environmental impacts, and public concern. The New Zealand Planning Institute (2023) recognises that utility-scale solar is set to take an increasing share of the renewable energy market, given the government's ambitious target of 100 percent REG by 2030 (MBIE, 2022a).

Across Aotearoa-New Zealand, there are approximately 160MW of grid-connected solar power, which represents some 0.5 percent of the total power supply. As prices fall for the purchase and installation of residential solar-photovoltaic (PV) panels, international and domestic investors are turning their attention to solar-farm development (Cardwell, 2022). In 2022, 78 percent of actively-pursed projects were for solar developments, overwhelmingly led by international companies (Electricity Authority, 2022). Areas like Central Otago – characterised by low population-density and high insolation – are set to be key targets for utility-scale solar development (Fraser & Chapman, 2018). Utility-scale solar farms utilise an array of PV panels (Figure 1) that inverters connect power back into the national grid. The efficiency of

Figure 1. A render of solar-photovoltaic (PV) farm proposed for Kaitāia. (Source: Lodestone Energy, 2022)

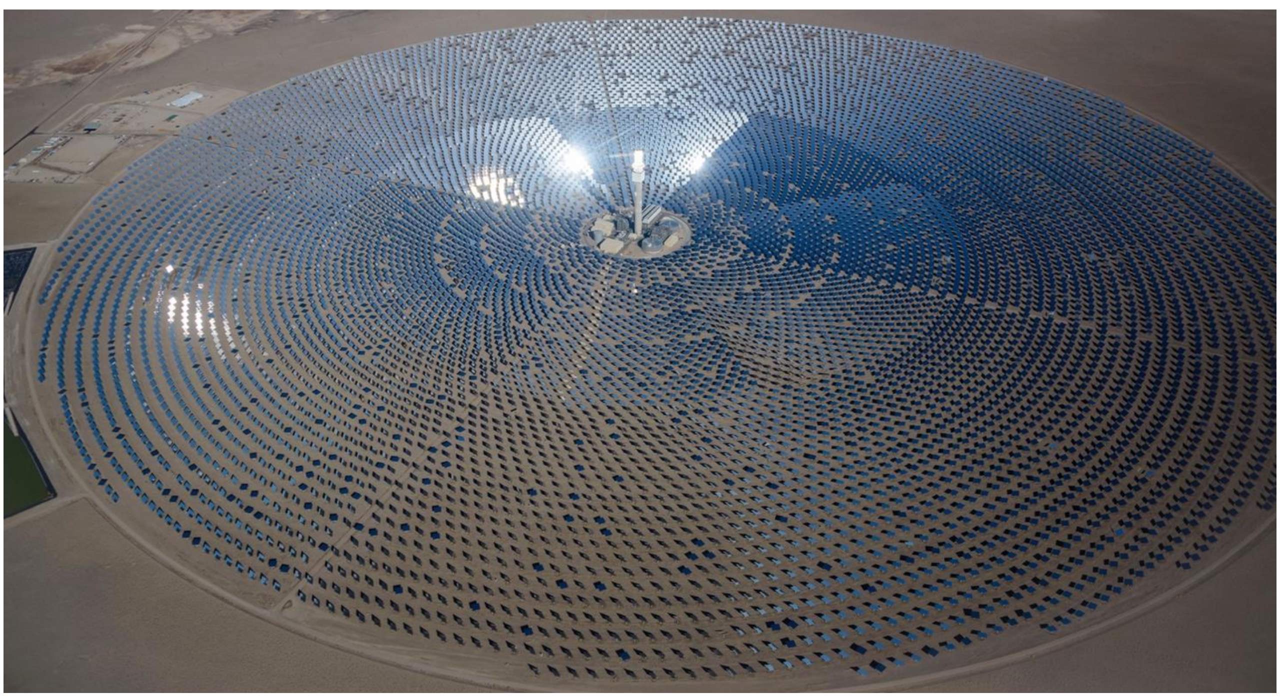


Figure 2. Concentrated Solar Power (CSP) installation in Tonopah, Nevada (Source: US Department of Energy, 2018).

the array directly proportional with the size of the installation (EECA, n.d.). Concentrated Solar Power (CSP) is another form of solar-electricity generation that utilises mirrors or lenses to concentrate energy into a receiver, as shown in Figure 2. Arrays of CSP have not been proposed in Aotearoa-New Zealand and fall outside the scope of the present report.

1.1 Research Problem

Solar farms are a relatively recent phenomenon in Aotearoa-New Zealand. There are few domestic examples of utility-scale solar farms and their implications; the recent interest expressed by developers in Central Otago raises questions about how District Councils ought to interpret REG policy in their plan review, and how REG policy may interact with national policy that seeks to protect food-producing soils from land-use changes (Parker & Quinn, 2022). Furthermore, it is unknown the extent to which solar farms will generate public opposition and unfavourable social impacts, as compared to Central Otago's experience with the proposed Project Hayes wind-farm and the High Court litigation that followed (*Meridian Energy v CODC and others*, 2009).

1.2 Interpretation of the Brief

The research brief was provided by the Central Otago District Council (CODC). The brief acknowledges the resource consent recently granted to Solar Bay for their solar farm venture at Fennessy Road, Naseby (hereafter referred as Naseby Solar Farm). Given the successful application by Solar Bay, the report-writers do not intend this report to duplicate an Assessment of Environmental Effects (AEE) as under the Resource Management Act (RMA). Instead, this report takes a strategic view on the potential future interest in utility-scale solar farms in Central Otago regarding siting, positive and negative environmental and economic impacts, and how small rural settlements may be affected by land-use change near them. The report-writers also acknowledge that while the development has received resource consent, there may be commercial contingencies in whether the development proceeds to construction.

1.3 Aim and Research Objectives

The aim of this research is to understand the solar conditions and infrastructure required to support a grid-scale solar developments, and the benefits of transitioning towards grid-scale solar renewable energy in the Central Otago context.

In support of this aim, the researchers devised the following four Research Objectives:

1. To investigate examples of grid-sized solar energy developments in Aotearoa-New Zealand and overseas;
2. To understand what environmental conditions, infrastructure and physical resources needed to make a grid-scale solar energy developments viable in Central Otago;
3. To consider the benefits and costs of grid-scale solar developments;
4. To consider the impact of a grid-sized solar energy development on a small rural community.

The researchers adopt the Kāi Tahu dialect for the te reo Māori vocabulary that appears in this report, including the correct spelling of place-names such as Māniatoto (often rendered as 'Maniototo').

1.4 Research Methods

The research in this report was delivered through a mixed-methods approach. Incorporating both qualitative and quantitative methods ensures that the limitations of one approach can be balanced by the strengths of another (Hay & Cope, 2021). The secondary methods used in this research include a literature review, and analysis of relevant regulatory documents. The primary qualitative methods included semi-structured interviews and photo-elicitation with a range of Key Informants. Primary quantitative methods comprised a survey-questionnaire, and Geographic Information System mapping (GIS).

This research incorporates both pragmatist and interpretivist paradigms, to guide the processes of inquiry (Kitchin & Tate, 2000). The first three Research Objectives were guided by pragmatist and interpretivist inquiry, used to gain insights from research participants about environmental indicators and siting conditions that the researchers could then compare to academic scholarship and policy documents. For the fourth Research Objective, the researchers employed a modified version of the grounded theory paradigm to shape the pragmatic approach. Grounded theory utilises inductive learning to understand emerging issues, where researchers immerse themselves in specific local contexts (Chang & Huang, 2022). This approach has been used previously to assess community perceptions and impacts of renewable energy infrastructures (Pedersen et al., 2007), and in the present study was used to glean the Naseby community's perceptions of impacts associated with the Naseby Solar Farm. Community perceptions were then compared against the expected impacts of these developments in Central Otago, allowing the researchers to propose a framework for recommendations. A comprehensive explanation of methodology is provided in Chapter 5 of this report.

1.5 Report Structure

The series of chapters used throughout this report is outlined below:

Chapter 1: An introduction that outlines the context of the research project.

Chapter 2: An overview of the Central Otago district and Naseby area, to focus on social, geographic, economic, and energy-generation matters relevant to utility-scale solar farms.

Chapter 3: A review of the relevant academic literature that establishes the conceptual base for the niche of this project.

Chapter 4: A review of national policy, statutory plans and strategic documents to identify policy guidance and regulatory gaps that are pertinent to grid-scale solar developments.

Chapter 5: An outline of the research methodology used to gather primary and secondary data through quantitative and qualitative methods.

Chapter 6: The results and findings obtained by GIS mapping and photo-elicitation.

Chapter 7: The results and findings obtained through key informant interviews and survey questionnaires.

Chapter 8: A discussion of the research results, analysed against academic scholarship and the policy framework. This chapter addresses each Research Objective in turn.

Chapter 9: A set of three recommendations to the Central Otago District Council, informed by the analysis in Chapter 8.

Chapter 10: A conclusion that summarises the research project and the extent of its contribution to the research aim and objectives.

2.0 Context

This chapter provides an overview of the Central Otago study area, including discussion of the district's geography, territorial jurisdiction, and wider social, economic and cultural aspects of Central Otago. The chapter then addresses the energy context of the district, including existing infrastructure and land-uses, to situate the emerging role of utility-scale solar generation. The section concludes with an overview of Naseby as the report's primary case-study area.

2.1 Central Otago Context

2.1.1 Geographic Context

Located in the lower South Island, Otago is Aotearoa-New Zealand's second largest region, encompassing a variety of landscapes from rugged coastlines to large mountain ranges and alpine lakes. The region comprises five districts: Clutha, Dunedin, Queenstown Lakes, Waitaki, and Central Otago. Figure 3 below outlines the boundary of the Central Otago District. Central Otago is the most inland district in Aotearoa-New Zealand, spanning approximately 10,000km^2. Landscapes include mountain ranges, fast-flowing alpine rivers, lakes, extensive flat plains, and sheltered alpine valleys. Hot, dry summers and cold, dry, and frosty winters are characteristic of Central Otago's inland location. Central Otago is the country's driest region, often registering less than 400mm of annual rainfall (Macara, 2015). Its four electoral wards include Cromwell, Māniatoto, Teviot Valley, and Vincent (CODC, 2022).

2.1.2 Social Context

The census data available for the Central Otago district estimates the district population at close to 22,000 people, an increase of 20.4 percent since the 2013 count (Statistics NZ, 2018). The district is expected to continue to grow to a total population of approximately 28,000 by 2043, with the proportion of residents aged 65 and over expected to reach 45 percent in the next decade (CODC, 2020). Central Otago has one of Aotearoa-New Zealand's lowest population densities, and population growth is likely to concentrate in Cromwell and Vincent Wards, whilst populations of Māniatoto and Teviot are expected to remain static (CODC, 2019). Approximately 90 percent of the population is of Pākehā/NZ European descent, and 8 percent identify as Māori (CODC, 2020).

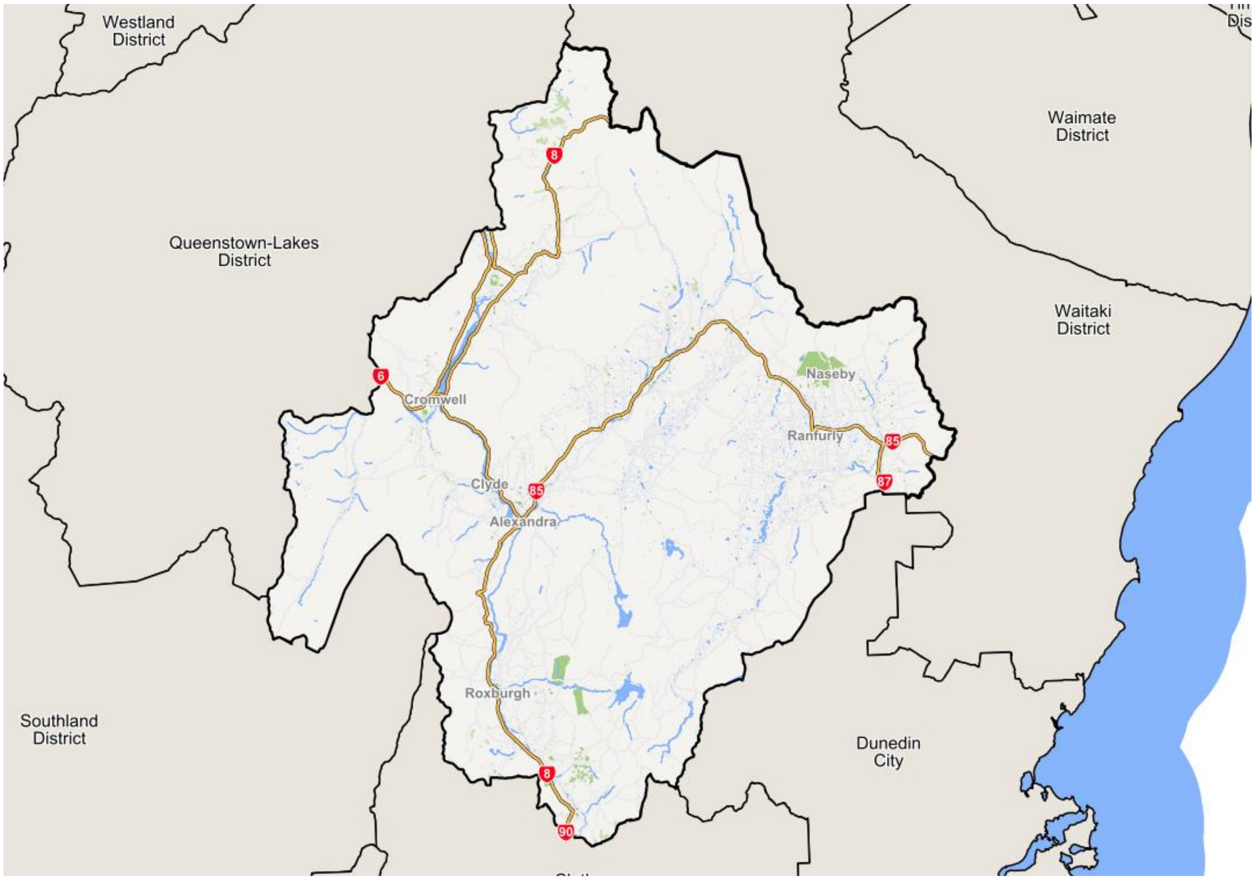


Figure 3. Boundaries of Central Otago District Council (Source: CODC GIS Maps, n.d.).

2.1.3 Economic Context

Historically, the Central Otago district has drawn benefit from gold-mining, with many small townships and businesses characterised by their mining heritage. The rich history of the mining towns situated throughout Central Otago have provided a key stepping-stone for the economic development of the district, also attracting in-migration from other parts of the country (CODC, 2019). The main economic drivers for Central Otago are highly seasonal: farming, horticulture, viticulture, and tourism (CODC, 2019; 2020). Due to labour-market pressures associated with seasonal work, low wages, and low affordability for accommodation, the CODC (2019) has recognised difficulty in competing with other districts for attracting and retaining skilled workers.

2.1.4 Cultural Context

As follows, the Kāi Tahu ki Otago Natural Resources Management Plan (NRMP) describes the Indigenous history of Te Waipounamu and Central Otago (NRMP, 2005). Ancestry to Waitaha and Kāti Mamoe are traced in the wider net of kinship that formed Kāi Tahu. Three Otago papatipu rūnaka represent mana whenua in Central Otago: Ōtākou, Kāti Huirapa ki Puketeraki and Hokonui Rūnanga share interests in the interior lands, lakes, and waterbodies. Interests in the Mata-au (Clutha) and interior are also shared with Ngāi Tahu ki Murihiku. It should be noted that in December 2022, the four Murihiku Rūnaka signed a Memorandum of Understanding with Meridian Energy to collaborate on a number of renewable energy projects in the region (Meridian Energy, 2022).

The interests of Kai Tahu hapū are recognised in statutory acknowledgments and tōpuni in the Ngāi Tahu Claims Settlement Act 1998. This statute followed the Kāi Tahu land claim (Waitangi Tribunal, 1991). An overview of the cultural policy context is provided at Chapter 4.

2.2 Research Location – Naseby, Māniatoto Ward

2.2.1 Geographic Context

Naseby is the central case-study of the present research. Naseby is located in the Māniatoto Ward of Central Otago, at an altitude of approximately 610 metres (Figure 4). Adjacent to the township is the privately-owned Naseby Forest: an area of larch and pine on the former sluiced ground of the old goldfield, that now provides mountain-biking and walking tracks (CODC, n.d.). The wider Māniatoto is located between the Rough Ridge and Rock and Pillar Ranges, with the Kakanui and Hawkdun Mountains towards the north of the valley. Māniatoto is characterised by its flat basin, low rainfall, dryland, and tussock grassland ecosystems, making it sympathetic to pastoral agriculture (CODC, 2007; LINZ, 2002).

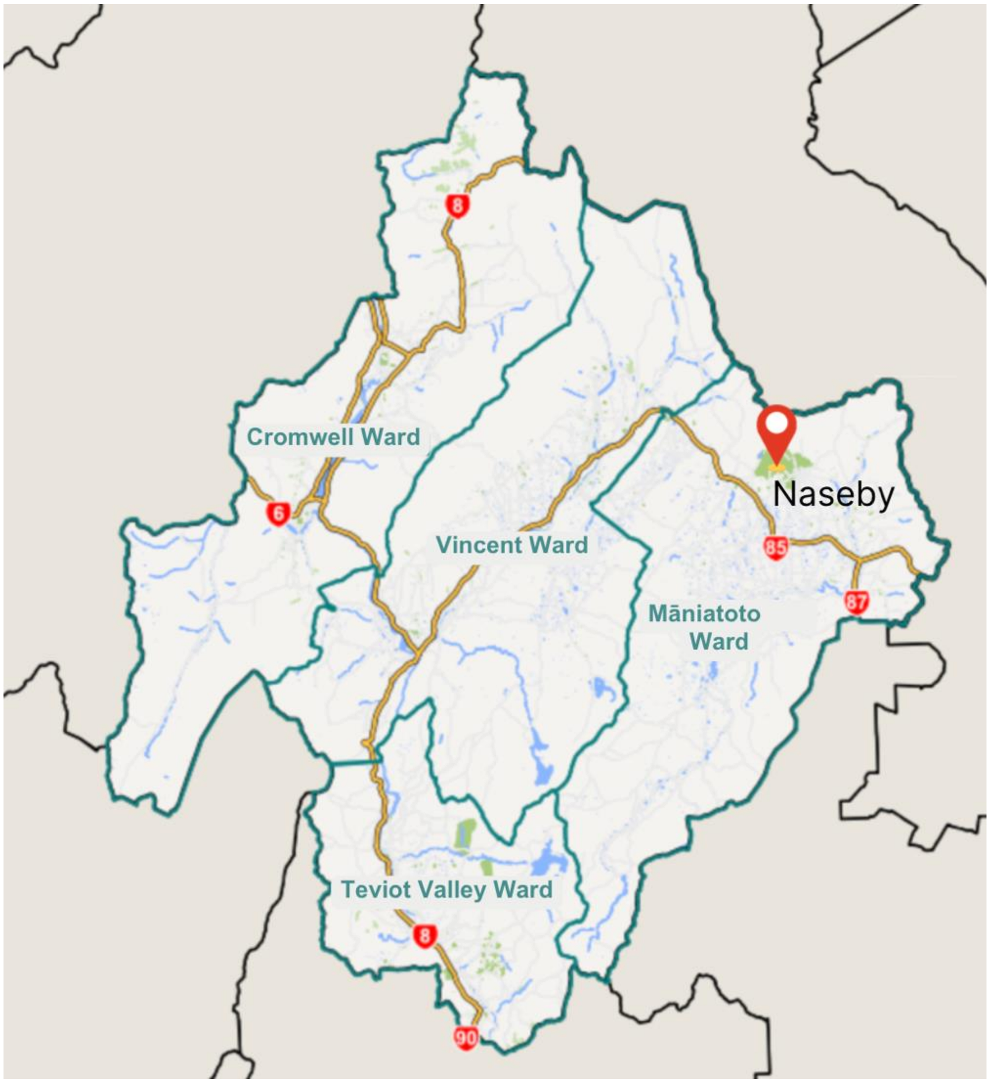


Figure 4. Location of Naseby, Māniatoto, and ward boundaries (Source: CODC GIS Maps, n.d.).

2.2.2 Social and Economic Context

Published estimates show Naseby's population to be around 125 permanent residents, and the population can swell to up to 6,000 people in the summer months due to holiday-makers, recreational opportunities, and Naseby's Curling Rink (CODC, 2006). Community-members largely represent retirees, farming families, and holiday-home owners. Land prices in Naseby have inflated over the last three decades, which has been attributed to investment and in-migration to Central Otago and Queenstown Lakes (CODC, 2006). Primary economic activities centre on pastoral farming and forestry. In 2022, the Gross Domestic Product (GDP) for the wider Māniatoto registered nearly 4 percent lower than the national GDP, reflecting a slower rate of growth (2.4

percent) for the last decade than the national average of 3 percent (Infometrics & CODC, 2022). Farming was predictably the biggest contributor to Māniatoto's economy in 2022 (21.6 percent). It should be noted that professional and technical services, and real estate, came in second and third respectively (Infometrics & CODC, 2022).

2.3 Energy Context

2.3.1 Energy Generation and Consumption in Aotearoa-New Zealand

As of 2022, 82 percent of Aotearoa-New Zealand's electricity was generated via renewable sources such as wind, dammed hydropower, solar and geothermal (MBIE, 2022a; Trixl & Lloyd, 2022). Despite historical records showing that Aotearoa-New Zealand occasionally produced 90 percent or more of its electricity from renewable sources – most recently in the 1970s and 1980s – achieving this level again could be challenging (Palmer & Grinlinton, 2014). Due to low lake levels, low-flow conditions and falling natural gas production in 2021, coal-generated electricity grew by nearly 30 percent in the same period; and around 60 per cent of broader energy use around the country relies on fossil fuels (MBIE, 2022a; Trixl & Lloyd, 2022).

Hydroelectricity holds the biggest share of electricity generation in Aotearoa-New Zealand, estimated at up to 60 percent of capacity (MBIE, 2022a). Geothermal generation actuates to 18 percent of national electricity production, largely concentrated in the Taupō Volcanic Zone (EECA, n.d.). Wind power supplies between 5 and 6 percent of total electricity; since the first wind power infrastructure was constructed in 1997, most generation is concentrated in the North Island (MBIE, 2023b). As of 2022, solar energy comprised 0.5 percent of electricity generation, but is expected to take up to 6 percent of market share come 2040 (EECA, n.d.). The remainder of electricity is generated by the combustion of coal, oil, and gas. There are over 20 oil and gas fields in Aotearoa-New Zealand, all of which are located onshore and offshore in the Taranaki region (MBIE, 2022a).

Dominant utility providers in the Aotearoa-New Zealand market include Meridian Energy, Genesis, and Mercury Energy, which rely primarily on hydroelectricity generation. These retailers were formerly State-Owned Enterprises under the eponymous 1986 legislation, but are now mixed-ownership companies pursuant to 2012 legislation.

2.3.2 Solar Power

The Ministry of Business, Innovation and Employment (2022) expects solar electricity to take a greater market share in coming decades, through both utility-scale and residential installations. The established utility providers are entering the solar market: Meridian has announced plans to develop a solar park at Ruakākā (Whangārei), whilst Genesis and Manawa have also announced partnerships for delivering utility-scale solar farms (Cardwell, 2022). Yet private investors and international joint-ventures such as Helios Energy are the main drivers of current utility-scale solar developments. Nine private-sector solar farms are scheduled through the COVID-19 Recovery (Fast-track Consenting) Projects Order 2020. These include Tauhei Solar Farm in Waikato (Harmony Energy); and Ōpunake Solar Farm (Energy Farms Ltd).

2.3.3 Energy Generation in Central Otago

As of 2023, grid-connected energy generation in the Central Otago district is dominated by hydroelectricity power stations and one windfarm (Table 1). The Clyde Dam is the nation's third-largest hydroelectric dam, with capacity to produce 432 MW of power (Contact Energy, 2023). Due to variability of water levels in Central Otago's hydro-electric lakes, a large amount of redundancy has been in-built to national grid infrastructure, providing further capacity from other renewable sources without requiring major transmission re-wiring (Dawber & Drinkwater, 1996). Recent transmission-line upgrades were completed for Central Otago and Naseby via the Fast-Track Consenting Order 2020.

2.4 Naseby Solar Farm – Solar Bay Ltd.

Solar Bay's Naseby Solar Farm received land-use consent in early 2023 for a location at Fennessy Road, in the outskirts of Naseby on the Māniatoto basin. The consented development will span 54 hectares and 80,000 photovoltaic panels. The solar farm will be constructed in phases and will provide for the landowner to graze sheep underneath. As indicated in Figure 5, the host property is adjacent to a substation, as well as a space radar and forestry operation. Figures 6, 7, and 8 are images that depict the substation and space radar that the solar panels will surround.

Table 1. Sites of renewable electricity generation in Central Otago

Name	Generation type	Company
Patearoa Power Station	Hydro	Manawa Energy
Paerau Power Station	Hydro	Manawa Energy
Roxburgh Hydro-dam	Hydro	Contact Energy
Clyde Hydro-dam	Hydro	Contact Energy
Upper Fraser Power Station	Hydro	Pioneer Energy
Talla Burn Power Station	Hydro	*Private**
Kōwhai Power Station	Hydro	Pioneer Energy
Horseshoe Bend	Wind	Pioneer Energy

* *–Talla Burn Generation Ltd. (local enterprise)*

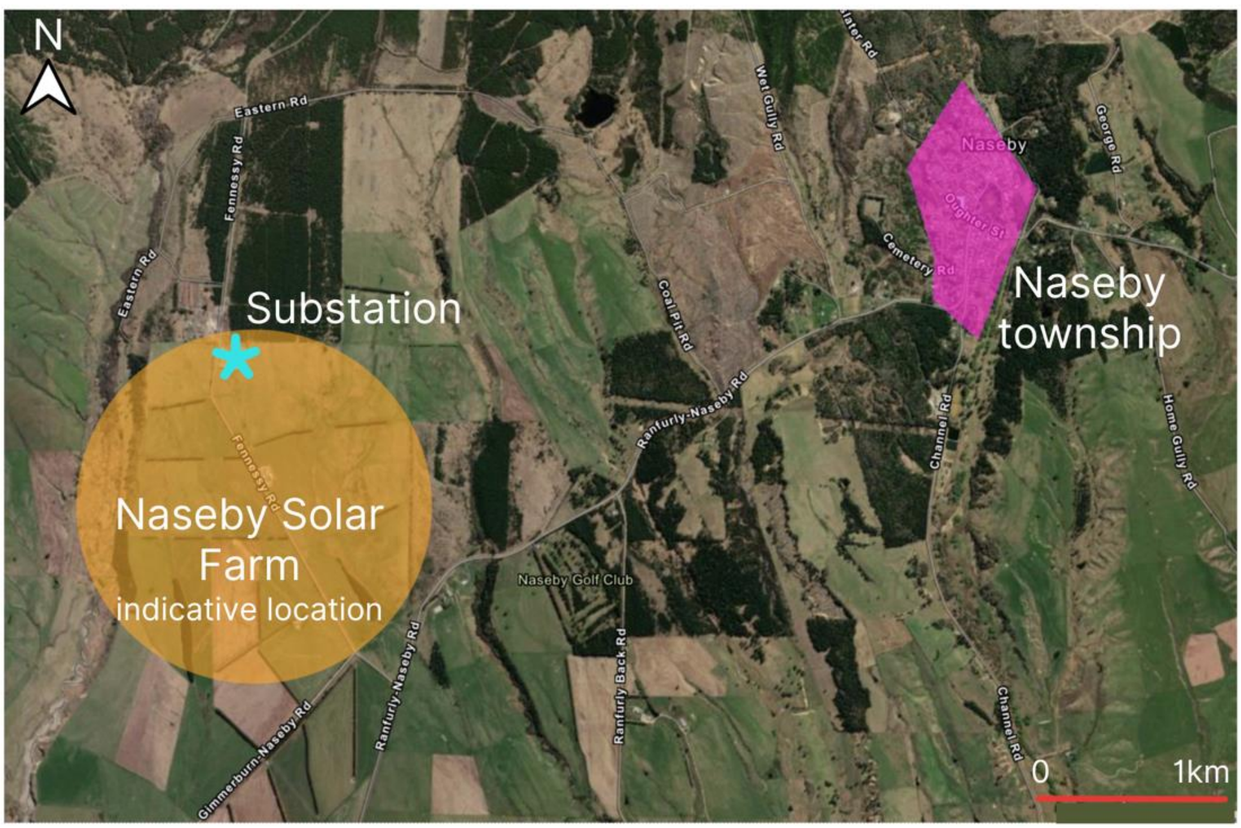


Figure 5. Indicative location of Naseby Solar Farm (orange) in relation to Naseby township (pink) (Source: Authors' own, 2023).

Figure 6. Image of substation and surrounding land in Naseby (Authors' own, 2023).

Figure 7. Image of substation in Naseby (Authors' own, 2023).

Figure 8. Image of Naseby space radar (Authors' own, 2023).

2.5 Summary

Within the takiwā of Kāi Tahu, present-day Central Otago is characterised by agricultural land-use, low population density, and ageing population demographics. The hydroelectricity stations in the district provide a large contribution to Aotearoa-New Zealand renewable energy capacity. Nationally, there is increasing energy demand and concomitant impetus towards transitioning from fossil-fuel-dependent industries. These factors have paved the way for domestic and off-shore investors to pursue solar-farm development in Central Otago, including Solar Bay's Naseby project.

3.0 Literature Review

This chapter traverses three key areas of academic literature. The first section focusses on international sustainability and policy drivers for renewables energy transitions. The second covers literature on substantive and procedural social impacts of solar energy transitions, before exploring concept of Social License to Operate (SLO). The third section examines economic and environmental impacts from grid-scale solar developments and agrivoltaic systems. The literature review concludes with four case-studies of grid-scale solar farm development.

3.1 What's Behind the Shift to Solar Farms?

3.1.1 Low Impact Energy Developments

Globally, the energy system has evolved through time with the influence of a range of material and contextual factors; from resource inputs and resource constraints to external supply-and-demand challenges (Gambhir, 2019). These factors encompass what is known as a 'shift' to renewable energy systems such as solar, wind, and hydropower (Stephenson et al., 2018). Renewable and sustainable energy systems have become more prominent with time, as a reflection of the growing concerns with global sustainability and increasing demand.

Current energy systems are heavily reliant on the utilisation of fossil fuels (Dhar et al., 2020). Fossil fuel-based energy is inevitably a short-term and unsustainable source of energy which does not provide security, or environmental benefit (del Río & Burguillo, 2008). In the late twentieth century, concerns with the finitude and environmental impact of coal and nuclear power led scholars to characterise these energies as a "hard energy path" (Lovins, 1978; Morrison & Lodwick, 1981). The energy sector's reliance on fossil fuels contributes to higher rates of greenhouse gas (GHG) emission and does not promise access to energy for future generations (Dhar et al., 2020). There is large uncertainty around the longevity of fossil fuel-based energy, and its ability to keep pace with global energy demand – thus giving further impetus for states and sectors to facilitate transition from carbon-intensive fuels to a more mixed energy system that includes renewable sources (Dhar et al., 2020). Low-impact energy developments present an alternative to fossil-fuel based energy systems, meeting the over-arching imperative to eliminate GHGs and attempt to limit global warming to 1.5 degrees (Davidson, 2019; Lisitano et al., 2018).

Not only do low-impact energy developments limit rates of GHG emission, but they also contribute to the sustainable development of cities, as well as the diversification and security of energy supply (del Río & Burguillo, 2008; Chapman et al., 2021). del Río and Burguillo (2008) state that an uptake in renewable energy sources enhances development opportunities within regional and rural areas, while creating employment opportunities. By diversifying the energy supply market and establishing energy supply security, the energy system transforms to be more sustainable in the long-term (del Río & Burguillo, 2008). In addition, energy systems that transition to low-impact renewables provide a means to combat environmental and social issues related to energy, for present and future generations. Sutherland et al. (2015, p.1543) characterised this as "multi-regime interaction". Renewable energy sources such as solar and wind are becoming more widespread and more technologically efficient, holding promise for accessible, secure, and sufficient supplies of energy (Dhar et al., 2020). Therefore, low-impact renewable energies are preferable to governments and authorities seeking a viable long-term response to energy management. This is what Lovins (1978) and Morrison and Lodwick (1981) have contrasted as a "soft energy path". 'Soft' paths are characterised by diversified energy resources, achievable climate targets, and energy industries which hold opportunity for employment (Burke & Stephens, 2018; Dhar et al., 2020).

Issues of sustainability, carbon emissions, security, and market price fluctuations have placed pressure on energy sectors to shift towards renewables (Tawalbeh et al., 2021). Importantly, Bridge et al. (2013) point out that social and geographical change commonly underpin the shifts seen in the energy sector. Historically, social change through periods of industrialisation, increase in consumer markets, and urbanisation have ultimately changed the way energy is produced and utilised (Bridge et al., 2013). The same can be said for the present day, where the implementation of climate-related policies, technological advances, and changes to the relative cost of renewable energy developments are drivers of the increase uptake in 'greener' and 'smarter' ways of supplying energy (Stephenson et al., 2018). A multitude of government authorities have set climate targets and GHG emission constraints, in turn promoting and facilitating uptake of renewable energy sources (Gambhir, 2019). With time, increased environmental awareness has led to implementation of stricter environmental regulation and guided the introduction of alternatives into the energy sector – largely consisting of renewable sources with alternatives for energy distribution and ownership (Tawalbeh et al., 2021; Burke & Stephens, 2018).

The concept of Sustainable Development has been an organising principle for national and international policy since the 1980s. In particular, the 1987 Bruntland Report led to the institutionalisation of Sustainable Development at the 1992 Rio Conference, which promoted a global shift to renewable energy sources (Chapman et al., 2021; Sutherland et al., 2015; Tawalbeh et al., 2021). Lisitano and others (2018) observe that urbanisation is another factor that drives the initiative for sustainable practices and development, particularly through outlook on national policy, law, and energy planning.

Many governments are concerned with the management and provision of reliable and accessible energy, where heightened demand for energy cannot be met through fossil-fuel based energy systems (Chapman et al., 2021; Sutherland et al., 2015). Chapman et al. (2021) mention the Sustainable Development Goals (SDGs), and how the SDGs specifically target the future development of how energy is supplied, maintained, and utilised. Under the SDGs, Goal 7 states the need for clean energy where "universal access to affordable, reliable, and modern energy services" is provided in combination with a "substantial increase in renewable energy within the global energy mix". Other SDGs encompass climate and energy concerns, namely Goal 13 which advocates for climate action – thereby further justifying the need for low-impact energy transitions (Chapman et al., 2021).

3.1.2 Zero Carbon Futures and Energy Transitions

For Chapman et al. (2021) and Sutherland et al. (2015), the main driver for transitions into renewable energy is to prevent global temperature rise and avoid detrimental effects of climate change. Large-scale development in the renewable energy sector makes it more likely that states will achieve such carbon emission goals, as well as mitigate climate change-induced challenges (Gambhir, 2019). Improved energy efficiency also makes it feasible to achieve a low- or zero-carbon future that can be sustainable for future generations (Chapman et al., 2021). Renewable energy sources create potential for a range of positive social and environmental outcomes that align with climate targets and the SDGs (Chapman et al., 2021). However, similar to the multi-regime transition encouraged by Sutherland et al. (2015), Burke and Stephens (2018, p.89) also point out the relevance of social context and social impact in renewable energy transitions:

> *"[t]he renewable energy transition is not simply a race against climate change nor primarily about substitution of fuel sources. […] However, climate mitigation requires a broad set of strategies including reducing fossil fuel investments and subsidies, lowering of aggregate consumption levels, and changing land use practices; strategies that may yield greater short-term social and environmental benefit than rapidly deploying renewables."*

In sum, renewable energy sources provide an answer to current and future demands for energy, whilst maintaining constraints on GHG emissions and following climate target policies (Gambhir, 2019). There is clear correspondence between the proliferation of renewable energy systems, and decreasing rates of carbon emission, indicating that renewable sources of energy are necessary to reach a zero-carbon future (Lisitano et al., 2018; Walker et al., 2021). The transition into sustainable and renewable forms of energy is steadily becoming the mainstream position. They can be regarded as the first step to complying with climate targets and climate policies (Burke & Stephens, 2018; del Río & Burguillo, 2008).

3.2 Community and Social Impacts

3.2.1 Types and Scale of Social Impacts in Renewable Energy Developments and Transitions

Social impacts may be broadly defined as the consequences upon human populations of any public or private actions that affect the way that people live their lives, or meet their needs (Burdge et al., 2003; Vanclay, 2003). Social impacts flowing from such public or private interventions may be intended or unintended; and may affect people directly or indirectly (Vanclay, 2003). According to Burdge et al. (2003), social impacts include cultural impacts upon norms, values, and beliefs. With the breadth of potential impacts that this definition can cover, assessing social impacts of solar and other renewable energy infrastructure has been described as complex (Terrapon-Pfaff et al., 2017). Impacts on social equity remain the least easily quantified and understood (Fraser & Chapman, 2018).

Due to the rationale that low-impact energy transitions support sustainable development (Chapman et al., 2021), scholars and policy-makers necessarily speculated that renewable energies, as a 'soft energy path', would produce more desirable social impacts than the so-called 'hard energy' paths of fossil fuels (Lovins, 1978; Morrison & Lodwick, 1981). Accordingly, Lovins (1978) proposed a five-limb typology of social impacts for 'soft' energy systems: (1) general system impacts; (2) socio-political impacts, including governance, equity, and international dimensions; (3) economic impacts; (4) quality of life impacts; and (5) environmental impacts. Building on Lovins' (1978) typology, authors such as Vanclay (2003) and Larsen et al. (2018) have accepted that social impacts are changes to one or more of the following spheres, summarised in Figure 9.

Figure 9. Typology of the spheres of social impacts (Adapted from Vanclay, 2003).

Alike sustainable development literature, this multi-factor typology can emphasise the personal, temporal, and scalar implications of large-scale energy interventions (del Río & Burguillo, 2008; Fraser & Chapman 2018). Yet it is important to consider that while renewable energy developments may be characterised by their "'green' characteristics", these "do not guarantee positive public views and support in all places and at all times" (Walker, 1995, p.50). Morrison and Lodwick (1981) noted that different communities could be 'vulnerable' to some social impacts and not others.

Furthermore, Morrison and Lodwick (1981) stressed that social impacts of energy developments will be experienced differently at the local scale to the national or global scale; what they label the "micro-macro continuum" (p.365), in which impacts range from personal attitudes to socio-structural organisation. It follows that a localised focus on social impacts can "incorporate environmental and economic impacts in as far as they are experienced and perceived by a local community" (Berka & Creamer, 2018, p.3401). In general, a subnational geographic focus will exclude social impacts pertaining to national-scale effects on electricity price, or emission-reduction targets (Berka & Creamer, 2018; Fraser & Chapman, 2018).

Due to spatial variation in regulation and rents for energy development, Harvey and Bice (2014, p.327) argue that "the distribution of local benefits and costs has been highly variable". Several studies have observed that whilst benefits of energy resource development accrue at national and global levels, the social costs are most frequently borne by local communities who have little "bargaining power" with capital-rich private companies who seek rural land (Fraser & Chapman, 2018, p.138; Harvey & Bice, 2014; Larsen et al., 2018). Despite the national-local split across a range of benefits and costs, renewable energy developments have generally "not reached the status of locally unwanted land uses," in the same way that extractive or nuclear technologies have been contested (Walker, 1995, p.57).

3.2.2 Publics – Defining Who Experiences Social Impacts

Social impacts are predicated by the way in which one interprets and defines 'the public' or 'the community' (Walker, 1995; Edwards & Trafford, 2015). As shown in Figure 10, social impacts can be differentiated depending on how relevant 'stakeholders' are identified, and how renewable energy projects contribute to localised development (del Río & Burguillo, 2008; Fraser & Chapman, 2018). Harvey and Bice (2014, p.330) suggest that the term 'stakeholders' is often used to refer to "*all* individuals or groups who can affect a project or operation," and in turn this term "tends to elevate the importance of many with peripheral or no connections". Determination of *who* is affected is integrally linked to what Ahmadvand and Karami (2017, p.70) called the "insider/outsider debate" in Social Impact Assessment (SIA): locals ('insiders') may have different perceptions of the nature and significance of social impacts than, for example, municipal government ('outsiders'). In the settler-colonial context, authorities have often failed to recognise Indigenous peoples as partners, or even as 'stakeholders', where renewable infrastructures are proposed on Indigenous lands (MacArthur & Matthewman, 2018; Walker et al., 2019). To create a tangible link between peoples and impacts, Harvey and Bice (2014) advocate that practitioners therefore adopt *communities* as an analytical frame.

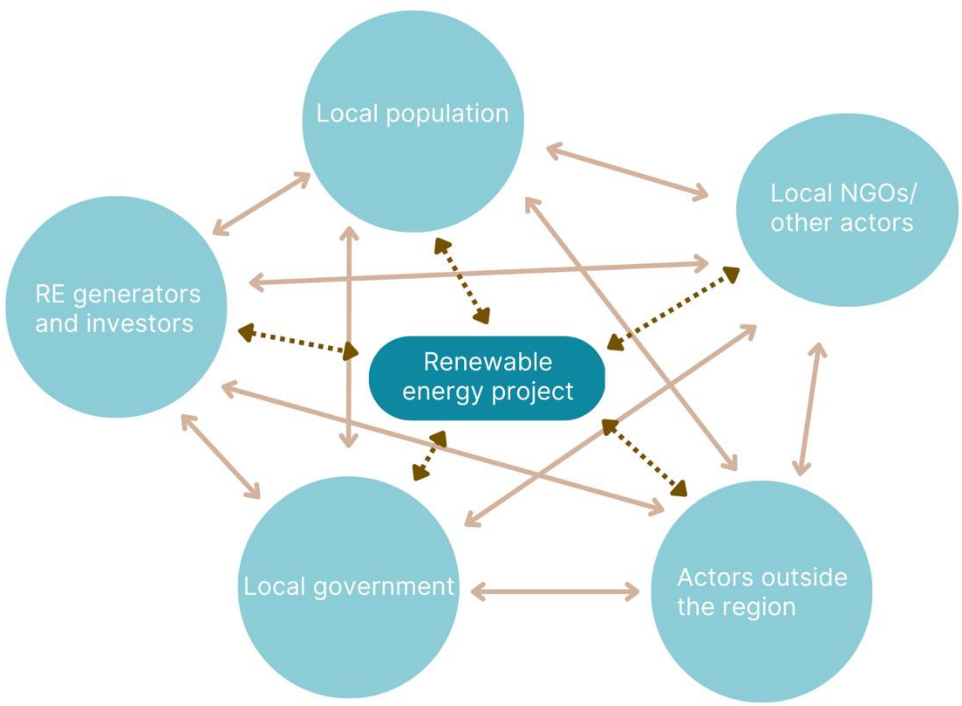


Figure 10. Identifying 'stakeholders' and stakeholder relationships in renewable energy project development (Source: del Río & Burguillo, 2008).

If planning for renewables is to be deliberative, collaborative, and fair (Wolsink, 2007), then it is suggested that decision-makers must be alert to dynamics of 'public' participation that can favour politically-active groups, in lieu of under-reached or overlooked populations (Walker, 1995, Żuk

& Żuk, 2022). The notion of 'energy justice' has been used to refer to the fairness and distribution of social impacts of renewables (Burke & Stephens, 2018; Fraser & Chapman, 2018; Sovacool & Dworkin, 2015). Żuk and Żuk (2022) adopted an 'energy justice' framework to consider how older persons may be overlooked or excluded in renewable energy transitions. Similarly, the fact that solar farms are more likely to be approved in economically-deprived areas, raises questions about distributive justice (the distribution of goods across society), and the extent to which procedural fairness can be achieved for large-scale renewable energy infrastructures (Fraser & Chapman, 2018; Larsen et al., 2018; Roddis et al., 2020; Wolsink, 2007).

3.2.3 Community Benefits and Community Acceptance

Community acceptance of renewable energy infrastructures is "deeply intertwined with wider policy context, and the context of which other energy policies are currently being deployed." (Roddis et al., 2020, p.242). Consonant with Harvey and Bice's (2014) call for Impact Assessment (IA) practitioners to focus on *communities*, Roddis et al. (2020) suggest a three-dimensional approach to 'social acceptance' of renewable energy proposals, which requires *community acceptance* by "communities of relevance", as well as *socio-political acceptance* (the acceptance of a policy) and eventually *market adoption*.

The presence of substantively beneficial social impacts may predict the likelihood of community acceptance for a development. Beneficial impacts can include compensation or other offsets (Berka & Creamer, 2018; Walker, 1995). For example, Roddis et al. (2020) observed that social acceptance of solar farms in California was positively correlated with improved understanding of the benefits of solar energy. Yet the same authors noted that aesthetic social impacts (such as effectiveness of visual buffers) could affect local people's attitude toward the development and engender 'Not In My Backyard' (NIMBY) attitudes – a finding consistent with other studies (Brewer et al., 2015; de Sena et al., 2016).

Analysis of "localised acceptance" can indicate the potential benefits or costs to specific communities, particularly as regards siting conflicts (Pascaris et al., 2022, p.1). Berka and Creamer (2018) distinguish between social impacts upon 'local values' versus 'public values'. They explain that the social impacts of a renewable energy development "are intrinsically related to whether its activities and outcomes concur with local priority values and needs, developed as a result of individual experiences," whilst 'public values' are more collective and general (Berka & Creamer, 2018, pp.3401-3403). In the case of countries with a declining agricultural sector, del Río and Burguillo (2008) suggest that rural communities may accept or support solar-energy developments where they can provide alternative land-use and employment opportunities. By contrast, other studies have cautioned that communities may fear adverse effects on property values (Jones et al., 2015; Pascaris et al., 2022). Moreover, solar mega-projects can 'lock up' rural land for the period of the project permit (Fraser & Chapman, 2018). Deployment of agrivoltaic systems appeared to improve local acceptance for solar developments, provided that other local interests were not threatened (Pascaris et al., 2022).

3.2.4 Socio-political Acceptance

Socio-political acceptance refers to the acceptance of policy by decision-makers, the public, and other actors (Roddis et al., 2020). Factors that may influence the socio-political acceptance of renewable energy technologies can include perceptions of landscape change, risk, and environmental consciousness (Zoellner et al., 2008). Given the spatial dimension of renewable energy infrastructures and policies, there may be a degree of "green on green tensions" in development outcomes, such as trade-offs between biodiversity protections and emissions-reduction targets (Roddis et al., 2020, p.239).

Crucially, *procedural impacts* can shape community attitudes towards the appropriateness and feasibility of a development (Larsen et al., 2018; del Río & Burguillo, 2008; Walker, 1995; Zoellner et al., 2021). It is accepted that community's perception of procedural fairness may soften their perceptions of negative impacts from a development (Parsons & Moffat, 2014). Large resource development projects are a good example of a "social impact setting" that falls within the jurisdiction of local planning officials (Burdge, 1987, p.141). Recalling Ahmadvand and Karami's (2017) analysis of 'insider/outsider' paradigms in SIA, 'weak' analysis of social impacts in environmental impact assessment (EIA) may undermine community confidence in planning for renewables (Larsen et al., 2018). By integrating IA data with GIS tools, one recent North American study aimed to determine the most environmentally, socially, and economically suitable sites for solar energy developments so as to avoid socio-political incongruence (Brewer et al., 2015).

Walker (1995) was critical of what he described as the *decide-announce-defend* approach to siting renewable energy developments with negligible public input. *Decide-announce-defend* "has been shown to repeatedly antagonize and create public mistrust, concern and ultimately conflict" (Walker, 1995, p.57). This concern has been echoed by decolonial scholars, who urge procedural fairness and transparency as factors on the pathway towards reconciliation with Indigenous peoples (MacArthur & Matthewman, 2018; Walker et al., 2021). It should be noted that where institutional planning processes are weak, and trust low, communities may elect to form their own relationships with private developers (Fraser & Chapman, 2018; Walker et al., 2021). As such, both *socio-political acceptance* and *community acceptance* may be shaped by the perceived fairness of the planning system.

3.2.5 Social License to Operate

The term SLO was generated within the mining sector in the early 1990s, to encourage the industry to rebuild its reputation at a community-level (Boutilier, 2014; Edwards & Trafford, 2015; Ruckstuhl et al., 2014; Thomson & Boutilier, 2011). Both SLO and IA originate in studies of business and society, however SLO focusses on organisational relationships, whereas IA emphasises organisational impacts (Parsons & Moffat, 2014). More recent applications of SLO have sought to integrate IA, by focussing on the relational dimensions of social, environmental, and economic impacts (Hall, 2014; Parsons & Moffat, 2014).

By using an SLO approach to renewable energy developments, Hall (2014, p.220) sought to transport SLO "beyond the formal regulation for impact and risk assessment". In harmony with the foregoing review of literature on social acceptance and sustainable development, SLO is characterised by trust, good governance, procedural fairness, and distributive fairness for host communities. Moreover, SLO draws attention to which 'publics' are included, and at what scale (Edwards & Trafford, 2015; Jijelava & Vanclay, 2018). Figure 11 reproduces Thomson and Boutilier's (2011) heuristic for inclusion of legitimacy, credibility, and trust in SLO.

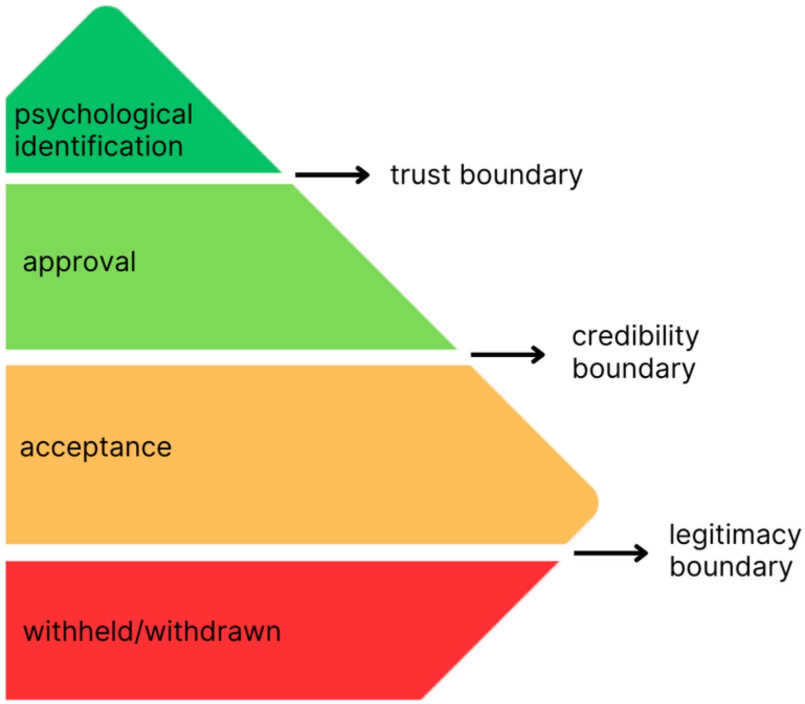


Figure 11. The continuum of Social License to Operate (Source: Thomson & Boutilier, 2011).

A SLO is affected by the extent to which community expectations are met by developers' commitments (Boutilier, 2014; Hall, 2014). As such, SLO is not defined by the presence of a development permit (Edwards & Trafford, 2015); and SLO is "not transferable from one place to another, nor one set of stakeholders to another" (Harvey & Bice, 2014, p.330). Furthermore, a relational approach avoids presuming that a SIA is the precursor to SLO (Parsons & Moffat, 2014). A SLO may be negated if consultation does not absorb critical input from key communities or stakeholders (Hall, 2014; Jijelava & Vanclay, 2018). Social license requires developers and decision-makers to 'earn' and then 'maintain' the SLO, through a dialogic process with affected communities, to establish legitimacy, credibility, and trust (Jijelava & Vanclay, 2018).

In Hall's (2014) analysis of SLO for wind-farms in Australia, the author categorised social license issues under a 'Traffic Light System' reminiscent of Thomson and Boutilier's (2011) SLO continuum. As shown in Table 2, Hall (2014) categorised observations as green (G) where they reflected a benefit from the project, or a known issue that was already addressed. Red (R) indicates costs or problems with the project. Amber (A) portrayed issues that Hall (2014, p.230) called "game-changers": those contextual, physical, economic, or social issues that, if managed appropriately, “ha[ve] potential to enhance SLO; if poorly managed, [they have] the possibility to increase opposition.”

For Hall (2014), as for other researchers (Jijelava & Vanclay, 2018; Parsons & Moffat, 2014), the role of local government in facilitating SLO differs from community to community. The contemporary usage of the term SLO implies that communities have a similar authority to local governments in granting permissions or ‘license’ for operation (Boutilier, 2014). However, the SLO concept indicates that developers need to build trust beyond the minimum constrains of the planning system (Parsons & Moffat, 2014). Planning controls, and local government engagement, are relevant to how private developers will approach further engagement with communities, to ascertain a community’s criteria for project acceptance and approval (Harvey & Bice, 2014).

Table 2. Traffic Light System for categorising aspects of Social License to Operate across contextual, physical, economic, and social impacts of wind-farms in Australia (Adapted from Hall, 2014).

Category of impact	**Colour**	**Observation in Hall’s (2014) wind-farm case-study**
Contextual	A *Game-changer*	For some, the planning system does not adequately consider contribution from individuals and communities, especially in the experience of court appeals and ‘critical infrastructure’ legislation
Physical	G *Benefit*	Environmental gains include low-carbon electricity, supporting farming, and improved access for firefighting
	A *Game-changer*	The layout and number of turbines in each cluster can minimise perceived negative visual impact
Economic	A *Game-changer*	Wind-farms can attract tourism, but may conflict with other tourism features
	R *Cost*	The expense of offshore turbines to avoid local visual impact is difficult to justify in Australia
Social	G *Benefit*	Developers acting beyond required compliance, including willingly engaging outside the formal planning process, contribute to more accepted energy projects
	R *Cost*	The reason for opposition by some participants suggest that wind-farm proposals are triggering a range of underlying cultural or ideological concerns which are unlikely to be addressed or resolved for a specific wind-farm development. These underlying issues include pre-existing concerns that rural communities are politically neglected by urban centres; commitment to an anti-development stance; and opposition to a ‘green’ or ‘climate action’ political agenda

3.3 Environmental and Economic Impacts

Solar energy developments have become one of the leading sustainable and clean energy sources in recent years, however, with the increase in uptake of solar energy it is important that economic and environmental implications are considered (Dhar et al., 2020).

3.3.1 Environmental Issues

Dhar et al. (2020) explain that although solar energy developments have significantly less harmful effects on the environment relative to fossil fuel energy, there are still a number of adverse environmental consequences. Environmental concerns include hazardous material emissions, water usage, visual impact, glint and glare, albedo effects, landscape fragmentation, microclimate changes, wildlife impacts, biodiversity reduction, and effects on soil (Dhar et al., 2020; Hernandez et al., 2014; Jones et al., 2015; Sánchez-Pantoja et al., 2018; Tawalbeh et al., 2021). Furthermore, these consequences are apparent to varying degrees over the different phases of the solar development lifecycle, from manufacturing and project construction to disposal after use of the plant ends (Dhar et al., 2020). In addition, it is important to note that the two solar technologies, PV and CSP, have similar potential environmental effects, but the effects from CSP are more widely debated (Dhar et al., 2020).

Some key potential environmental effects in the manufacturing phase include emissions of GHGs and hazardous materials that are produced from fabrication of the solar panels; whilst during the construction phase of a solar farm, land fragmentation, soil quality decline and erosion may result (Dhar et al., 2020; Hernandez et al., 2014; Tawalbeh et al., 2021). Land fragmentation is significant as it can lead to habitat loss and threaten biodiversity, though the extent of biodiversity impacts will depend on the natural characteristics of the land used for solar development (Hernandez et al., 2014). Hernandez et al. (2014) illustrate how land fragmentation is a concern for local wildlife as it may impact movement of species, leading to an increased risk of gene flow distribution and displacement of species throughout the duration of solar development operations. In addition, during the construction phase, there is vegetation removal, land grading, and soil compaction, which decreases soil quality and increases likelihood of soil erosion due to greater susceptibility to wind and rain (Dhar et al., 2020; Hernandez et al., 2014). Moreover, the removal of vegetation and disturbance to soil can produce dust, which could affect neighbouring properties and human health (Nordberg et al., 2021). Land-use conflicts and reverse sensitivity affects are linked to adverse environmental impacts as well as the broader environmental implications of land-use change and fragmentation (Jamil et al., 2023). These potential adverse environmental effects may influence siting decisions, and also must be factored into assessment of solar development proposals and guidance for mitigation and management.

During the operational phase of a solar developments, water use remains one of the most significant issues to consider. International reviews consistently find that use of water is an explicit concern for solar farms, especially in regions that already experience water stress (Dhar et al., 2020; Hernandez et al., 2014; Nordberg et al., 2021; Sánchez-Pantoja et al., 2018; Tawalbeh et al., 2021). Water is used in the cleaning and cooling of the solar panels, although Tawalbeh and others (2021) observe that the amount of water needed is dependent upon several design and use factors. First, in regard to cooling of the solar panels, Tawalbeh et al. (2021) explain that dry or hybrid cooling schemes can be employed to reduce water usage, as well as recirculating cooling water. As regards cleaning, the volume of water usage is dependent on environmental characteristics such as dust, wind speed and direction, panel orientation, temperature, vegetation, rainfall, air pollution, humidity, tilt angle, and glazing properties, all which affect how often the panels need cleaning (Tawalbeh et al., 2021). Site selection, therefore, underscores the issue of water use and availability (Hernandez et al., 2014; Nordberg et al., 2021).

In the decommissioning phase of a solar energy development – which typically occurs 25 to 40 years after installation – the main potential impact on the environment is chemical pollution and disposal of hazardous waste (Dhar et al., 2020; Hernandez et al., 2014). Dhar et al. (2020) emphasise the need for reclamation or post-operational planning to be considered in the design phase, before a solar development goes ahead, with particular attention to decisions regarding whether the system will be decommissioned, upgraded, or replaced. If the solar facility will be decommissioned, detailed planning needs to be in place well in advance to ensure that ecosystems and habitats are suitably cared for, and that infrastructure is dismantled and recycled appropriately to mitigate the chance that people and environment are exposed to hazardous waste (Dhar et al., 2020; Hernandez et al., 2014; Invernizzi et al., 2020). Furthermore, incorporating reclamation planning into the initial design phases will reduce the likelihood of ineffective and expensive processes for decommissioning (Dhar et al., 2020). To pre-empt negative waste scenarios, Trypolska et al. (2022) propose that manufacturer responsibility could be extended, whilst Invernizzi et al. (2020) advocate for circular economy principles, which can also mitigate against the potential for developers to underestimate the costs of decommissioning. It is thus crucial to plan for decommission during the design phase, because in all likelihood the expanding solar-PV market will generate increasing quantities of waste materials (Invernizzi et al., 2020; Welsh, 2023).

It is evident from previous research that there are environmental implications across the lifecycle of a solar development, which require careful scrutiny for Central Otago climate and context. Key considerations for siting and mitigation are related to the specifics of the local environment, such as water, visibility, glare, land use, land stability, dust, microclimate, biodiversity, and soils.

3.3.2 Economic Issues

Proliferation of solar energy development can generate many economic and socio-economic benefits. Solar energy developments may lead to increased energy independence, more employment opportunities, deregulated energy markets, an increase in rural development, improved rural electrification, and secure and diverse energy supply (Dhar et al., 2020; Hernandez et al., 2014). The economic benefits from solar energy development vary across the short- and long-term, and have both *direct*, *indirect*, and *induced* effects. Direct impacts from a solar development relates to any money the company is itself spending on site preparation, construction, operations, and maintenance by local labour (Tuck, 2021). In addition, in the short-term, site preparation and construction require a large influx of workers, entailing an induced effect, through *consumer-to-business* economic interactions, such as increased use of local accommodation, restaurants, shops, healthcare, and other businesses (Jones et al., 2015; Tuck 2021). Moreover, in the early phases of a solar development, there may be further indirect *business-to-business* effects relating to real estate, healthcare, and other relevant goods and services (Tuck, 2021). Jones et al. (2015) suggest that long-term solar farm employment prospects may be slightly smaller in comparison to the construction phase. However, employment related to site maintenance, management, and environmental stewardship continue. One should note that, according to Dhar et al. (2020), solar energy plants can create 2.5 times more employment in comparison to other energy source plants over the long-term.

3.3.3 Agrivoltaic Systems

Solar energy developments are a valuable source of renewable energy generation. However, there are further opportunities to expand the benefits they provide, both environmentally and economically (Nordberg et al., 2021). The co-location of solar-PV and agriculture, known as agrivoltaic systems, is an initiative that researchers suggest can create improved environmental and economic outcomes, whilst increasing land productivity by 60 to 70 percent and mitigating or resolving some of the environmental issues discussed above, such as sedimentation or soil degradation (Nordberg et al., 2021; Pascaris et al., 2022). Agrivoltaic systems encourage productivity of crops beneath solar panels, and can increase soil carbon, reduce water evaporation, reduce conflicts over land-use, create further employment prospects, and generate greater development of rural areas (Nordberg et al., 2021). Nordberg et al. (2021) explain that environmental issues related to land fragmentation, water usage, soil quality and erosion, and dust can be alleviated considerably when agrivoltaic systems are employed. In the example of agrivoltaic crop systems, introducing crops diminishes soil erosion, therefore reducing levels of dust, which reduces the need for cleaning of the panels. In addition, water used to clean panels will drain into the soil, thereby watering the crops, whilst shade from the solar panels reduces evaporation and means crops can be watered less frequently. Yet, it is important to consider what types of crops or livestock will be appropriate to the specific location of a given solar farm, as well as how the solar panels are mounted in relation to height off the ground (Nordberg et al., 2021). In addition, MacKenzie (2022) points to concerns around market uncertainties, reduction in farmer revenue, land viability, and visual appeal; as well as increased farmer workload, and health and safety issues arising from hosting a farm on an electrical site. It should be observed that whilst concerns arise about land viability and visual appeal, Pascaris et al. (2022) showed that agrivoltaic systems are associated with increased social acceptance of solar farms. They may create economic opportunities for the local community, distribute economic benefits fairly, do not jeopardise local interests, and are not located on public property. Looking forward, agrivoltaic systems may be of significant value to energy companies and rural communities due to the various environmental, economic (and perhaps social) benefits these systems provide, as a form of "multi-regime interaction" (Sutherland et al., 2015) between the agricultural and renewable energy sectors.

3.4 International and Domestic Case-studies

This section illustrates four contemporary examples of grid-sized solar energy developments in international (Japan, India, and Germany) and Aotearoa-New Zealand contexts. These case-studies synthesise academic literature as well as relevant grey literature.

3.4.1 Japan: Policy and Equity in Siting Mega-Solar Projects

Utility-scale solar projects have been a focus of Japan's renewable energy transition, particularly in the wake of the 2011 earthquake and renewed concern about the environmental impacts of nuclear energy (Fraser, 2020; Mohammadirad & Nagasaka, 2015). The government's 2012 "Feed-in Tariff" (FiT) policy created financial incentives on investors to pursue "mega-solar" projects in Japan's rural prefectures (Fraser, 2020). This form of land-use change is being led by extra-prefectural investors either as private developments or partnership ventures (Fraser & Chapman, 2018). Solar parks are generally sited on 'second-class' or 'third-class' farmland as there are planning restrictions for approval to convert 'first-class' farmland (Tajima & Iida, 2021). Despite the national direction created by FiT, one 2020 study noted that many prefectures and municipal authorities had not implemented clear zoning frameworks for renewable energy (Fraser, 2020).

With the proliferation of renewable energy infrastructures in Japan, social cohesion and socio-economic conditions may be key factors in the extent that communities 'resist' new developments, even where the projects are controversial (Fraser, 2020). In a 2018 analysis of Japan's mega-solar projects, Fraser and Chapman (2018) reported that the top four social equity impacts were:

1. Minimal or no social impacts for host communities, such as low municipal revenue or employment gains;
2. Increase in stable tax revenue for the rural land on which mega-solar was sited;
3. Land-related revenues for individual landholders, such as rental of otherwise under-utilised land; and
4. Negative social impacts related to environmental quality and access. These included aesthetic issues, negative effects of erosion and water runoff on nearby agriculture, and 'freezing' of land for the period of the project's permit.

Fraser and Chapman (2018) note that equity concerns centred around the distribution of benefits. Though positive social impacts related to rents obtained by individual land-owners, there were "few concentrated local benefits for communities" by way of ongoing employment opportunities or ongoing rates payments to local government (Fraser & Chapman, 2018, p.136).

The FiT programme has also encouraged proliferation of agrivoltaic developments in Japan's agricultural prefectures. These agrivoltaic developments are generally small-scale (89 percent of agrivoltaic farms are 0.5 hectares or less), which partially reflects the skew towards small-holdings in the agricultural sector (Tajima & Iida, 2021). Water availability and shade-tolerance are key factors in crop selection for agrivoltaic farms. Nevertheless, Tajima and Iida (2021) suggest that selection of high-value crops, such as tea, would improve commercial viability of agrivoltaic small-holdings.

3.4.2 Bhadla Solar Park: Grid-scale solar in Rajasthan, India

Throughout India there has been a great uptake in the utilisation of solar energy, facilitating energy security by reducing dependence on imported fossil fuels (B. R. Kumar, 2022; Saxena et al., 2020). The Rajasthan government launched an overarching Solar Energy Policy in 2019, which promoted expansion of the renewable energy market through enabling policies for private developers (Misra, 2023; Saxena et al., 2020). Bhadla Solar Park was commissioned in 2017 to meet the need for renewable energy transitions (B. R. Kumar, 2022; Saxena et al., 2020). The project was further motivated by the need for new energy supply infrastructures to bridge the gap of high energy demand in the state of Rajasthan, for which it has been considered successful (H. Kumar et al., 2012; Misra, 2023).

Bhadla Solar Park is among the largest solar parks in the world, with a capacity of 2,245MW (Saxena et al., 2020). The park encompasses 5700 hectares of land area and employs around one thousand individuals (B. R. Kumar, 2022). This industrial solar park represents a tool for economic growth, promoting sustainable development, lowering carbon emissions, and creating a sense of justice within the energy system (B. R. Kumar, 2022; Rajaram & Balamurugan, 2020; Sareen & Kale, 2018). The environmental conditions and solar resource within Rajasthan make it an ideal location for solar electricity (B. R. Kumar, 2022; Misra, 2023). Relevant site-selection factors included high solar incidence, swathes of barren land, and necessary clear weather conditions for over 300 days of the year (B. R. Kumar, 2022; Misra, 2023). These site-selection factors enhanced Bhadla's energy yield by 15 percent as compared to areas of low-moderate insolation in Rajasthan (Rajaram & Balamurugan, 2020). Furthermore, Bhadla Solar Park was sited on a previously unoccupied land parcel that had been deemed uncultivable, with limited irrigation resources. Thereby, minimising potential of adverse environmental impacts in the receiving environment, or land-use conflicts stemming from alternative uses (H. Kumar et al., 2012). H. Kumar et al. (2012) note that adverse social and environmental effects were in fact limited to the construction period. Taken together, the Bhadla case-study establishes how a successful solar development can be determined by the contextual and environmental setting in which the project is developed. Misra (2023) adds that Rajasthan's expanding solar sector might initiate an endogenous solar-panel manufacturing sector, providing other employment opportunities for young people. This case-study reflects the benefits that solar-farms may provide towards high-level goals (such as meeting energy demands and transitioning to renewable energy) as well as local-scale social and environmental impacts (including appropriate site-selection and reducing land-use conflicts). The prominence of Bhadla's environmental and socio-economic impacts can be linked to the sheer scale of the project. However, such range of impacts would be recognisable in developments at smaller scales.

3.4.3 Agrivoltaic development at Heggelbach Farm, Germany

In Germany, solar farms are becoming a popular development option as demand increases for renewable energies (Hager & Hamagami, 2020). The Fraunhofer Institute for Solar Energy Systems (Fraunhofer ISE) has explored the potential energy-production and environmental outcomes of agrivoltaic farming systems. Fraunhofer ISE operates Heggelbach Farm: an agrivoltaic development near Lake Constance in Baden-Württemberg, Germany. Fraunhofer ISE (2022) express that the purpose of the Heggelbach agrivoltaic farm was to ascertain the potential of vegetable farming under grid-scale solar developments, and to investigate the economic, social, technical, and environmental aspects of such a system. Fraunhofer ISE (2022) described that during 2017 – the first year of the project – land utilisation rates at Heggelbach Farm increased by 160 percent, and the crops cultivated beneath the solar-PV modules maintained a yield of over 80 percent, surpassing both the threshold for commercial viability, as well as the rate-of-yield in control areas (areas with no solar-PV array).

Trommsdorff et al. (2021) evaluated crop growth, microclimate impacts, and energy production of the agrivoltaic array at Heggelbach Farm. The authors found that co-locating agriculture with solar panels resulted in a favourable microclimate, with reduced temperatures and evaporation rates. These conditions directly impacted crop growth, leading to increased yields. Moreover, the shading provided by the solar panels contributed to reduced water consumption, thereby improving water-use efficiency. Altogether, Trommsdorff et al. (2021) identified the agrivoltaic system as a source of clean and sustainable energy, that also presented farmers an opportunity to diversify their income. The results of both Trommsdorff et al. (2021) and Fraunhofer ISE (2022) are consistent with the improved environmental implications concluded by Nordberg et al. (2021), and Pascaris et al. (2022).

3.4.4 Aotearoa-New Zealand: Solar developments at Edgecumbe and Taupō

In Aotearoa-New Zealand there is growing uptake of solar technologies, available through utility providers, private developers, and residential or community schemes (Stephenson et al., 2018). However, there has been limited academic attention to solar energy production of scale within the Aotearoa-New Zealand context. This is partly because, to date, many utility-scale solar developments remain in the planning stages, with a small number either consented or under construction. The following case-studies draw on grey literature and media reporting.

Helios Energy, a private developer, has proposed a solar farm in a rural area of Edgecumbe in the Eastern Bay of Plenty, with a target operation date of 2025 (Fuller, 2022). While smaller than the Bhadla Solar Park example, the Edgecumbe project shall be leased on 207 hectares of rural property and has the potential to generate up to 115MW of electricity due to the high insolation of the site location (Helios Energy, n.d.). According to Helios Energy's estimates, the Edgecumbe solar farm will create benefits for nearby communities, through short and long-term employment, and secondary economic activity via patronage at local food and accommodation venues (Helios Energy, n.d.). Helios Energy also state that they are committed to a partnership with mana whenua and affected communities. Alike other solar farms proposed by Helios, the Edgecumbe facility will enable phase-in of agrivoltaic opportunities such as sheep-grazing, crop-planting, and beekeeping (Fuller, 2022; Helios, n.d.). By co-locating land-uses, there are opportunities to promote agricultural production and biodiversity, in addition to renewable energy – similar to the Heggelbach example from Germany. As a condition of Helios Energy's lease for the Edgecumbe solar farm, Helios must decommission the site and return land to its original state. This heeds the call of Dhar et al. (2020) to determine decommission plans during the planning and design phase.

Another solar development that has received resource consent is Todd Generation's utility-scale farm in Taupō District, known as Rangitāiki. Rangitāiki is the largest farm currently proposed in Aotearoa-New Zealand. Its projected capacity of 400 MW is achieved with 900,000 panels over 1022 hectares, on farmland currently being used for dairying (Martin, 2022). Rangitāiki is also smaller than Rajasthan's Bhadla Solar Park, but it is expected that the size of this development will incur impacts across environmental, economic, and social aspects, including land-use change, visual amenity, and glare. The resource consent decision acknowledges that positive effects accrue to the land-area through its retirement from dairying, and "any adverse effects on existing rural character and amenity are acceptable in respect of the subject site and its location" (Taupō District Council, 2022, p.19). In addition, Daalder (2022) reports that Rangitāiki holds potential for agrivoltaic cropping, or co-location with smaller livestock.

3.5 Summary

Objectives of sustainable development and zero-carbon transitions provide the backdrop for utility-scale solar farms to enter the electricity market. Since scholars made a distinction between fossil fuels as a 'hard' energy path, renewable energies have been thought of as a 'soft' path with gentler social and environmental impacts. The concept of SLO, too, has developed beyond the mining sector and recently been applied to wind-farm developments (Hall, 2014). Environmental impacts range across the construction and decommission phases of development, and include changes to soil, albedo, biodiversity, and wider land-use change. Water stress arises as another key issue. Depending on the environmental context, agrivoltaic systems present an opportunity to mitigate against negative soil, water, and biodiversity impacts, whilst providing for economic benefits and greater social acceptance.

Along with examples from Japan, India, and Germany, the Edgecumbe and Taupō case-studies illustrate the burgeoning interest in utility-scale solar farm development in Aotearoa-New Zealand. Agrivoltaic systems have been considered in each of the two North Island examples, which connotes the feasibility of co-located land-uses in the Aotearoa-New Zealand context. Environmental, social, and cultural conditions in Te Waipounamu may provide points of departure for the present report.

4.0 Policy Context

Aotearoa-New Zealand’s policy framework relating to energy has been relatively stable for over 25 years. However, in recent years, central government has assigned significant effort to investment and policy development for renewable electricity generation (REG), following the country's commitment to the Paris Agreement in 2015 (Trixl & Lloyd, 2022).

4.1 National Scale Policy Framework

Following the Paris Agreement, national goals were made for 100 percent renewable energy generation by 2030. All GHG emissions, excluding biogenic methane, to be reduced to net-zero by 2050. This approach was reinforced during the United Nations Climate Change Conference (COP26) in 2021, where the government pledged to phase out coal in the next 10-20 years. Domestically, this pledge was followed by two announcements: the Government Investment in Decarbonising Industry Fund announced its first recipients, alongside national scale reform of resource management legislation. Governmental energy strategy is actioned by three organisations. The Energy Efficiency and Conservation Authority (EECA) is mandated to promote renewable energy consumption and policy. Together with the Commerce Commission, which may control access to and prices for electricity lines, the Electricity Authority is legally mandated to regulate the energy market. International commitments have driven action at a national scale across sectors and involving many organisations. Collectively, these goals drive national direction on electricity generation (Trixl & Lloyd, 2022).

Aotearoa-New Zealand is no stranger to renewables; as detailed at Chapter 2.3, the greatest proportion of electricity is generated through hydropower. However, solar and wind electricity generation are a much younger phenomenon on Aotearoa-New Zealand shores and have therefore been less prominent within REG policy. This is particularly significant given that since the mid-1990s, increasing energy demands are instead being offset through greater use of fossil fuels (Palmer & Grinlinton, 2014). To achieve the sustainability goals that manifest Aotearoa-New Zealand’s commitment to the Paris Agreement, transition to REG must be facilitated through the resource management policy framework.

4.1.1 The Resource Management Act 1991

Resource management in post-contact Aotearoa-New Zealand originally took its template from British town planning legislation, adopted as the Town and Country Planning Act (1953). The Resource Management Act (RMA), enacted in 1991, introduced an "effect-based" planning system via a reliable framework to regulate environmental consequences (Memon, 2002). Per section 5, the RMA aims to achieve "sustainable management" of land, air, water, pollution, geothermal, and coastal environments. The RMA definition of "sustainable management" has two interconnected components. First, a "management" function for resource use and protection, is qualified by the overarching goal of enabling individuals and communities to meet social and economic needs. Second, environmental protection obligations are listed under section 5(2)(a)-(c), which also address intergenerational issues. Since the 2014 Supreme Court case known as *King Salmon*, decision-making authorities are called to consider all factors listed in section 5 before reaching an "overall broad judgement" (Palmer & Grinlinton, 2014). Despite this, the RMA has been criticised for neglecting to plan for long-term environmental outcomes (Memon, 2002). Following the *Randerson Report*, in 2021 the government announced reforms to the national-level resource management framework as split between three new statutes, to be guided by a new National Policy Framework (MfE, 2022a). Time delays in implementing the new system mean that current renewable energy transitions will need to take place under the current resource management system.

The RMA stipulates multiple regulatory considerations for REG developments. Section 6 determines "matters of national importance" that public decision-makers must "recognise and provide for". The resources from which electricity is generated often overlap with matters of national importance. These include significant natural landscapes, historic natural heritage, significant indigenous vegetation, and outstanding natural landscapes or features, as well as possibly interfering with Māori traditions and kaitiakitaka of tāoka. Section 7 of the RMA states that authorities "shall have particular regard to" matters such as: "efficiency of the end use of energy" (section 7(ba)); "the effects of climate change" (section 7(i)); and "benefits to be derived from the use and development of renewable energy" (section 7(j)). After amendments to the RMA in 2004, local authorities are required to take into account energy efficiency, and the value of renewable energy, when evaluating proposals (Parker, n.d.).

Though the RMA generally devolves resource consenting decisions to local authorities, under section 142(3) the Minister for the Environment may 'call in' a matter of national significance should a proposal activate any of the matters contemplated by section 142(3). These include: matters of electricity generation and transmission (paras (3)(a)(iiia) and (x)); widespread public concern (para (3)(a)(i)); new technologies (para 3(a)(vi)); or Te Tiriti o Waitangi (para (3)(vii)). One commentator has observed that large-scale wind projects have often been 'called in' as they trigger matters of GHG-mitigation and public opposition; by contrast, international precedent indicates that solar installations have not weathered the same concerns (Schumacher, 2019).

4.1.2 National Direction on REG

The RMA enacts a hierarchical framework for national direction. National Policy Statements (NPS) and National Environmental Standards (NES) are given effect in territorial and regional plans. The NPS for Renewable Electricity Generation 2011 (NPS-REG), the NPS on Electricity Transmission 2008 (NPS-ET), and the NES for Electricity Transmission Activities 2009 (NES-ETA) together provide policy guidance for the promotion and management of REG throughout Aotearoa-New Zealand, while avoiding adverse environmental outcomes from electricity generation and transmission activities.

The NPS-REG outlines the national significance of REG, to allow for its development in a sustainable way, and includes solar energy in its definition of 'renewable electricity generation' (Palmer & Grinlinton, 2014). The Preamble to the NPS-REG sets out the impetus for expansion of REG through the lens of two major energy challenges that face Aotearoa-New Zealand currently. First, the shift away from fossil fuels and reducing GHG emissions to reduce the impacts of anthropogenic climate change. Second, to deliver secure and affordable energy across the country "while treating the environment responsibly" (NPS-REG 2011, p.3). These challenges are simultaneously tackled by the NPS-REG, NPS-ET, and the NES-ETA.

The implementation of the NPS-ET recognised REG as a matter of national significance. It facilitated the operation, maintenance, and upgrade of the transmission network, while increasing network capacity through new transmission connections. During review of the NPS-ET, Transpower submitted that it was a “hugely important strategic document” as it formally requires them to complete a thorough site selection process that ensures alternatives are considered within technical and operational constraints (MfE & MBIE, 2019, p.27). The NPS-ET seeks to safeguard the national grid from the negative impacts of conflicting third-party operations. Housing, agriculture, and other types of development would likely surround grid assets without the NPS-ET, increasing the possibility of reverse sensitivity effects, restricted access, and electrical hazards. However, Transpower has raised concerns that the NPS-ET lacks ‘levers’ that would enable energy expansion to meet projected national and regional growth over the next 30 years (MfE & MBIE, 2019).

According to a 2019 review, the NES-ETA is largely achieving its objectives to facilitate the operation, maintenance, and upgrade of the existing transmission network, and to ensure national consistency in implementing the NPS-ET (MfE & MBIE, 2019). However, it is less clear how the NES-ETA has achieved other objectives, like minimising the cost to councils of implementing the national direction, or RMA costs and delays (MfE & MBIE, 2019). Along with national regulatory frameworks, non-statutory documents support the development of REG. For example, the New Zealand Energy Strategy 2011-2021 highlighted the need for energy markets that are competitive and open to both large and small generators. It emphasised that smart-grid infrastructure provides more sophisticated network management, which might allow for distributed generation and the integration of smaller-scale power into the system, such as solar infrastructures. NPS-REG and NPS-ET will be further supported by the application of the strategy, along with aiding the New Zealand Emissions Trading Scheme to incorporate GHG costing into electricity investment decisions (Parker & Grinlinton, 2014; Trixl & Lloyd, 2022).

4.1.3 Interaction with National Direction on Highly-Productive Land

The National Policy Statement on Highly Productive Land (NPS-HPL) took effect in October 2022, with the aim of protecting the country’s quality soils for food and fibre production. The NPS-HPL requires that Regional Councils map land against eight Land-Use Capability (LUC) classes. The NPS-HPL requires authorities to protect HPL classes LUC-1, LUC-2 and LUC-3 from “inappropriate subdivision, use and development” (under Policy 8 and clause 3.9).

As solar farms represent a change to rural land-use activities, it has been observed that NPS-HPL may potentially constrain the development of solar farms on LUCs 1-3 (Parker & Quinn, 2022). Under the NPS-HPL, a land-use or development will not be inappropriate as regards operation, maintenance, upgrade, or expansion of "specified infrastructure" such as REG, and where there is a "functional or operational need" for the use or development to be on HPL (cl 3.9). However, a new development – such as a solar farm – will be required to demonstrate that it "minimises or mitigates any actual loss or potential cumulative loss" of HPL, as well as avoiding or mitigating "actual or potential reverse sensitivity effects" (NPS-HPL, cl.3.9(3)). Non-productive activities may be permitted where they restore or enhance indigenous biodiversity, or retire land from primary-production in order to improve water quality (cl. 3.9). Compared to the NPS-HPL's permissive direction on existing REG, these exemption requirements may be a "higher bar" for new solar projects (Parker & Quinn, 2022). Consent authorities could therefore decline a land-use consent for developments on HPL if an activity is contrary to the policy and implementation measures of the NPS-HPL (MfE, 2022b). It should also be noted that a proposed development could be 'called in' should it raise matters of concern for one or more NPSs (RMA, section 142(3)(a)(iiia)). Though the NPS-HPL is of prominence for anticipated land-use changes in Central Otago, national direction contained in the NPS for Freshwater Management (NPS-FM 2020) may influence implementation within Central Otago, in which many catchments are water-stressed (Macara, 2015).

4.2 Regional Policy and Relevant Plans

4.2.1 The Otago Regional Policy Statement 2019

The present report considers the Partially Operative Otago Regional Policy Statement 2019 (RPS), as the proposed Otago Regional Policy Statement 2021 continues through hearing.

Objectives 4.3 and 4.4 address REG most explicitly in the RPS, although other objectives ought to be considered such as those concerning integrated management and significant natural landscapes. Objective 4.3 outlines guiding principles for managing infrastructure and the sustainable development of infrastructure across the Otago region, through a lens of social and economic wellbeing. Highlighted in Objective 4.3 is the sustainable promotion of regionally and nationally significant infrastructure, whilst Policy 4.3.5 directs management of adverse effects of infrastructure that has national or regional significance. Policy 4.3.4 outlines the policy framework for managing adverse effects from REG developments by "giving preference to avoiding" locating REG in certain locations, alongside integration with district plans, and non-regulatory strategies. In accordance with the NPS-ET, the RPS also outlines provisions for the National Grid infrastructure in Policy 4.3.6.

Objective 4.4 outlines the aim for energy resources and supplies to be secure, reliable, and sustainable. Mainly this naturally revolves around REG being recognised through district plans, education, advocacy, and facilitation by district councils. As well as REG generally, small and community scale generation is to be promoted through education, advocacy, and facilitation under Policy 4.4.2. The NPS-ET is enabled through Policies 4.4.4 and 4.4.5 that state transmission and distribution infrastructure is to be provided through district plans while maintaining security and reliability of supply, recognising functional needs, avoiding, remedying, or mitigating adverse effects from the activity. These provisions together create a framework for which district councils approach development of REG in the Otago region.

4.2.2 The Central Otago District Council Plans

The CODC's *District Plan 2008* outlines provisions for infrastructure, energy, and utilities under Section 13. The potential adverse effects of energy resource development are recognised in Section 13.2.3 which provides a list of factors which must be taken into account when considering REG developments in the district. These considerations include land disturbance, modification of natural ecosystems and habitats, land inundation, increased risk of flooding, visual impact, air and water pollution, noise, glare, light spill, and dust, disruption of and impact on infrastructure and communities, health and safety risks, loss of landscape features, loss of recreational opportunities, loss of biodiversity, changes to local climate, loss of sites of value to Kāi Tahu, and loss of heritage sites and structures. While the District Plan acknowledges that energy infrastructure can create adverse effects, it also acknowledges that energy contributes to the economic, physical, social, and recreational well-being of communities. Section 13.2.3 notes that energy development can provide employment and other social benefits, as well as new community infrastructure, irrigation, and recreational opportunities. Additionally, energy development could contribute to habitat creation and visual amenity while also harnessing renewable sources and avoiding GHGs. Section 13.2.3

recognises that such positive impacts must be considered in consideration of energy development. This demonstrates CODC’s commitment to addressing the challenges around responsible energy development and use. Under 13.4.8, the policy for reducing the environmental impact of power generation encourages investigation into a wide range of REG sources across the district. While this acknowledges Central Otago’s scope for a range of REG including solar, Policy 13.4.14 ‘Renewable Electricity Generation’ is the only other explicit policy addressing REG and simply states “to recognise the locational, operational and technical constraints associated with renewable electricity generation activities” rather than giving direction for sustainable development.

In tandem with the District Plan is the CODC's *10 Year Plan 2018-2028* (10 Year Plan) which outlines the strategic direction and work programme for the next decade. Throughout the 10 Year Plan, three sections appear to apply to REG. These include: *Planning, Regulatory and Community Development*; *Regional Identity, Tourism and Economic Development*; and Infrastructure *Strategy*. The 10 Year Plan characterises community outcomes as “thriving economy, sustainable environment, and safe and healthy community” (CODC, 2018). Similar characterisations are included in published Community Plans for Māniatoto and Naseby (CODC, 2006; 2007). The development of REG could arguably contribute to all elements of these community outcomes. The *Planning* and *Regional Identity* sections discuss general issues such as regional identity and economic resilience, without mention of REG in the district. Further, the *Infrastructure Strategy* stipulates little as regards transition to a low-emission economy. Although there are mentions of the shift to more renewables in 30 years' time, there is no description of how to prepare for this. The only projects mentioned in detail relate to retrofitting LED lighting for the public pool and adapting the heat-transfer system for Molyneux Aquatic Centre.

The CODC has published a non-regulatory *Economic Development Strategy 2019-2024* (CODC, 2019). This Strategy identifies five dimensions of higher living standards for the district: sustainability for the future, equity, risk, economic growth, and social cohesion. The Strategy acknowledges that hydropower infrastructure is vulnerable to low-flow conditions, but the document tends to focus on enabling sustainable tourism. The Strategy contains two aims that have relevance to the present report. These include having “greater value sustainably derived from our natural environment” (p.15), and “provision of the right infrastructure to provide for sustainable growth and equity across the district" (p.17). The critical enablers include "being business friendly" and pursuing business partnerships in recognition of local challenges (p.15).

4.2.3 Iwi Management Plans

The RPS and Central Otago District Plan are also required to recognise and provide for tākata whenua values under the RMA, many of which are expressed through Iwi Management Plans. The Kāi Tahu Ki Otago *Natural Resources Management Plan* (NRMP, 2005) provides no explicit direction on mana whenua intentions for REG, aside from commenting on managing hydroelectricity infrastructure. However, the NRMP does reiterate that Māniatoto and the Mata-au are traditional trails and cultural landscapes for mana whenua (NRMP 2005, p.107). The Ngāi Tahu ki Murihiku *Natural Resource and Environmental Iwi Management Plan* (2008) makes express mention of solar energy potential in their takiwā (Section 3.4.3). This plan provides more explicit direction about the intentions of southern Māori as regards REG, including support for renewable energy and the management of adverse effects (Policy 3.1.2(3)). Policy 3.4.3(1) sets the intention that the Treaty rights of Murihiku Ngāi Tahu are provided for in development of REG in the high country and foothills.

4.3 Summary

Under the RMA, a myriad of national direction, strategies, regional, and district planning has occurred in the REG space. However, as technologies progress at a speed faster than planning, policy at each level has become weakened by time. It is because of this that national direction is being updated and should be integrated at regional and district levels. Developments in REG need to be considered at a place-based scale, and therefore should be statutorily obligated to undergo these processes by council. While there is no specific mention of REG developments in the CODC's 10 Year Plan, investors are showing interest in areas across the district and therefore cannot be ignored.

5.0 Methodology

This chapter outlines the methodology that structured data collection and interpretation for the Central Otago solar-farm case-study. First, the section discusses the pragmatic and grounded research paradigms that guided the project. The research design comprises collation of primary data (semi-structured interviews, supplemented by photo-elicitation, a survey, and GIS mapping) and secondary data (via literature review and policy analysis). This mixed-methods approach enabled detailed analysis of the Central Otago case-study, and triangulation of results.

5.1 Research Approach

The present research has two key focus areas: first, the feasibility of utility-scale solar electricity generation in Central Otago; and second, how to conceptualise the potential environmental, social, cultural, and economic impacts upon local communities. These topics are encapsulated in the Research Objectives in Chapter 1.

To guide processes of inquiry and interpretation, both pragmatist and interpretivist philosophies informed the research paradigm (Kitchin & Tate, 2000). The first three Research Objectives relate to environmental indicators and siting conditions. Hence, use of pragmatist and interpretivist inquiry permitted the researchers to elicit insights from study participants that could then be appraised against academic scholarship and policy documents. The fourth Research Objective concerned community perceptions about how solar farms might impact their way of life. To meet Research Objective four, this report employed a modified version of the grounded theory paradigm to shape the pragmatic approach (Chang & Huang, 2022). Grounded theory situates the researchers in specific local contexts and uses inductive, reflexive learning to develop "grounded planning" for the unfolding nature of the research topic (Chang & Huang, 2022, p.407; Glaser & Strauss, 1967). This approach has been used previously to assess community perceptions and impacts of renewable energy infrastructures, such as windfarms, where little was known before (Pedersen et al., 2007). In the present case-study, the researchers took an inductive approach to interpret how the Naseby community perceives the environmental, economic, and social impacts associated with planning for a utility-scale solar farm. These perceptions could then be triangulated against the impacts established by the first three Research Objectives.

5.2 Research Design

A multi-method approach was used to triangulate qualitative data against quantitative preference (Likert-scale) survey data. This was particularly important for achieving depth, accuracy, and rigour in the study's insights, and to mitigate against potential biases or gaps that may result from a mono-method approach such as using semi-structured interviews alone (Hay & Cope, 2021). It was pragmatic to use secondary methods (literature review and policy summary) to achieve comparative analysis with similar rural case-studies and constrain inquiry within the existing policy framework.

5.3 Research Methods

Aligning with an interpretivist approach, a predominately qualitative method was used to collect a range of viewpoints from significant stakeholders and members of the local community. Secondary data collection from a range of sources was undertaken including wider scholarly literature and analysis of the policy framework under which grid-scale solar developments are managed. Primary data collection was mainly completely in the Central Otago district between 2 May and 5 May 2023 in the form of semi-structured interviews with Key Informants, and distribution of a survey-questionnaire to the public. This was later followed by GIS mapping to identify site suitability for grid-scale solar developments.

5.3.1 Literature Review

A review of academic literature was conducted to define the Research Objectives and situate the findings within a larger theoretical framework (Leite et al., 2019). This allowed the researchers to identify scholarly consensus, research gaps, and appropriate methodologies for research into the viability of solar farms in the Central Otago District (Rowley & Slack, 2004). International and domestic academic research were used comparatively, across three key themes of inquiry: drivers for renewable energy transitions; assessment of social impacts and community perceptions for solar farms; and environmental and economic impacts from solar farms.

5.3.2 Geographic Information Systems (GIS)

The researchers utilised GIS to gain a better understanding of how and where the Central Otago District might be suitable for utility-scale solar developments. Geographic features and spatial patterns are visually depicted in GIS maps; vectors can be included or excluded depending on their relevance to the spatial phenomenon under study (Maguire, 1991). Remote-sensing criteria were gleaned from the literature review, and refined based on indicators provided by Key Informants who were technical experts for solar farms. The resulting GIS maps highlighted areas where solar developments may be environmentally appropriate to construct throughout the region, with an overlay for HPL. Other studies have used remote-sensing in a similar manner to identify townships that are likely to be impacted by a given development (Brewer et al., 2015).

5.3.3 Key Informant Interviews

Semi-structured interviews are a qualitative approach that enables participants to offer distinctive, in-depth remarks (Tracy, 2013). The research team developed three sets of indicative question schedules, with the purpose of capturing different information from Key Informants (KI) depending on whether they were a planning practitioner, technical expert, or local resident. The semi-structured methodology allowed the line of questioning to develop naturally, as participants shared their unique experiences and areas of expertise (Roulston & Choi, 2018; Tracy, 2013). The researchers divided into two teams to achieve consistency and efficacy in the execution of interviews. A total of 11 interviews were conducted, comprising 12 Key Informants. Table 3 shows the range of participants that were interviewed. The majority of interviews took place in-person, and the researchers complied with health and safety advice regarding COVID-19 testing and transmission. Three interviews took place over Zoom, and one over phone-call.

Four interviews were arranged through the connections provided by the CODC prior to the field-week. Through these contacts, a snowballing sampling method was employed (Tracy, 2013). Snowballing sampling improved the reach of participants in different parts of the community, which was necessary due to the population size and community dynamic of the Māniatoto study area.

Table 3. List of Key Informants and their role.

Key Informant (KI)	Identifying role
KI 1	Planning Practitioner
KI 2	Technical Expert
KI 3	Local Resident
KI 4	Planning Practitioner
KI 5	Local Resident
KI 6	Local Resident
KI 7	Local Resident
KI 8	Local Resident
KI 9	Local Resident
KI 10	Local Resident
KI 11	Planning Practitioner
KI 12	Technical Expert

5.3.4 Survey Questionnaires

A short survey-questionnaire was used to gain greater scope of how rural community-members perceived grid-scale solar developments. The survey-questionnaire was designed for quick completion, and incorporated two quantitative questions (Likert-scale) and one qualitative open-field question to provide context to the Likert-scale data (Murray, 2013). From 2-4 May 2023, the researchers completed in-person distribution by approaching local business and members of the public in Clyde, Alexandra, and Naseby. Through in-person distribution, snowballing sampling was again used to reach a greater number of community-members, as well as provide flexibility amid public health regulations for COVID-19 (Singh & Sagar, 2021). The survey-questionnaire was distributed through the mailing lists of two local interest groups, and through personal connections (see Appendix A). Resultantly, 65 responses were recorded across the Central Otago District.

5.4 Data Analysis

5.4.1 Qualitative data analysis

Interviews were individually transcribed and thereafter the raw, qualitative data were organised via coding. In the present study, codes were "grounded" in the content of the participants' own observations regarding criteria for siting of solar farms, environment and economic impacts, and social perceptions, allowing new codes to emerge as analysis continued (Mohajan & Mohajan, 2022). Raw data were organised under codes, and codes were thereafter nested under broad themes.

5.4.2 Statistical data analysis for survey questions

The survey included two questions about participants' attitudes towards renewable energy developments in general (question A) and their attitudes towards the development of solar farms in Central Otago (question B). These questions and the survey options are shown in Appendix A.

To understand whether participants' support for renewable energy would indicate their support for solar farms in Central Otago. The researchers performed a bivariate correlation using Spearman's *rho* correlation coefficient (ϱ), where $\varrho = -1$ indicates a perfect negative correlation, and $\varrho = +1$ shows a perfect positive correlation. As summarised by Murray (2013), Spearman's *rho* is appropriate for statistical analysis where:

- The data are non-parametric, as for ordinal Likert-scale data;
- There are only two variables (here, the variables are question A and question B);
- There is a monotonic relationship between variables;
- There is a sample size greater than 20 (for the present study, $n = 59$ valid responses);
- There may be outliers.

The statistical software SPSS was used to perform Spearman's *rho* correlation at significance level $p > 0.01$. A Spearman's *rho* value of <0.3 or >0.7 is considered a strong correlation, with values around 0.5 considered moderate correlation (Murray, 2013). The results of statistical survey analysis are presented at Section 7.3.2.

5.5 Ethical Considerations

The researchers were expected to comply with all relevant University of Otago Codes of Ethics pertaining to research with human participants, in order to respect participants' rights and dignity. In the present study, individuals were provided with a Consent Form, to enable individuals to provide free and informed consent should they choose to participate, and indicate their freedom to withdraw at any stage (see Appendix A). Information Sheets also detailed how information gained from participants would be used, and their roles and responsibilities as a research participant (see Appendix A). Participants anonymity was protected throughout the research, though they could indicate on the Consent Form their assent to be named in the report. Prior to the commencement of the field research, ethical approval was sought and achieved under *Category B* criteria, via the University of Otago's Human Ethics Committee (see Appendix A).

5.6 Positionality

Research positionality is the acknowledgment that the researchers' individual perspectives and experiences may affect how data were collected and interpreted (Panelli, 2004). The authors of the present research come from a range of cultural, economic, and gendered backgrounds. By drawing on the range of perspectives in the group, the researchers sought to mitigate against any biases that presented during processes of investigation and report-drafting. The authors registered no personal conflicts of interest, and sought to achieve a neutral position within the research and analysis presented in this report.

5.7 Summary

This chapter presented the research design, interpretive paradigm and ethical measures that comprised the methodology for investigating grid-scale solar farms in Central Otago. By adopting pragmatic, interpretivist, and grounded theory philosophies to the research paradigm, the researchers integrated reflexive understanding of siting and environmental aspects of grid-scale solar developments. The report utilises a mixed-method approach. A literature review and policy summary comprised the secondary sources of information, whilst primary data were gathered via interviews, survey-questionnaires, and GIS-mapping. Through mixed-methods, the researchers could embrace uncertainty and triangulate the information that was collected, to ensure that the results were consistent with the objectives set out by the CODC brief.

6.0 Site Selection Results

This chapter presents the results collected from mapping and photo-elicitation methods. Geographic Information Systems was used to develop a series of maps that to identify potential locations for grid-scale solar development across Central Otago. Photo-elicitation with Key Informants allowed the researchers to gather nuanced data about community preferences for location and design of solar farms. These results are displayed under Sections 6.1 and 6.2 in turn.

6.1 Geographic Information Systems

Through use of GIS mapping, the researchers achieved insights into the spatial dynamics of the potential for grid-scale solar farm developments in the Central Otago District and provide a comprehensive understanding of the potential locations of such developments. As a result of using GIS mapping six maps were developed using the software which produced maps that outlined the

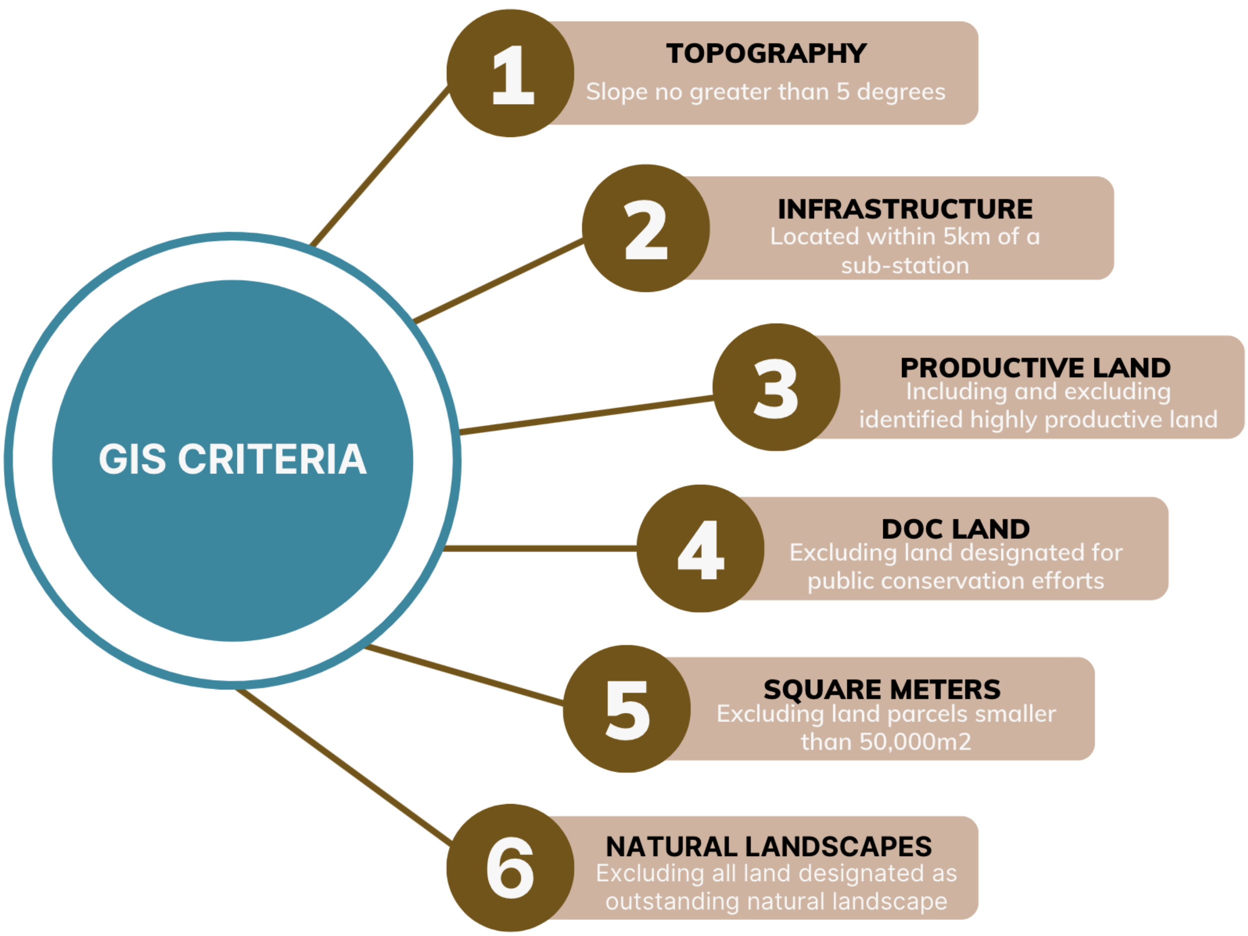


Figure 12. Geographic Information Systems (GIS) criteria.

spatial relationship between solar farm development and the following areas: Māniatoto, Alexandra, Cromwell, Clyde, Roxburgh, Lake Roxburgh, and Queensberry (Tarras). The GIS maps were all subject to a consistent set of criteria which was used to filter out land which was deemed not suitable for the solar farm developments, the criteria are depicted in Figure 12. There are still several hectares of suitable land in the district when HPL is excluded. This section provides a comprehensive understanding of the results generated by GIS software.

The first map (Figure 13) provides an overview of the Māniatoto area located in the eastern-most corner of the district. This map illustrates the location of six key substations within the area. In order to identify potential sites for a grid-scale solar farm, a 5km radius was defined around each substation, delimiting the analysis to the land encompassed within these respective areas. The areas depicted in green on Figure 13 signify the extensive portions of land surrounding the substations that align with the established GIS criteria, thus being deemed suitable for the development of a grid-scale solar farm. Most of the surrounding land of the substations in Naseby, Ranfurly, Lauder, and Wedderburn is suitable for grid-scale development, whereas Waipiata and Ōmākau have significantly less land available for development.

Figure 14 provides a visual representation of the same area as Figure 13. However, the green overlay – showing 'suitable' land – has excluded land which is classified as HPL. The exclusion of HPL reduces the total area of 'suitable' land to 18,357 hectares; a reduction of nearly 50 percent. Most of these reductions are concentrated in and around the substations at Ranfurly, Waipiata, Ōmākau, and Lauder, as the majority of that land is HPL. Nevertheless, there are minimal exclusions near Naseby and Wedderburn, indicating that these areas can be considered suitable for utility-scale solar developments.

The following maps provide the land suitability for some of the more highly populated areas of the Central Otago District: Alexandra, Clyde, Cromwell, and Roxburgh and are shown in Figures 41 and 42 (see Appendix B). In these maps, substations are located much closer to residential areas. In Alexandra, Clyde and Cromwell, there is a high density of land that is suitable for grid-scale development. As one moves further away from the substation in these areas, the topography at the 5km boundary is unlikely to allow for solar farm development. There is a paucity of land available at Roxburgh and Lake Roxburgh that is suitable for solar developments, though there is suitable land at the convergence of two substation inclusion zones. Within this part of Central Otago, it is much harder to determine whether HPL will play a significant factor in the allocation of suitable land for grid-scale developments by looking at the maps alone. The data in Table 4 indicate that, when HPL is used as an exclusion criterion, there is a significant loss of ‘suitable’ land for grid-scale solar farm development.

Table 4. Spatial extent of land that is suitable for grid-scale solar development, factoring for HPL.

Location	Including HPL	Excluding HPL	Total Loss
Māniatoto	31,775 ha	18,357 ha	13,418 ha
Cromwell	3025 ha	2477 ha	548 ha
Alexandra/Clyde	4828 ha	4107 ha	721 ha
Roxburgh	2454 ha	1724 ha	730 ha
Queensberry	3709 ha	2798 ha	911 ha

The valley between Queensberry and Tarras presents an additional promising region for grid-scale solar farm development, situated in the northern quarter of the Central Otago District (Figure 39, see Appendix B). This area offers substantial potential for the establishment of grid scale solar farm development, with the third-greatest extent of 'suitable’ land. Table 4 shows that once HPL is accounted for in Queensberry, about 25 percent of the hectarage is excluded. Suitable land is located largely to the south-east of the substation, meaning it may be necessary to cross the Mata-au (Clutha) to implement solar infrastructure.

The researchers were unable to integrate land-tenure considerations in the present study. Technical experts had explained that the number of landowners was a key site-selection criterion for grid-scale solar farms. However, these data were not available for GIS mapping within the time-constraints of the project.

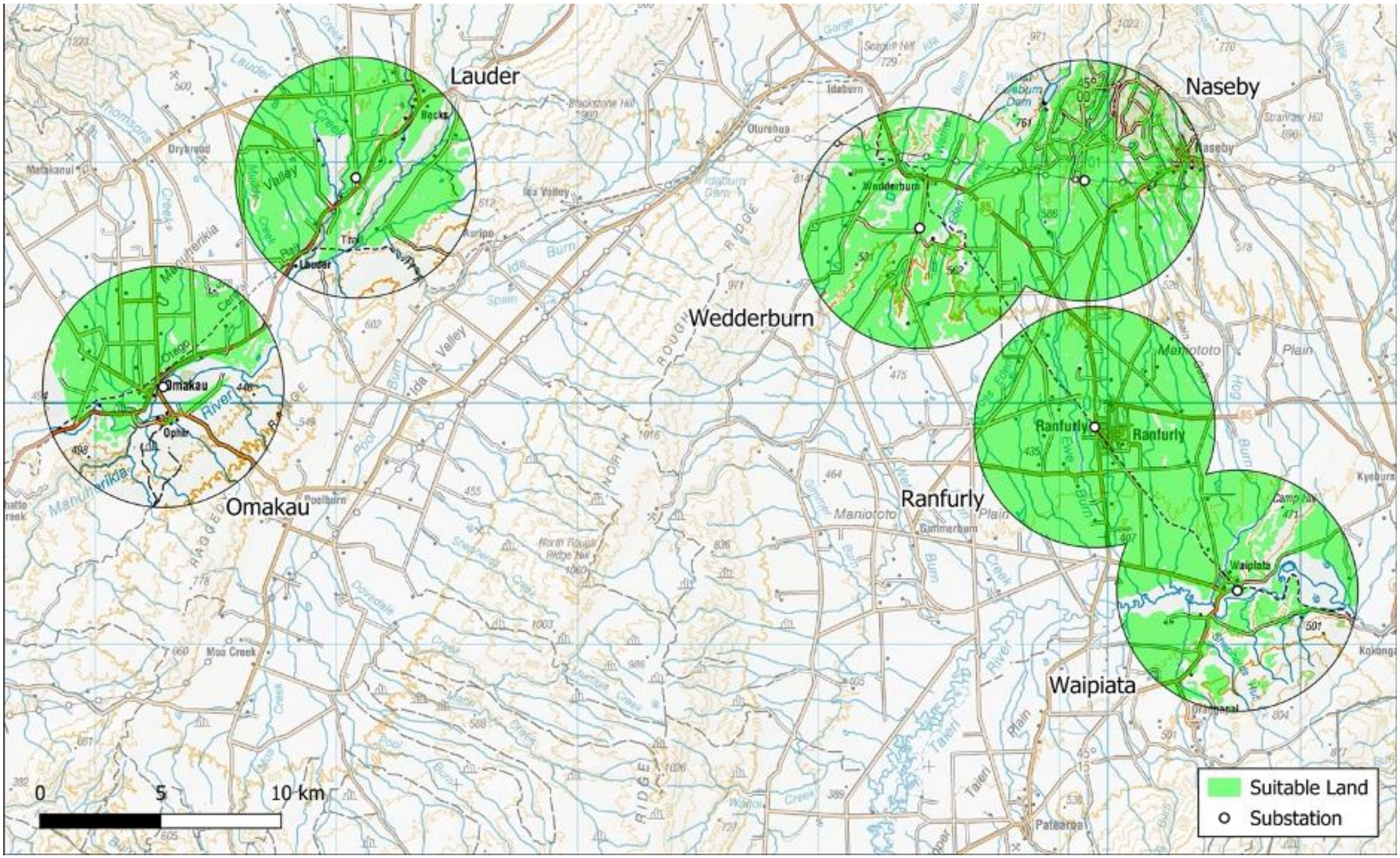


Figure 13. Māniatoto Ward solar suitability map (Including HPL).

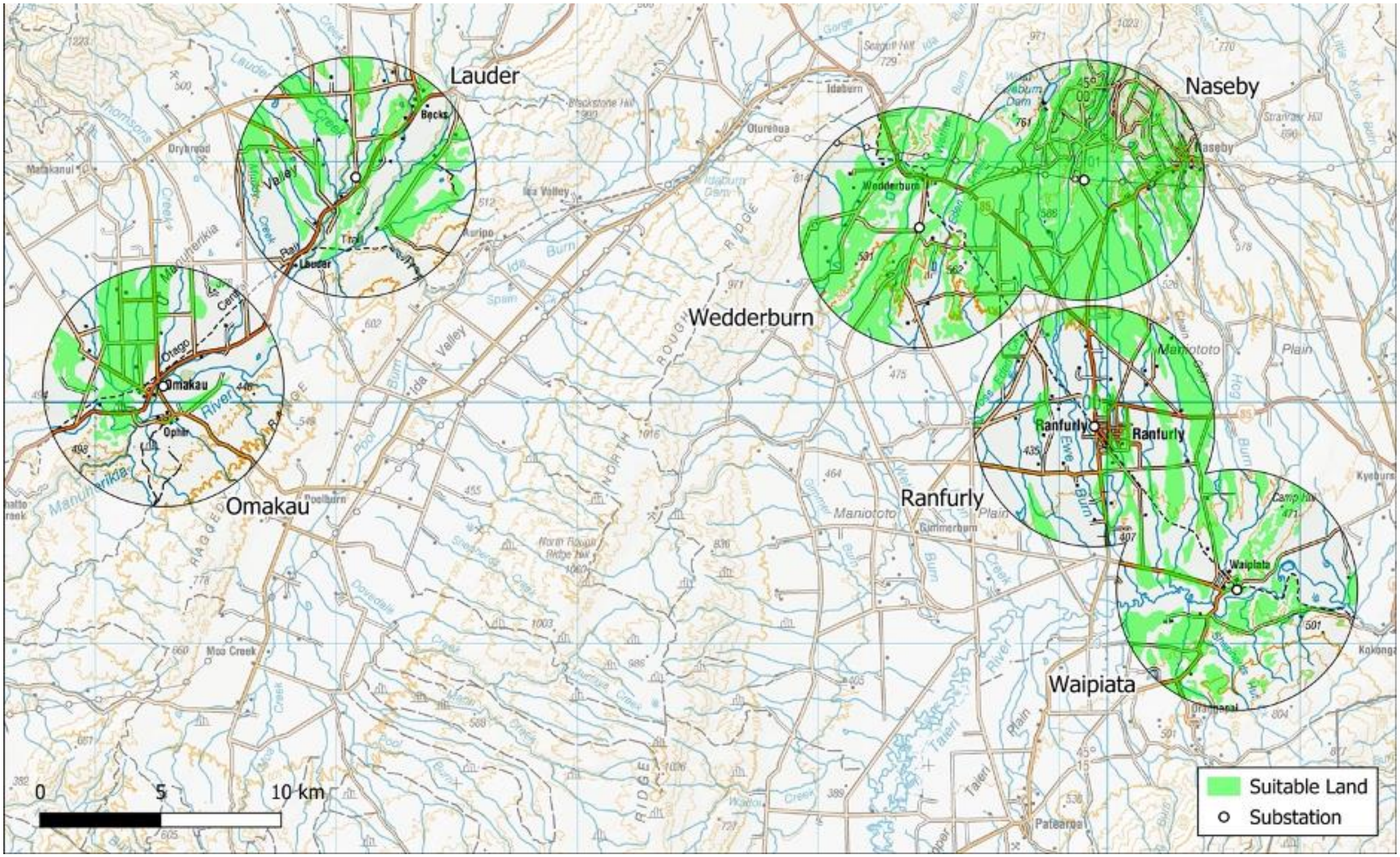


Figure 14. Māniatoto Ward solar suitability map (Excluding HPL).

6.2 Photo-elicitation

Using photo-elicitation in KI interviews illustrated what components and types of solar developments residents did and did not want to manifest in the landscapes. These results refer to all potential solar developments, not just the proposed development in Naseby. Only three KIs undertook the photo-elicitation process, which can be attributed to methodological barriers in connecting with the appropriate people to interview for this process. The results from the three KIs are nonetheless valuable, and present notions that should be examined when considering potential future solar developments. The results also demonstrate how worthwhile such elicitation would be with more residents of Central Otago. This section presents the results of the photo-elicitation by exploring each image that was shown.

6.2.1 Photo 1 – Small-scale Solar Development in Residential Space

The first image that was shown to participants is a picture of a small solar farm in a residential zone in Detroit (Figure 15). In response to this image, KI 8 commented that "I think it's pretty ugly. I'd rather see it away from residential… I would rather see it multi-use because the grass is going to grow. What's the point in cutting down good grass just so you can make electricity? We have sheep that would do that for us." In addition, KI 9 noted "I could see some people would

Figure 15. Urban Solar Farm, Detroit, USA (Source: West, n.d.).

have objection to that right next to houses." Both remarks illustrate a distaste for this sort of placement of a solar farm, and the quotation from KI 8 demonstrates a that it seems a waste to have the space as being singular-use rather than multi-use. However, KI 5 expressed a greater sense of acceptance for the siting of the Photo 1 development. As KI 5 explains: "none of those are offensive, are they? They're no different than the block of apartments." Despite of some difference of opinion towards the solar development depicted in Photo 1, it is evident that community-members are interested in efficient land use.

6.2.2 Photo 2 – Small to Medium Sized Solar Development

The next photo that was shown to participants was of a small to medium-sized solar development in a rural area in South Taranaki (Figure 16). KI 8 mentioned that "my preference would be to see more multi-purpose." This again highlights how some local residents may see it as being significant to enable multiple land-uses in solar developments, to ensure that the land is used to its full potential. Furthermore, KI 9 stated that "I don't find that as obtrusive [in comparison to Photo 1]." Key Informant 9 preferred the fact that this development was sited rurally, rather than in a more residential zone. Hence, KIs' feedback suggests that they found a rural location to be more acceptable for this style and size of solar development.

Figure 16. Solar farm in South Taranaki (Source: Sunergise, 2021).

6.2.3 Photo 3 – Large Solar Development

The third photo that was shown to participants was of a large-scale solar farm in Queensland (Figure 17). In response to this image KI 8 asserted "no I don't think that is practical at all for [Māniatoto]." The reaction from KI 9 aligned with that of KI 8, as they explained "that's too big… what I like about the Fennessy Road one is that it's out of the way, it's out of sight and I like that." Similarly, KI 5 aligned with these notions of distaste for such a large development, as they expressed "I wouldn't like it." These three quotations illustrate that the size of solar developments is a significant matter. Furthermore, it is clear that the issue of visibility is a factor in the acceptability of a solar development. The larger the solar farm, the more difficult it would be to keep it out of sight from the public, depending on the surrounding topography, adjoining land-use, and proximity to main roads. Nevertheless, KI 5 raised the discussion point that these larger solar developments must be more efficient than smaller ones, and would therefore make more sense with regard to economic benefits. This raises several questions as regards who owns this type of larger-scale development; who is benefitting from it the most; and in what ways does this matter to the local 'host' communities.

Figure 17. Solar farm in Queensland (Source: Tisheva, 2022).

6.2.4 Photos 4 and 5 – Agrivoltaic Solar Developments

Photos 4 and 5 exhibit two variations of agrivoltaic systems for growing crops (as opposed to grazing sheep). The first of these solar developments is in Kajiado County in Kenya (Figure 18), and the second photo (Figure 19) depicts a development in Colorado, USA. When KI 5 was shown these images, they stated “Well, and if that worked, that's the ultimate isn’t it. You've got highly productive land being highly, highly productive land because it's feeding and energising.” This quotation demonstrates a strong level of positivity towards agrivoltaic solar developments, whilst also commenting on the nature of these developments having two outputs rather than one. The responses from both KI 8 and 9 did not present quite the same level of positivity. However, they still showed acceptance of this type of solar development. For example, KI 8 said “I don’t have an issue with that”, and KI 9 remarked that “you could see it [agrivoltaic systems] happening.” From these results, it does not seem unreasonable to suspect that community responses to agrivoltaic solar developments would be more positive than to single land-use solar developments.

Figure 18. Agrivoltaic solar farm in Kajiado County, Kenya (Source: Kamadi, 2022).

Figure 19. Agrivoltaic solar farm in Colorado (Source: Siegler, 2021).

7.0 Thematic Results

This chapter explores the thematic results derived from our research. Section 7.1 discusses the considerations required for site selection and identifying the necessary infrastructure. Section 7.2 outlines the potential impacts that such developments might have on the locale and wider Central Otago district. Section 7.3 identifies the community perceptions of grid-scale solar farms which aims to capture the viewpoints, attitudes, and concerns of the local community. Additionally, Section 7.4 looks to investigate the importance of the Central Otago landscape by exploring the unique natural surroundings and how grid-scale solar farms may impact these. Finally, Section 7.5 looks to identify how the Council and planning processes will influence the development of these farms. Figure 20 below gives an overview of the Chapter structure.

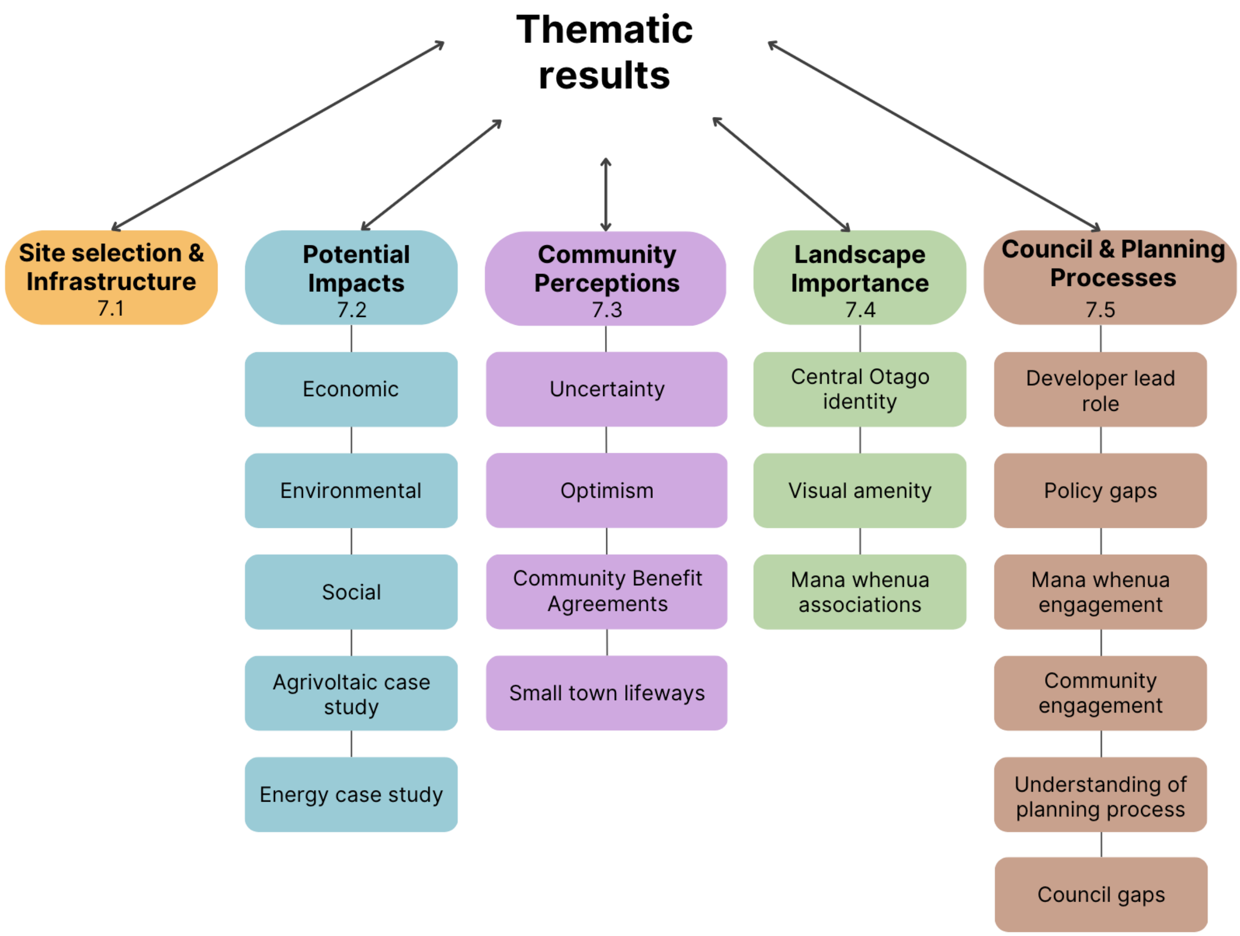


Figure 20. Themes of Chapter 7.

7.1 Site Selection and Infrastructure Factors

To understand whether a particular site would be effective for solar-farm development, one must assess the extent of the site's exposure to solar radiation. Key Informants emphasised various strategies to achieve this, such as employing GIS mapping to assess insolation, and selecting wide open sites with minimal shade from structures and natural elements. Table 5 outlines the insights from KIs in regard to the importance of solar radiance exposure.

Table 5. Key Informant responses regarding solar radiance exposure

Key Informant	Quotation
KI 2	*"In terms of criteria for a solar farm, you have what's called the "solar resource," and there's maps of New Zealand that show where the solar is. So basically, the dark spots on the maps, the better the resources, the better productions. You can have a farm which is going to have higher yield than if you build exactly the same thing somewhere else. So, a higher production of energy. That's number one."*
KI 4	*"I do understand that the radiance, the amount of solar energy received, is pretty similar across most of the country – even going from far north to far south. And it's not much affected by cloud cover [...] as soon as the sun's up, you'll have a real bell curve of generation, starting out quite small, and then really picking during the day, and drop back again, and obviously nothing in the dead of night."*
KI 12	*"There's some management and maintenance associated with making sure that the panels are relatively clean and debris-free. For example, snow and ice loading can cause significant problems. Similarly, large amounts of leaves and all sorts of other debris that can collect is quite significant."*
KI 5	*"Logistically, one in the middle in the big open space would be a better bet and have more minutes of sunshine. That's what they'll be measured: by how much they can suck out in a second. It's only a few select few that would be able to do it."*

Key Informants emphasised grid-connectivity as a crucial consideration when prioritising the development of a solar farm. As shown in Table 6, several quotations underline the significance of proposed sites needing to be near a substation of sufficient capacity. They further stressed that the closer the solar farm to the substation, the more cost-effective the transmission lines or trenches. As KI 12 highlighted, "you can't build a giant solar farm 10 kilometres away from a *[substation]* because your loss across that line becomes uneconomic."

Table 6. Key Informant responses regarding accessing the grid

Key Informant	Quotation
KI 2	*"You're looking for substations, ideally, that have capacity already because it's how they're designed. They've got a bit of room so you can add more generation there, or you can also go to the overhead lines in some cases. But that's quite expensive because you have to build a new substation underneath the lines.* […] *When you're looking at a substation with capacity, once you've got one, you can then do about a 5-kilometre radius from that."*
KI 12	*"They also usually require that the supplier is relatively close to the GXP [substation]. The rationale behind that is to do with line losses."*
KI 6	*"I think the closer you are, the better* […] *It's half a million dollars a kilometre to put on underground. So if you really get too far away, all of a sudden your efficiencies of the pricing gets tougher."*
KI 8	*"It's right by a substation now – they don't need to build a new substation. I'm sure that was part of the planning process, and I could see the concept spreading"*

Furthermore, KIs highlighted several siting factors that ought to be accounted in the site selection process. These factors include ensuring that the land slope does not exceed 5 degrees; considering land parcels owned by only one or two individuals; the presence of existing shelter belts; assessing the soil quality; and the willingness of landowners to utilise the land for solar farming purposes. These criteria are shown in Figure 21.

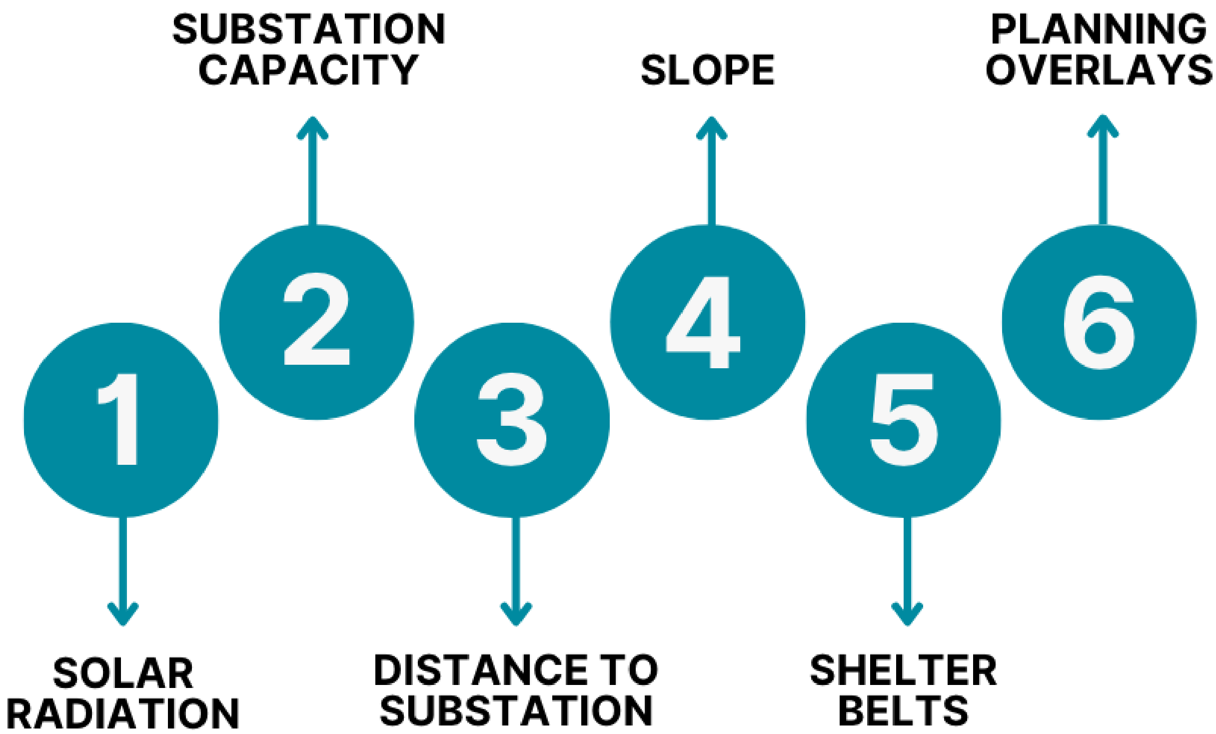


Figure 21. Site selection criteria for solar farms.

Key Informants expressed that infrastructure and transportation factors were necessary considerations for solar developments. It was highlighted by KIs 2 and 4 that a well-devised transport management plan is crucial to facilitate transportation of equipment to the site while minimising disruptions to the local road network. Specifically, KI 4 mentioned that it was important to set aside times for heavy vehicle use, to avoid conflicts with activities like school pick-ups and drop-offs. Finally, KIs communicated uncertainties regarding the optimal method of transmitting power from the solar panels to the substation. While pylons and power poles are considered the most cost-effective approach, KI 12 acknowledged that they are generally unpopular among the public.

7.2 Potential Impacts

7.2.1 Economic Impacts

The collation of survey and KI responses revealed a number of potential positive and negative economic impacts from grid-scale solar farms. Local residents generally placed their focus on the positive economic impacts a grid-scale solar development may have for the wider district. Professionals questioned the extent of positive economic impacts, and whether benefits would be long-term and wide-ranging, rather than just short-term.

(a) Direct economic benefit

Survey Respondents focused on the potential economic benefits that could be directly drawn from a grid-scale solar development. Focal points concerned benefits from employment and servicing of accommodation; matters raised in 18.5 percent of survey responses, the second most mentioned impact. Survey Respondent 3 took a broader approach to the question and stated that there would be "positive economic benefits to New Zealand" on a national level, through the use of renewable energy. Survey Respondent 49 mentioned "Personally the direct effects to my family may be small. It is possible a small reduction in power price. [...] Some local jobs created especially during construction". Similarly, SR 47 broadly hoped that economic benefits would flow to the local setting.

As shown by SR 49, many individuals commented on the hope for cheaper power or energy rates in their place of residence as a positive economic impact (SRs 30, 33, 34, 57). Key Informant 3 summarised the views of many other respondents by stating "I can see the economic benefits of being able to generate power for local populations from solar."

Many SRs were of the view that it would be positive if solar developments would augment local employment (SRs 42, 44, 49). Most of these reflections were centred around the creation of jobs during the construction and development stages of solar farms (SRs 29, 42, 49). Two responses specifically acknowledged that construction employment would be a short-term benefit (SRs 54, 55). The short-term economic impact from construction was observed by technical experts KI 2 and KI 12, whilst local resident KI 10 was uncertain how much employment would be generated by solar-farm construction in comparison to agriculture (Figure 22).

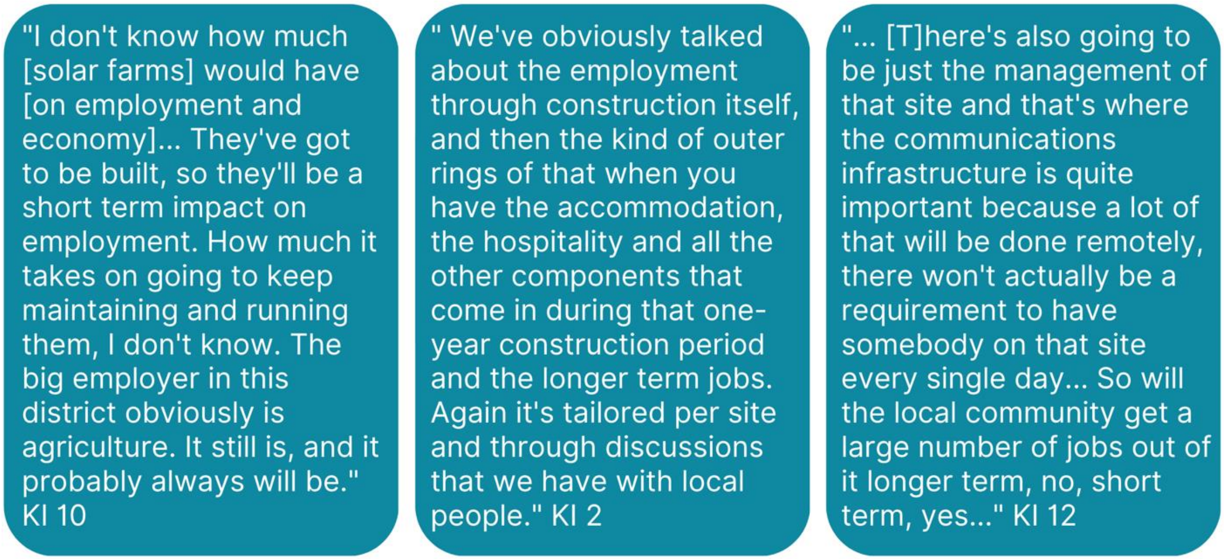


Figure 22. Key Informants 2, 10 and 12 comment on direct economic impacts from solar farms.

(b) Secondary economic benefit and economic resilience

Several KIs discussed how employment could have flow-on benefits for accommodation and facilities. From the developer perspective, KI 2 observed the potential secondary economic benefits to contracting landowners:

> *"We are leasing the land, so the land is staying in local ownership; providing income to them so they can stay local and invest their time and money opportunities in other areas as well … so they have a bit more capital to do what they'd like locally with it."*

Practitioner KI 1 noted they were uncertain about the scope of potential secondary economic benefits to communities like Naseby, but "as far as accommodation and servicing to those households, that could be quite stimulating." Naseby resident KI 7 commented that:

> *"it's always good to have those workers coming to town, we only have one pub, that keeps it busy, accommodation probably going to get a few houses in Naseby long-term, it's all good for the town."*

As shown in Figure 23, KIs 1 and 7 specifically noted that previous transmission-network upgrades had boosted opportunities for business, technology, and investment in the district.

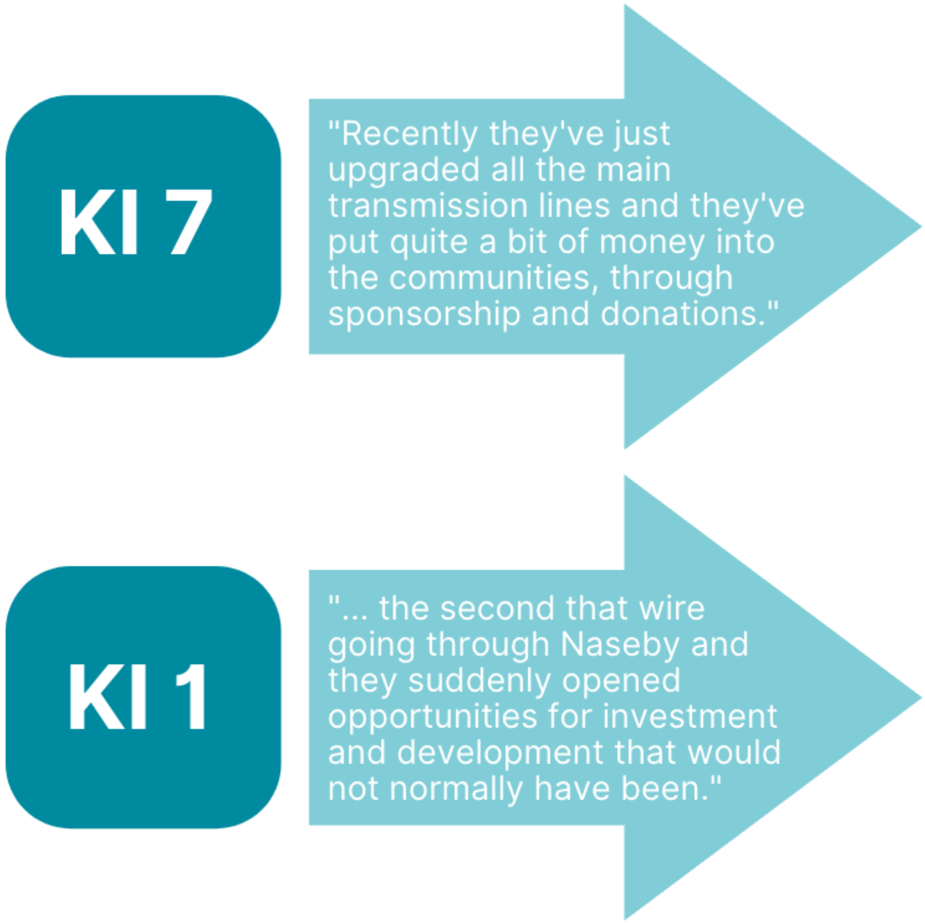


Figure 23. Economic diversification from previous transmission-network upgrades in Māniatoto.

The notion of economic resilience also appeared across survey and interview responses. Key Informant 1 hoped that solar farms in Central Otago could support diversified and "sustainable" economic opportunities for residents:

> *"It's a way that can diversify livelihoods and sustain and subsidise incomes…so this is an opportunity to see how you can continue to diversify based on your assets, your natural assets, your fakeable assets. [...] The better outcomes for us [are in] things that need servicing, because that means you've got a sustainable yield from the resource. That means our little dairies and our cafes, and our little petrol stations continue to get used."*

Local resident KI 5 also spoke about the potential for economic diversification and growth in Māniatoto's small settlements, stating "if we want to have that ownership and be a big community, we've got to keep going forward". They expressed a determination that their family, alike other farm holders in the Māniatoto, wanted to explore business opportunities where land was held intergenerationally. However, KI 5 wondered about the economic opportunities to be gained from proposals that were immediately in view for Māniatoto:

> *"Onslow, solar farms, two gold mines and an airport all could be built in the next 10 years. Now in that, there's a massive opportunity for* [young people]."

Key Informants revealed some of the uncertainties around the potential for economic benefits to arise from large-scale solar developments. Key Informant 1 mentioned that the benefit may in fact be very underwhelming, or a solar development may be operated "remotely" through little local human resource, which would grant fewer economic benefits for locals. Similarly, KI 6 did not anticipate huge economic benefits to the Naseby community, aside from short-term boost during the construction phase.

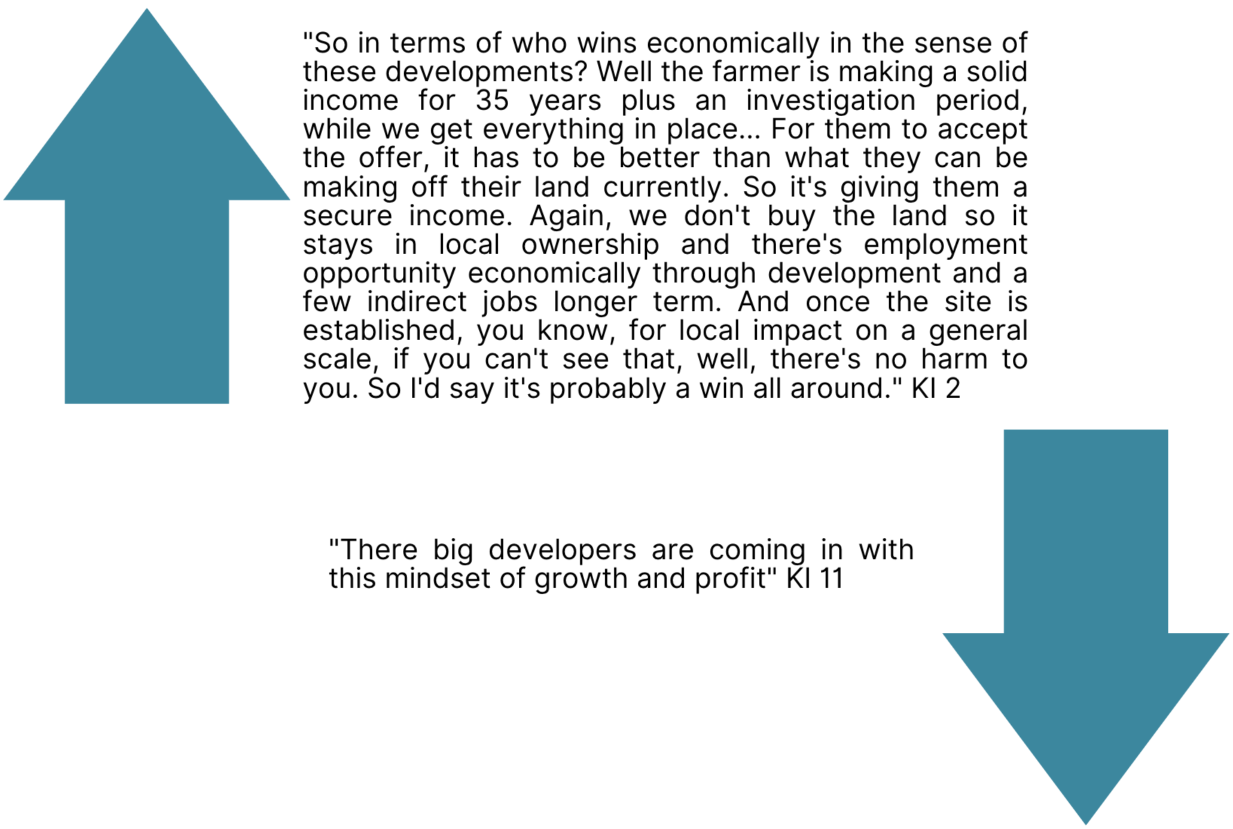


Figure 24. Discourses about economic benefits: community gains versus developer profits.

Several KIs, such as KI 1, discussed whether economic benefits would accrue to one sole "singular winner", or to the broader community. Local resident KI 9 questioned if it would only be the landowner who received economic benefit from solar developments. Practitioner KI 11 related this to how the planning system treated economic, social, and environmental outcomes: "economic usually gets prioritised. Then you get some environmental, and then maybe you'd get some social as an afterthought."

Key Informant 8 also commented on how there is not a lot of space for the town of Naseby to gain economically from this development, due to limited places where one can spend money. In relation to the potential for tourism-based economic benefit from solar farms, KI 10 stated that tourism "is the cream on top", but agriculture was the important wealth-generator for the area.

7.2.2 Environmental Impacts

Throughout KI interviews and survey data, environmental impacts arose as concerns from the local community, and explanations from professionals. Community-members were concerned about negative consequences including the solar panels' lifecycle, impacts of construction on rural transport networks, and negative impacts on agricultural productivity.

Multiple respondents compared solar farming as a land-use to current land-uses occurring in Central Otago and the Naseby environs. Compared to the few dairying farms that have established since irrigation was introduced to the area, KI 10 indicated that solar farming would be an improvement in terms of impact on the environment. More commonly across the district is less-intensive sheep farming. This was commented on by KI 8, who specifically referred to the consented development: "...none of that's high value high density grazing, so there's probably very little change to the farming practices." Similar comments from KI 10, referring to the wider district, suggest that some residents see solar developments as an opportunity to improve productivity of less-intensively used land.

Community-members also raised their concerns on the sustainability and lifecycle of the components that make up solar developments. Their main concern was the potential for waste from batteries and panels after decommissioning (KIs 5, 11; SRs 13, 61). The technical professionals who were interviewed provided detail on efforts to minimise waste throughout the construction, operational, and decommissioning phases (Figure 25). While technical experts (KIs 2, 4) acknowledged the risk of waste and the related environmental impacts, they also postulated that this is not only a matter of what technology that is currently available, but what will be available in 35 years when decommissioning of these consented developments will occur. Although most participants shared a concern for waste as an environmental consequence of solar developments, this was not shared by all. Key Informant 1 remarked that "... I do think that fact that it doesn't have a long-lasting impact on environments is quite fundamental", showing a need for further understanding from all involved in the planning process.

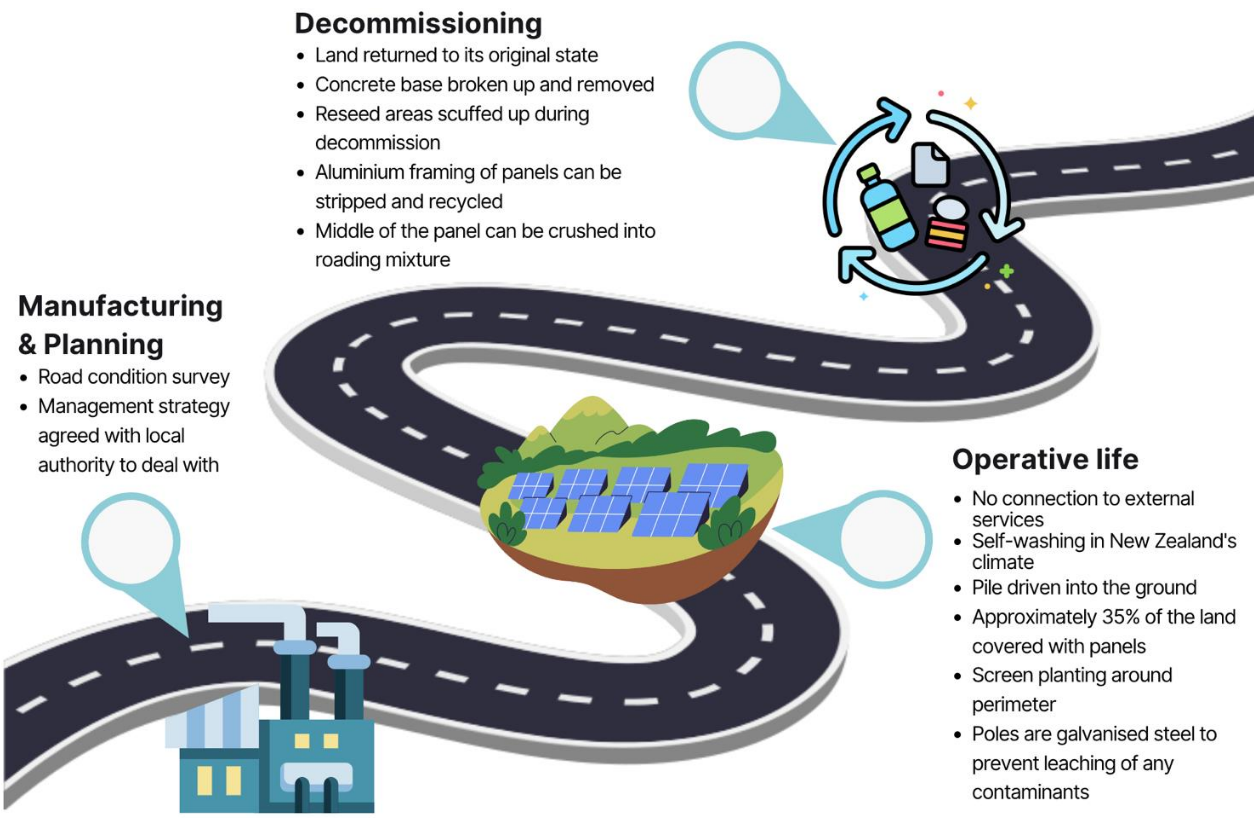


Figure 25. KI 2 discusses efforts made to minimise waste throughout the life of solar developments.

7.2.3 Social Impacts

Research participants identified social impacts and considerations across a range of themes. Impacts ranged across the lifespan of the project, and were perceived positively, negatively, or context-dependently. Many social impacts overlapped with those economic impacts addressed under Section 7.2.1. Social impacts are categorised across Tables 7, 8, 9 and 10.

Table 7. Positive and negative social impacts during Phase 1: Community engagement, planning and siting phase.

<table>
<tr><th>Positive social impacts</th><th>Negative social impacts</th></tr>
<tr><td colspan="2">Phase 1: Community engagement and planning + siting phase</td></tr>
<tr><td>Alignment with renewable energy attitudes
'Low impact, better than Huntly coal and adds a bit of employment in the district' (SR 44)

'Major benefits [sic] for the environment [sic]. May spoil the view for some people but not for us as every time we will see a solar or windfarm, we will think it is a good thing [sic]' (SR 49)

Community buy-in if sited "carefully" or "sensitively" (KI 8 – Local resident)

Landowners have another option for income
"So, the land is staying in local ownership: providing income [...] so they have a bit more capital to do what they'd like locally with it" (KI 2 – Technical expert)

Contracting landowner can "protect income" - a post-Covid consideration
"We discussed how we wanted to continue farming. … It's to protect our income really. Like when Covid-19 came in and people got buggered - we wouldn't be affected with our income, which is a steady income which will still be there." (KI 6 – Local resident)

Ancillary impacts of development
"Recently they've just upgraded all the main transmission lines and they've put quite a bit of money into the communities, through sponsorship and donations." (KI 10 – Local resident)</td><td>Concern for identity, visual impacts on valued unique landscape
"Sensitively done, [impacts] could be very minimal [...] If it was too intensive or too widespread, it could be considerable, but if we don't get greedy, we can do it right and not offend people, not have massive areas of high visibility, valuable land taken up." (KI 8 – Local resident)

Landowner, developer benefit at community expense of other opportunities
"[the developers] run away with the money and they are occupying our space, and what could that space be used for. Quite often, it's in the private ownership anyway so it's a commercial decision." (KI 11 – Planning practitioner)

"So, would this be a singular winner? Or would it be something that that a lot of people could benefit from?" (KI 1 – Planning practitioner)

Private energy developments misalign with community values
'Want it to be totally community owned. no private ownership and no chance of it being "broken" up by any future entity' (SR 59)

Impacts on community cohesion
"There's going to be a certain amount of jealousy when you know [a local farmer] gets $250,000 a year and [another farmer] gets $250,000 a year and the guy next door that's two miles away from the transformer can't get anything." (KI 5 – Local resident)</td></tr>
</table>

Table 8. Positive and negative social impacts during Phase 2: Solar farm construction phase.

Positive social impacts	Negative social impacts
Phase 2: Construction phase	
Accommodation impacts for local communities “We really [stay] as local as possible in terms of that detail of where they'll stay.” **(KI 2 – Technical expert)** **“**It could be a benefit [...] because they were w**ell looked-after here** and they were able to rent houses at prices that would be considered laughable compared to what you pay for rent in Queenstown or Auckland” **(KI 10 – Local resident)** **“**If it's done, and the workforce is stationed within the community, the community feels a whole lot better about it” **(KI 5 – Local resident)** **Localised opportunities** “So particularly site maintenance and some [...] replacement of parts [...] that's all things we'd like to do locally, and then you have the more specialist skills as the industry develops, hopefully they'll be more local skills […] But hopefully through again the scholarship opportunities and upskilling, we can also go local as it progresses.” **(KI 2 – Technical expert)** **Vibrancy and commerce** “It's always good to have those workers coming to town. We only got one pub now - that keeps it busy. Accommodation [is] probably going to get a few houses in Naseby long term. It's all good for the town.” **(KI 7 – Local resident)**	**Trade-offs related to accommodation** *‘Jobs for central but we need accommodation’* **(SR 29)** **“**So, you will probably you're quite likely have, have some people, move into the area temporarily. Yeah, how they're accommodated?” **(KI 4 – Planning practitioner)** **“I**t would be interesting to talk to local people out there to see what the views are on if accommodation was provided [...] in Cromwell. [...] they might feel a bit jilted.” **(KI 1 – Planning practitioner)** **“**Accommodation for the workers [...] They've got nobody to do their cleaning and stuff” [regarding enough able-bodied workers]” **(KI 9 – Local resident)** **Changes to local culture** “Some people in those communities might also see some short term dis-benefits. It's kind of like, ‘well, we don't really want these people here, and that might be causing trouble and standing at my favourite, table in the pub,’ or whatever” **(KI 4 – Planning practitioner)**

Table 9. Positive and negative social impacts during Phase 3: Solar farm operational phase.

Positive social impacts	Negative social impacts
Phase 3: Operation phase	
Tourist interest "I guess it depends on how widespread the development of solar farms is, I mean if they've become quite commonplace, then probably not much [tourism] interest. But if it's unique I think certainly there'll be an interest." **(KI 3 – Local resident)** **Diversification of options in a predominantly rural district** "In principle I like the fact that it's a way that can diversify livelihoods." (**KI 1 – Planning practitioner)** Little impact on 'day-to-day' life "[solar development] would have relatively little impact in terms of what goes on day-to-day. And I don't see it having a big impact on our community" (**KI 10 – Local resident**) **Potential improved access to technologies** "When you get like the second wire going through Naseby, and that suddenly opened opportunities for investment and development that would not normally have been there." **(KI 1 – Planning practitioner)**	**Expectations of significant social benefits may not eventuate** **"**It could be very underwhelming, … even in that dam, Roxburgh, [there are] few people working. There's very little human resource." (**KI 1 – Planning practitioner)** *'Personally, the direct effects to my family may be small'* **(SR 49)** ***Concerns for fire risk and local capacity to meet fire risk*** "I'm on the fire brigade and we've got to buy a new truck or first responder. [...] well, actually, you're going to put solar farm, and there's going to be 15 Australian companies over here. [...] but our community's only got a bike and Fire & Emergency aren't going to give us [an appliance]" **(KI 5 – Local resident)** Trade-offs between competing benefits or disbenefits: *'Jobs for central but we need accommodation'* **(SR 29)**

Table 10. Positive and negative social impacts during Phase 4: Solar decommissioning phase.

Positive social impacts	Negative social impacts
Phase 4: Decommission phase	
Land can be returned to former use after lease period **Increase in local economic activity during the decommission phase, comparable to the construction phase**	**Concerns about solar e-waste** "I think it's something which is becoming more and more an issue for some people, certainly something which I think probably the public and possibly also can see authorities would like to know that the developer you know has taken into consideration." (**KI 4 – Planning practitioner)** "One of our main concerns was [...] what happens at the end of the deal. So, you got a whole lot of stuff in your paddock. So that [...] written in the deal anyway: what's going to happen here at the end." **(KI 6 – Local resident)** **Decommissioning is a large-scale process** "[a decommissioning plan] is something needed at the time of commissioning, as decommissioning is as big a job as actually building the thing." (**KI 4 – Planning practitioner)**

(a) Discourses about social impacts

Social impacts, including noise impacts, were important considerations in the viability of solar energy as compared to other forms of renewables. Practitioner KI 4 stated that "on a really generalised basis, solar is way easier to consent than wind." Key Informant 4 added that a SIA could be useful "for a small rural community and a large development." Planning professionals were clear that social effects could be considered but fell outside of the resource consenting process. One planning practitioner, KI 11, completed the AEE for the Naseby Solar Farm. However, KI 11 explained that "there was an absence of any policy levers to ensure that social outcomes were realised, alongside economic outcomes [...] in my [AEE]." Key Informant 11 opined that "maybe you'd get some social [considerations] as an afterthought."

(b) Trade-offs

Community-members and practitioners both commented on trade-offs between different environmental, economic, and social effects. Opportunity cost was pointed out by KI 11, who gestured to the financial gains that developers seek when they enter a community:

> *"...they are occupying our space, and what could that space be used for. Quite often, it's in the private ownership anyway so it's a commercial decision."*

Other trade-offs were identified by Naseby residents, who had recently accommodated workers during the recent transmission-line upgrades. While the workers were "well looked-after" in Naseby (KI 10), there was a shortage of able-bodied workers able to support with accommodation needs (per KI 9). Survey Respondent 29 also directly addressed how jobs for central would be traded off against the accommodation shortage.

Conversely, KI 1 indicated that local residents, such as the Naseby community, might feel "jilted" should workers be accommodated in Cromwell instead. KI 5 echoed this sentiment more broadly, in relation to a skilled local workforce: "Let's have a look at a system that would subsidise a young truck driver to like in Ranfurly to work on the solar farm. But what you'll find is, oh no, they're coming from Cromwell."

7.2.4 Agrivoltaic Case-study

Aside from the photo-elicitation results, a number of KIs, and a couple of SRs, conveyed varying knowledge and opinions on agrivoltaic systems and whether they would be viable in Central Otago. Across the data, there appears a general consensus that employing agrivoltaic systems would have positive impacts. Regarding more specific effects of agrivoltaic systems, SR 54 contended that agrivoltaic systems are a "great land use for farmers… [with] ongoing positive environmental impact". Solidifying this point was KI 2, who expressed "I can't say really that on the whole we'd have negative impacts in that space. It's another land use and the correct place that really, we think, complements the existing rural environment." Each quotation demonstrates how participants imagined that agrivoltaic systems would adduce positive environmental impacts. In addition, KI 10 mentioned an economic impact explaining "that paddock there I use for cropping, I could put solar panels in there, it might affect my cropping a bit, but I can still get use out of that and … I presume that whoever owns those areas will expect some return … So, there's potential for [agrivoltaic] to be a win-win." However, while KI 10 portrays some understanding of the economic benefits from agrivoltaic systems, with regard to crops, none of the other KIs mentioned potential economic impacts.

Some participants had reservations about the possibility of agrivoltaic systems, specifically with regard to growing crops. For instance, KI 7 pointed out "the old cropping down here [...] especially vegetables, it's a very short growing season for a start, and you need plenty of water, which we don't have around this area too much." Further, KI 6 explained that the "soil is too light to grow those good crops." Although there appeared to be some scepticism regarding the co-location of crops with solar, numerous participants discussed grazing sheep under solar panels (Figure 26). It should be noted that, according to KI 6, the proposed Naseby Solar Farm would incorporate sheep-grazing under the solar panels.

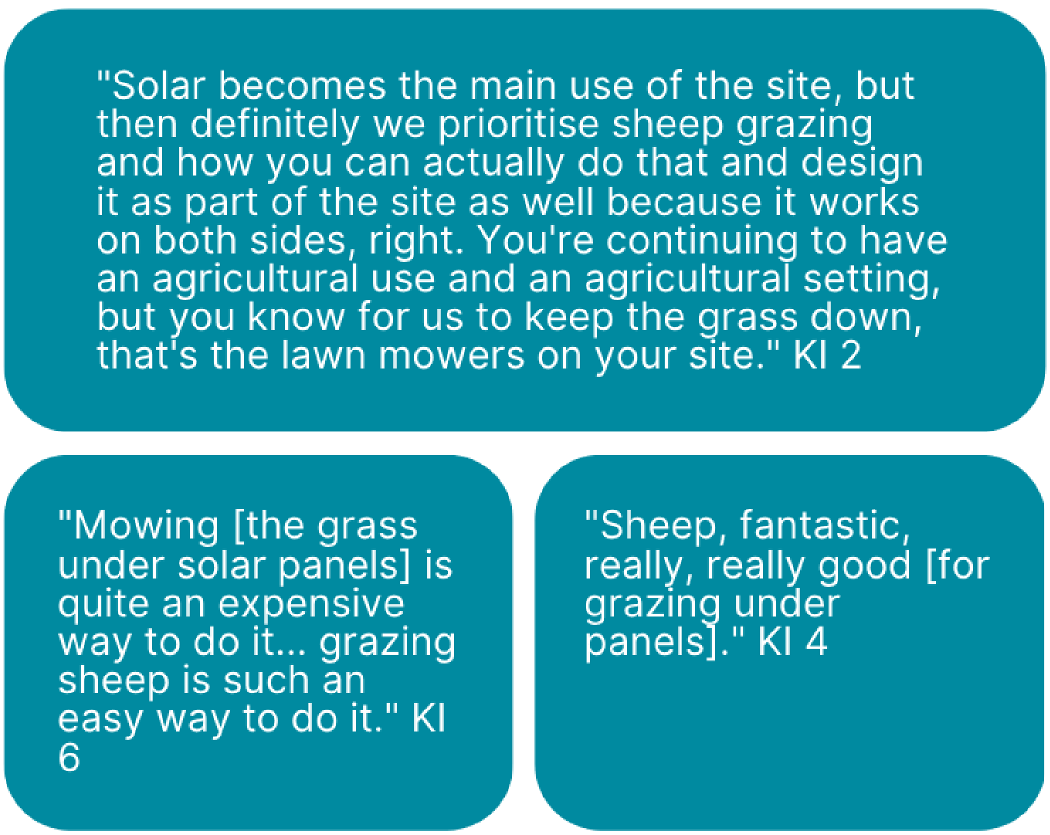


Figure 26. Quotations that comment on agrivoltaic impacts from grazing sheep.

7.2.5 Energy Case-study

The increase in REG was acknowledged by local residents, technical experts, and practitioners. Responses congregated on the idea of renewable energy and its benefits, whilst also contrasting solar with other technologies. Many respondents commented on the national need for greater REG supply.

Key Informant 2 asserted that "you guys are at the forefront of what's happening in New Zealand." They explained that "there's been a kind of 'lull' where there hasn't been much renewable energy development in New Zealand, but we're now facing some quite pressing needs to develop more renewable energy in this country." Key Informant 2 reflected on the nature of Aotearoa-New Zealand's current energy situation and the increased need for renewable energy:

> *"By 2050 we need 70 percent more power in New Zealand. We're framing that up, trying to get it how people can understand in real terms. That's the equivalent of us building a new Clyde Dam every year for the next 27 years – so it's huge in scale, the amount of power that we need in this country just to keep the lights on and keep things moving. It's a lot of power and every region's going to have to take its part because of the scale of this."*

Key Informants 5, 8, 9 and 10 all indicated that Māniatoto has been the subject of interest by energy developers for some time. Key Informants 8, 9 and 10 described a preference for the passiveness of solar in contrast to previous proposed wind developments, such as the Project Hayes windfarm. Survey Respondent 59 appeared to reference their resistance to the sale of State-Owned Enterprises, and specifically advocated for community ownership of energy:

> *"want it to be totally community owned. no private ownership and no chance of it being ''broken'' up by any future entity."*

Table 11 collects the ideas from KIs 2, 4 and 10 who expressed the need for there to be national prioritisation of REG. Similarly, SRs portrayed the idea of more renewable energy as a positive endeavour for Central Otago (Figure 27).

Table 11. Key informant responses about renewable energy in Aotearoa-New Zealand.

Key Informant	Quotations
KI 2	*"… you've got population growth, you've also got electrification of private transport, public transport, a variety of sectors […] there's a lot of pressure to electrify because of our targets around emission reductions […] Framing these discussions, I'd say what are the opportunities, what are the types of technology, and what makes a good mix?"*
KI 4	*"We've got a lot of renewable generation in New Zealand and within the last month, I think up to about 95 percent of the electricity generated in New Zealand came from renewable sources in a particular week, which is pretty huge. But we have dry years, we have a massive increasing demand over the coming decades for electricity use […] We also need to take industrial things. There's a lot of coal boilers, for instance, and dairy factories, and in other industries […] the need to replace fossil generation and to provide electricity for new users, which also helped offset fossil fuel use. The demand for renewable energy, in which solar is at, is really, really important."*
KI 10	*"One of the things that's very clear is that New Zealand has a power generation issue. Stunningly, in a country of only 5 million people, so many rivers running to the sea, we can't generate enough power and we have to currently import coal and oil from overseas to generate power to drive electric cars […] but that's the reality of the country's situation, so it's got to be addressed. Either we accept the fact that EVs aren't the answer, and right now they're dirtier than petrol cars and we go back and advance petrol and hydrogen technology, which puts less demand on having to generate electricity. Quite frankly, I'm a proponent for that. […] [either] we increase our generation by some means or another, because we're going to have to if we replace all of our current fossil fuel vehicles with EVs."*

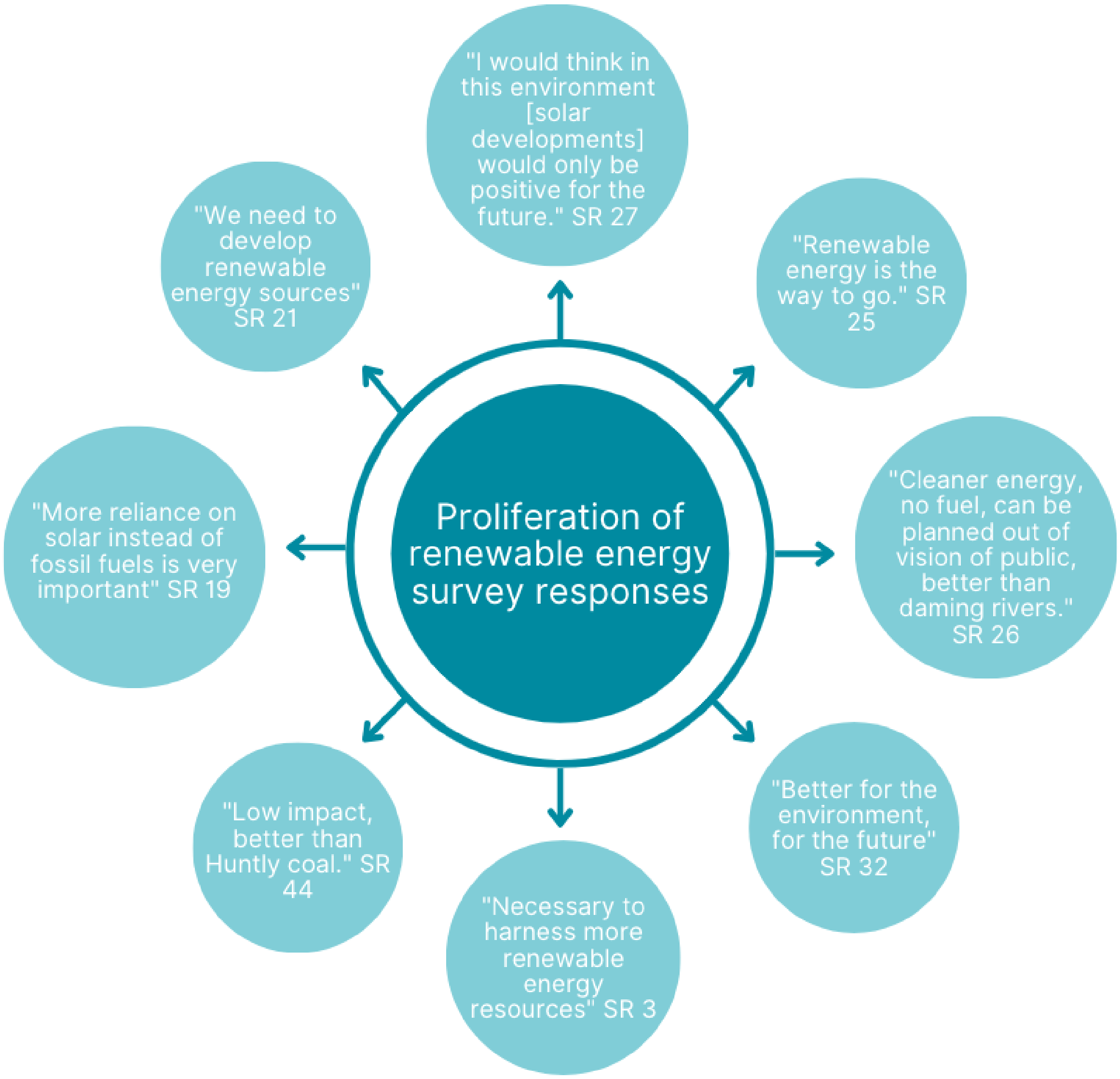


Figure 27. Survey Respondents comment positively on the proliferation of REG in Central Otago.

Twelve of the SRs (18.5 percent) commented on how renewable energies were a future-focussed form of electricity supply. Several SRs (SRs 26, 44, 49 and 62) contrasted the impacts of solar with other forms of energy production such as coal, hydro and wind, to demonstrate how solar was a preferable option for the future. According to SR 42, "the long-term power that will be made *[from solar]* will help our struggling electricity industry…can't be heavily reliant on electronics and not have ways of getting electricity." Key Informants responded similarly, stating that "solar seems like one of the viable options going forwards" (KI 10) and is "part of the solution" (KI 2).

Local resident KI 10 maintained that "either everyone in the country *[installs residential solar panels]* and takes care of themselves, or we have to do it on a larger scale to take care of the people."

On the policy dimensions of REG, KI 2 was keen to see greater directive from government:

> *"It's just the fact of the matter we need more power and so […] there needs to be more enabling policy and that's been recognised by government and that's currently underway. You can see it in the prioritisation renewable energy is getting and resource management amendments and these national policy amendments and across the board."*

In terms of large-scale solar farms, KI 7 perceived the practical risk of hazards from electrical fire:

> *"It's purely the fact that when the sun is out, you can't stop it producing electricity. It's probably more about us knowing where to isolate things, and what you can and can't touch. In the [United] States, they've had shopping malls burnt down because of the solar grids across the top. They haven't been able to do anything because they can't stop from producing power. That's the only concern you'd have, then the grass floor underneath it. But it's something that you'd have to isolate areas. I suppose, not too sure how it works."*

Planning practitioner KI 4 also commented on technical risks that solar farms could present:

> *"You're at the mercy of being able to sell the power, which you're generating at that time, into the grid. […] That's the real dilemma with renewable energy generation, other than hydro, because it's not only an energy generator, it's actually it's also a battery, in the sense that [hydro] stores potential energy behind it in the form of water. […] To do that with either solar or wind, you need to include a BESS* [battery electric storage system]. *That's a massive bank of batteries onsite."*

(a) Energy Resilience

Alike the responses on economic resilience, participants conveyed their thinking about long-term solutions, energy security and resilience. Nine out of 65 survey responses (13.9 percent) related to achieving energy resilience through solar farming in Central Otago District. As shown in Figure

28, several respondents (SRs 36, 46, 52, 59) were attentive to whether solar energy production would, in practice, benefit locals, and SR 57 had concerns about “grid instability”.

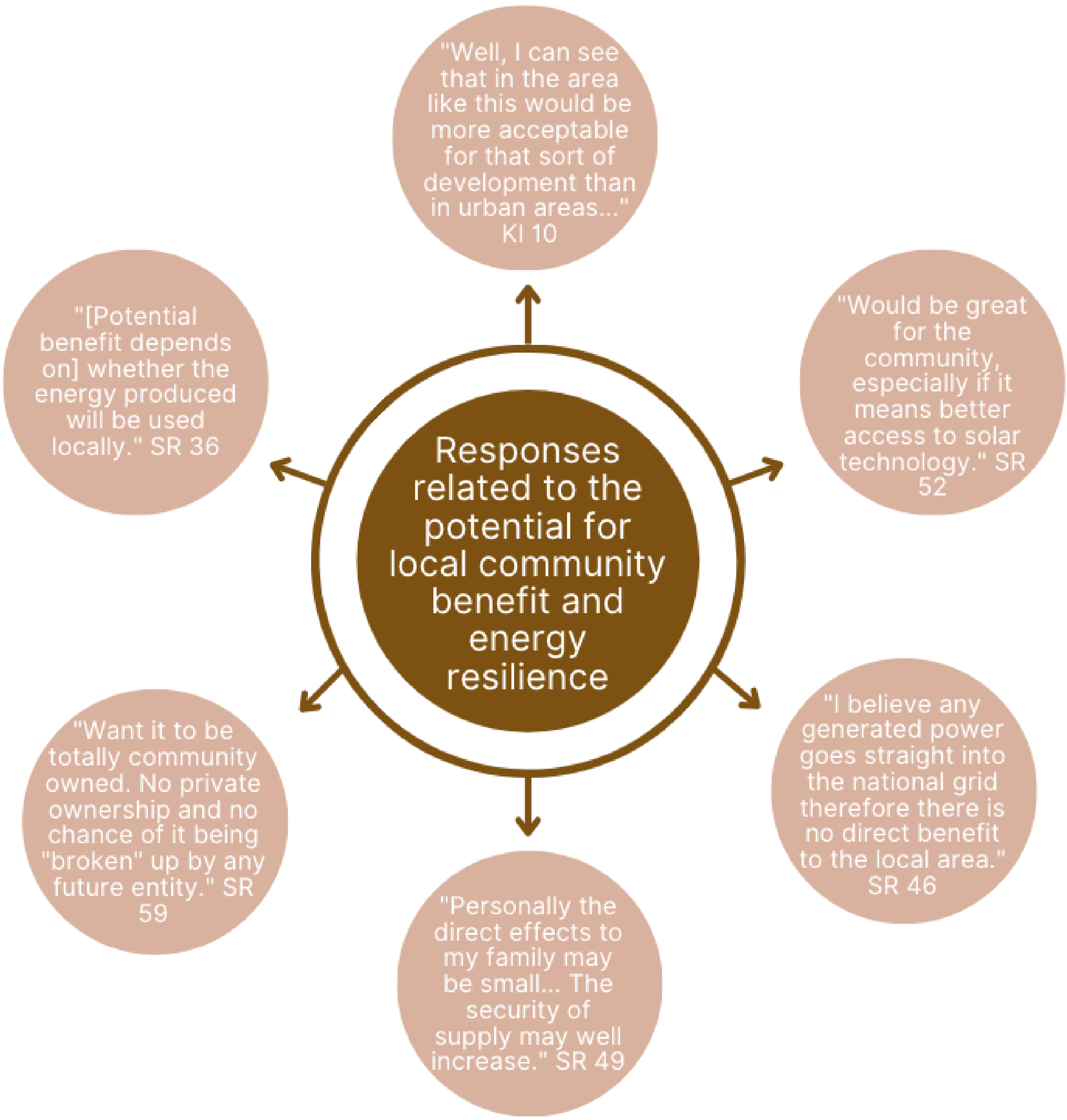


Figure 28. Survey and interview responses concerning energy resilience.

Key Informants 8 and 9 highlighted that wood-burners were their key source of heating, adding that “we have power cuts here” (KI 9). Local resident KI 10 observed that “we do need to have a reliable power source going forwards even locally, although most of our houses are not huge consumers of power." Key Informant 10 was unsure whether there was community consensus on REG in Māniatoto, but they added that:

> *"I would think that most people* [in Naseby and Māniatoto]*, if they sat and thought about it, would figure that that was a reasonable way forwards because, say, we know that coal-firing is not a way forwards. We know that hydro has become resisted here because of its effect on the landscape."*

Community resilience was crucial to energy developments. According to KI 11, new solar developments "need to be contributing to this idea that we are a collective, and that it's not basically profit. It's about supporting our community." Similarly, KI 2 focussed on community aspects:

> *"Resilience is a pretty wide topic in terms of energy resilience. It's* [solar farms] *absolutely helping in that sense. While it goes into transport, it is the local area that's supported by that solar farm. You're increasing energy resilience."*

7.3 Community Perceptions

7.3.1 Uncertainty

A cross-cutting theme in survey responses and interviews was a sense of uncertainty surrounding all aspects within the development of grid-scale solar. Many responses highlighted a lack of understanding of grid-scale solar, and the advancements which have yet to be made in the energy industry, as exhibited in Table 12. Technical expert KI 2 reflected upon the uncertainty surrounding solar developments due to their recent appearance in the domestic energy market:

> *"We don't have anything of scale in New Zealand at all, but this is all happening quite quickly. It's a lot about taking people on the journey of what will this look like? What do they actually need to be worried about? What is the concern? You need to help them understand what this technology is a lot more, because we're right at the start of that journey."*

Another technical expert, KI 12, was of the view that "it's a space that actually needs to be more well-defined than it is. If [industry] can help with that definition, even in a small way, I think it's worth encouraging."

Planning practitioner KI 4 highlighted a sense of uncertainty within the solar industry itself in Aotearoa-New Zealand:

> *"the* [NPS-HPL]*, it's a big uncertainty for the solar industry … because it is unclear at a local level how it will be interpreted."*

Table 12. Quotations from Key Informants expressing the role of uncertainty in solar farm developments.

Key Informant	Quotations
KI 3	*"I have no issues with panels on roofs and those sorts of things. I'm just not sure what those large-scale farms actually look like."*
KI 4	*"Good thing about solar panels, they're not reflective as such. They're made to absorb light.* [...] *I think people's lack of understanding of things like that triggers their distaste for anything."*
KI 5	*"How do you know you're going to yield? Because the sun costs the same. If it's on production and the cost of power, then that would be relevant. I guess other things that I would be worried about, knowing three or four of the people [*who have been approached by developers]: *what does the standardised charge look like for a solar panel?"*
KI 6	*"Negatively there shouldn't be too many, because it's out of sight, so pretty much that's part of the farm* […] *Honestly, I don't know how they bring all this gear in, but probably big trucks to bring it in, I'm presuming. It's going to be a reasonably in-depth project to do, because there's a lot of stuff to bring in.* […] *I don't actually know what the whole process is there."*
KI 9	[Interviewer: How do you currently feel about what you know about these types of developments?] *"Probably uncertain."*
KI 10	*"I'm not enough of an* expert [about solar developments] *to really make that informed a judgement on it* [environmental impacts]."

Six SRs commented on feeling uncertain about what impacts could be anticipated from solar-farm developments (SRs 7, 14, 31, 35, 60, and 62). The three quotations shown in Figure 29 demonstrate the sense of uncertain for SRs 31, 60 and 60.

Figure 29. A sense of uncertainty from SRs 31, 60 and 62.

7.3.2 Optimism

In contrast to the uncertainty surrounding grid-scale solar developments, optimism was apparent throughout many survey responses and interviews. Overall, survey responses showed participants' positive attitudes towards low-impact renewable energy infrastructures in Central Otago. Survey responses are summarised in Figure 30 and at Appendix C.

Of responses to questions (A) and (B) (n = *59*), 95 percent of respondents *agreed* or *strongly agreed* that 'low-impact renewable energy developments would be a good thing for Central Otago'. Though a similar proportion (92 percent) agreed or strongly agreed that they supported 'development of solar farms in Central Otago', a greater proportion indicated that they 'somewhat agree' or had a neutral view. Statistical analysis of SRs' answers for questions (A) and (B) showed a moderate but statistically significant correlation. On its face, this correlation suggests that SRs' positive attitude towards renewable energy infrastructure would be a likely predictor of their support for solar farms in Central Otago. An exegesis of survey results and statistical analysis is included at Appendix C.

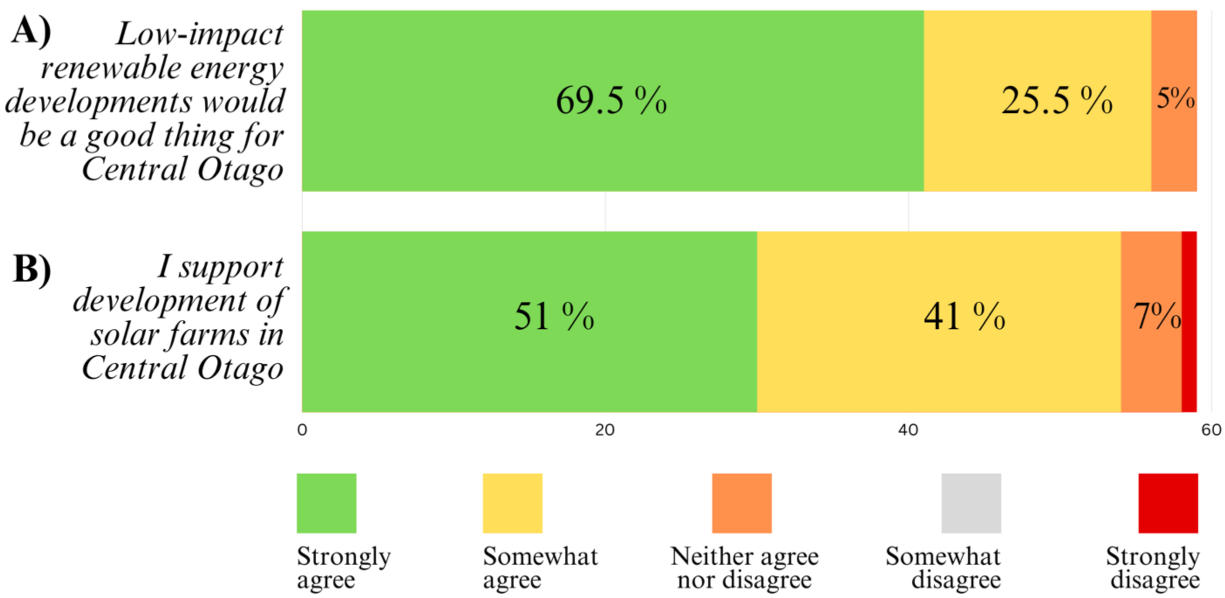


Figure 30. Summary statistics for SRs' attitudes towards low-impact renewable energy developments in Central Otago (question A); compared with their individual level of support for solar farms in Central Otago (question B).

An optimistic outlook characterised 12.3 percent of survey responses, compared to the uncertainty conveyed by 9.2 percent of SRs. Seven SRs (SRs 8, 32, 42, 47, 52, 53, and 58) were optimistic about solar farms, however, they were less detailed in describing what positive impacts they anticipated. Table 13 below presents some of the survey responses which communicate optimistic views towards solar developments.

Table 13. Survey responses which portrayed optimistic views towards solar developments.

Survey Respondent	Comments
SR 8	No problems. Bit of visual impact, can be shielded by trees to hide.
SR 32	Better for the environment, for the future.
SR 42	Economic effects would be massive for the area, i.e., workers here in the development stages, also the long-term power that will be made to help our struggling electricity industry. Can't be heavily reliant on electronics & not have ways of getting electricity.
SR 47	Positive environmental effects and hopefully economic benefits.
SR 52	Would be great for the community, especially it means better access to solar technology.
SR 58	Positives – obvious.

Interview participants also demonstrated a sense of optimism. Technical expert KI 2 emphasised "the future of New Zealand *[is this]* technology." They added that "there's a lot to really like about solar because it is really positive technology." Other optimistic responses included KI 7, who stated that "we're quite happy with it *[the consented development]*, it's not going to affect us at all." Likewise, local residents KI 9 and 3 remarked positively on the Naseby Solar Farm. Key Informant 9 said "I was excited, I thought *[the proposed solar farm]* was great", whilst KI 3 commented that "it's being viewed as a positive thing at least by the people I've spoken to anyway."

Agrivoltaic systems were another point of optimism for local residents. When asked for their views on agrivoltaic systems, KI 8 was "in favour of solar and we have high sunshine hours. That's relatively passive. It's multi use. You can still graze underneath it." Key Informant 10 thought they may be more accepted in Māniatoto:

> *"I'm sure it would, because what happens under there is probably hard for people in the city to utilise, perhaps. But I can see here where farmers could say, 'well, yeah, that paddock there I use for cropping, I could put solar panels in there'."*

7.3.3 Community Benefit Agreements

(a) Options for Community Benefit Agreements

Naseby residents described their recent experience with accessing a Community Benefit Agreement (CBA), after the Māniatoto pylon upgrades. According to KI 10, the project managers for the upgrades "left a fund here previously [...] and it went into putting a heat exchange unit in our curling rink". Key Informants 6, 8, and 10 spoke about how the Naseby Curling Rink was expected to receive a solar panel installation, according to the CBA for Naseby Solar Farm. For KI 10, the Curling Rink was the most appropriate recipient of CBA funding as it could benefit the greatest reach of people (Figure 31). However, KI 6 indicated that there were contingencies associated with this CBA:

> *"It just depends on the probability of the whole project too I suppose but there's indications that it's a one-off type thing."*

Planning practitioner KI 1 spoke about how in the past, CBAs had benefitted community institutions and recreational facilities:

> *"…what we have seen from big players* […] *is that there is some well-being that goes back to communities; some community contribution where there [are] recreation spaces or there's support funding for community service".*

From the developer perspective, KI 2 explained that their company approach to CBAs was to "be a good neighbour" for the lifespan of the development:

> *"We have a Community Benefit Fund that we put in place for every project. That's for the length of the time that the solar farm runs for. It's an allocation of funds every year for community good, and in the areas of upskilling and training opportunities. Scholarships and electrical engineering; anything related to the area of energy.* [...] *There's a lot of solar farms that are coming in New Zealand.* [...] *Upskilling in that area, there's going to be a lot of work for the next 15 years."*

As shown in Figure 31, KI 2 identified that other focus areas for CBAs included education in schools, "and energy hardship as well." Whilst KI 2 mentioned energy hardship, it was unclear how a CBA for energy hardship might function. However, KI 2 did comment that their company could, depending on the context, commit to supporting power costs.

Figure 31. Ideas from the community regarding Community Benefit Agreements.

Both KI 1 and SR 52 conveyed their hope that residents would gain greater access solar technology, with KI 1 questioning "can it be scaled so that households can benefit from that?" Key Informant 1 alluded to the opportunities that could present if households had improved access to PV technology.

(b) Council involvement in CBAs

Planning practitioner KI 11 explained that despite their professional experience, they had had limited interaction with CBAs or development contributions. For KI 11, CBAs and development contributions fell within Council-led process: "Councils have got their particular way that they calculate these development contributions, and also how they allocate it." Local resident KI 5 was supportive of community and Council taking more leadership for CBAs. It appeared that KI 5 had some concerns that developers might try to avoid negotiating a CBA: “they'll say they pay it in the rates, and they probably do.” Key Informant 5 advocated for community to determine a "target rate,” particularly in the context of the big projects announced for Central Otago.

7.3.4 Small Town Lifeways

(a) How Naseby identity interacted with solar developments

Many local residents highlighted their family histories and agricultural associations with the Māniatoto. Key Informant 5 explained their family’s heritage as early settlers in the Māniatoto, and how this had influenced their perspective on retaining the farmland in long-term family ownership.

Key Informants 8, 9 and 10 all identified as members of a special interest group, comprising Naseby ratepayers who took responsibility for council engagement, community initiatives, and investment. They highlighted how their group had sought to protect the heritage aspects of the town, through investment in solar-electric heritage lighting, bicycle-repair stations, drinking fountains, picnic tables, and refurbishing the war memorial and heritage gun. For KI 10, Naseby’s heritage was the key to its future, stating that:

> *“if this town doesn't protect its heritage aspect, which is what sets it apart – the only real thing that sets it apart from a lot of other places around here – we haven't got much to pin our future on in terms of tourism.”*

Key Informants 8 and 10 also spoke about the agricultural identity of Naseby and Māniatoto. Agriculture is the big employer and a landscape factor that tied them to their rural associations with the area. Though KI 3 was unsure how solar farms might affect the local community, KI 3 thought issues might arise if the solar interacted negatively with agriculture: “If it's a vast area and it affected farming, for instance, and affected employment of people living in the area, then I think that would be another totally separate sort of issue.”

Landowner KI 6 was equivocal on whether the Naseby Solar Farm would represent a tourist attraction: “For people that do ride to Naseby to do other activities that'll be easy, very easy access, if they are keen to look at it. The planner didn't think they wanted to look at it.” Similarly, KI 10 thought that the solar farm could “possibly” be a tourist attraction at Naseby “but I think it would be minor. Tourism is such a fickle thing.”

There were differing opinions about the role of tourism upon small-town lifeways for Naseby and Māniatoto. Key Informant 5 had seen extensive injection of money and growth in the region as a result of the Central Otago Rail Trail, allowing for him to develop a tourism and accommodation enterprise alongside maintaining the family farm. For KI 7, mountain-biking presented a key opportunity for Naseby through the development of the nearby Earnslaw One forest area.

(b) Energy attitudes

Residents KIs 8 and 9 made a generalised distinction between the energy attitudes of local residents, versus those who owned holiday homes in Naseby. According to KI 8:

> "...[bach-owners] *have a TV in every room, and they have underfloor heating all over the show and things. Here, we tend to take a different view, and if it's a bit cold we put socks and clothes on.”*

However, KIs 8, 9 and 10 corroborated KI 6’s description of the high energy demand from the community’s Curling Rink, and all expressed a positive opinion regarding Solar Bay’s sponsorship of PV panels. Key Informant 10 also commented that their special interest group had sought to use a different CBA to install an electric vehicle charger. More broadly, KIs 5, 8 and 10 were all concerned that an unsustainable rate and demand for growth in Central Otago might impact on rural character and lifeways. For instance, KIs 8 and 10 each commented on their concern that Naseby might become “another Queenstown”, with greater energy needs as a result.

(c) Small town relationships can underpin attitudes to solar developments

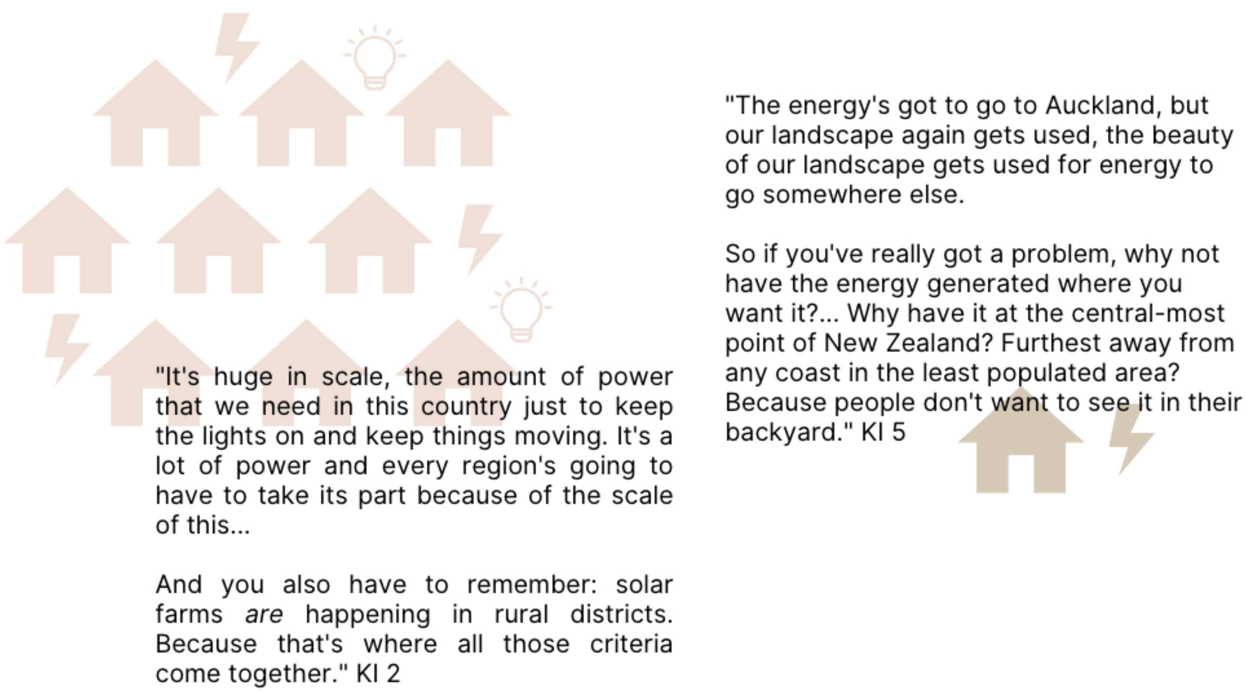
For the Naseby Solar Farm, it was KI 8’s relationship with the landowner (KI 6) that underpinned KI 8’s attitude toward the proposal: “I would trust [KI 6’s] judgement as it’s very long term. And he's 5th generation here. Yeah, I would trust his judgment ahead of a company that's coming in which has got an obvious commercial bent.”

The landowner for Naseby Solar Farm, KI 6, communicated a similar attitude about valuing relationships. Key Informant 6 explained that a sense of direct relationship with Solar Bay drove his decision to engage with Solar Bay over a dominant utility provider. By contrast, KI 5 stated his concern that the amplified interest in solar farms would come at the expense of equity and community cohesion between Māniatoto farmers:

> *“Of course, there’s going to be a certain amount of jealousy when you know* [a local farmer] *gets $250,000 a year and* [another farmer] *gets $250,000 a year and the guy next door that’s two miles away from the transformer can’t get anything. [...] That's what happened with the Styx* [referring to Project Hayes]. *One lady looks around, says ‘I'm going to get one million dollars a year.’ But you and the people sitting in the other houses, looking out the window to see all the wind turbines, got nothing.”*

(d) ‘Small-town responsibility’ versus ‘problem-shifting’

Across community-members and practitioners who were interviewed, two key discourses emerged. As shown in Figure 32, the first discourse centred on a notion of small-town responsibility to support energy transitions that would benefit the whole country, as rural districts were where all the necessary planning criteria “come together” (KI 2). The second key discourse emerged mainly from local residents. They communicated the sense of ‘problem-shifting’ to small towns, and concerns about how this would affect their ways of life. In particular, KI 5 drew



attention to how Māniatoto ratepayers had effectively subsidised development in Cromwell, due to demands of in-migration, higher-wealth individuals building in the region, and loose district planning regulations. For KI 5, their concern revolved on how energy demands of urban centres like Auckland, Wellington, and Christchurch would be problem-shifted to Central Otago, putting a burden on Māniatoto ratepayers and their enjoyment of the landscape.

7.4 Landscape Importance

7.4.1 Central Otago Identity

It is evident on the results that people in Central Otago, and especially in Māniatoto, highly value the iconic landscapes and see them as a part of the identity of Central Otago. Figure 33 displays quotations from participants that exhibit the value given to the landscape, and the concern about solar developments impinging on these spaces. In addition to these quotations, there were four other SRs and three interview participants that commented on the identity of landscape in Central Otago and how solar developments may affect such places.

Figure 33. Quotations that display value of landscape in Central Otago.

There was one idea from KI 1 that particularly stood out, as they explained that:

> *"...the message around that [tourism in Central Otago] is going off-road, going to those places that aren't so well travelled, in the big skies, beautiful spaces.[…] that whole idea of renewable energy and having e-charging opportunities and things like that along the way, it helps that message about "visit our place", "don't leave a negative footprint." So, it's reinforcing that messaging on sustainable, and carbon neutral lifestyles and opportunities."*

This quotation contrasts with those in Figure 33, as KI 1 suggests how incorporating more renewable energy, such as solar developments, could become part of the identity in Central Otago, rather than interfering with this identity.

7.4.2 Visual Amenity

Visual amenity was the most cited concern of impacts from grid-scale solar development, with 32 percent of SRs raising concerns (Table 14). Many SRs referenced visual impacts generally, however specific concerns were also raised for visual amenity across the local community, including glare, scale, and location. These were commented on through a comparison to other REG established in Central Otago, mitigation efforts, and locational differences that influenced respondents' perspectives (Figure 34).

Table 14. Participants voice concern for grid-scale solar developments impacting the visual amenity of Central Otago.

Key Informant	Quotation
KI 3	I just think it's all about ensuring our landscapes preserved. We've got pretty unique landscapes here...
KI 10	The landscape here is sort of big open sky. It's quite different to a lot of other parts of New Zealand. And these things are worth protecting to some extent.
SR 21	We need to develop renewable energy sources. We need to do this in a way that does not spoil our unique countryside.
SR 22	Negative [impact] - not fitting into the landscape, not attractive
SR 36	Aesthetics of having fields covered in solar panels may detract from natural beauty.
SR 48	Aesthetic effects are my only reservation. Don't destroy the beauty of the region
SR 50	We all need electricity, but the location and visual impact of generation needs to be carefully considered.

Figure 34. Elements impacting visual amenity as discussed by Key Informants.

(a) Comparison to other types of REG

When asked to voice any concerns around grid-scale solar developments, many respondents discussed other types of REG such as hydro and wind that has been present in Central Otago. As grid-scale solar does not yet exist in this area, many had unrealistic expectations of their impacts and based these assumptions about other REG developments. This was exemplified by SR 35 when asked about possible impacts: 'could take up space and make the countryside look ugly, would have to have loads of panels to make an impact and would take up more room than something like the dam does.' This comment, and others relating to proposed wind REG developments, exemplify some of the community's misunderstanding of what a grid-scale solar development would entail, and even misunderstanding of the impacts of REG developments altogether. However, there are a range of perspectives when it comes to severity of impacts. For example, KI 10 discussed the impacts of hydropower:

“We know that hydro has become resisted here because of its effect on the landscape […] flooding things [...] personally I think that quite a bit of the flooding that's been done here has maybe enhanced the areas. […] *I guess it was horrible losing all the stonefruit industry through the valley where the Clyde Dam is built, but it's not a bad looking place. Now when you drive along, there's a lot of people enjoying riding, push bikes along the side of it now.”*

This interpretation of the impacts hydro developments would differ significantly to those who protested to protect natural landscapes and ecological systems. It became apparent that previous REG proposals have been controversial in these communities, but this influenced many community-members' perspectives on solar developments in a more positive way (KIs 3, 5, 7, 8, 10; SRs 25, 62). These differences in interpretation of visual effects are exemplified in Figure 35.

(b) "If people don’t want to look at them, then don’t look at them”

As previously discussed, there is a general positive attitude towards solar developments. Some residents were less bothered by the prospect than others, for example KI 7 stated “...if people don’t want to look at them, then don’t look at them.” However, this positive attitude was significantly dependent on site location for most respondents (KIs 3, 6; SRs 21, 50). Speaking as a representative of the Māniatoto community, KI 5 added that “ten 50-hectare farms spread out in 10 different regions within the region, or 60 or 70, it would be far more than 2000 hectares in one spot. Because it's just that because of the sparseness of the landscape.” This sentiment of sparseness was also referenced by KI 8. No KIs had an issue with the effects on amenity from Naseby Solar Farm because they thought the amenity of surrounding land was already compromised by the substation and satellite (KI 3) and its location back from the main road (KIs 3, 6, 7).

(c) Mitigation efforts

Interview and survey responses offered ideas for mitigation of impacts on visual amenity. This mainly involved screen planting as a condition of consent for developments on main roads (KIs 2, 4, 8). Aerial power lines were discussed by KI 12 as a cheaper way to connect developments to substations, which therefore may be favourable for developers with sites that do not border a substation. Key Informant 12 observed that there has been a shift towards underground lines, rather than aerial, due to the RMA’s stringent visual amenity prioritisation.

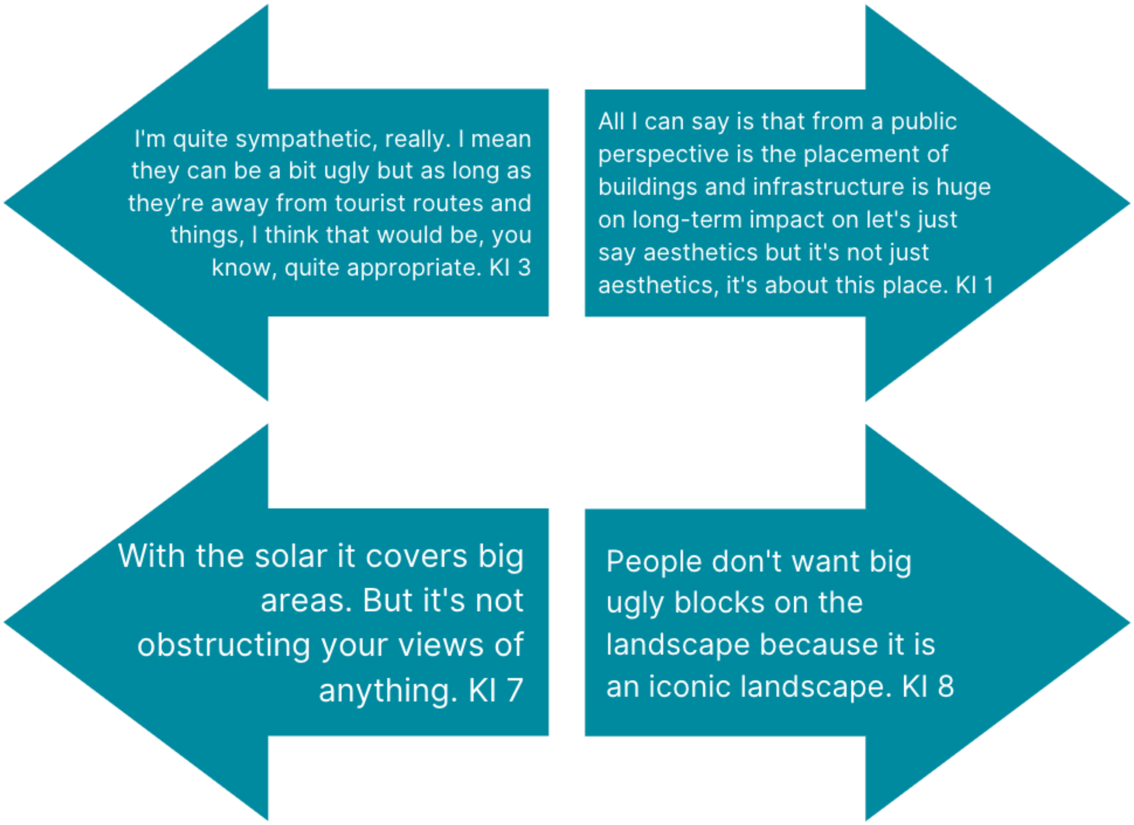


Figure 35. Conflicting perspectives of severity of visual impacts on amenity value from Central Otago community-members.

7.4.3 Mana Whenua Associations

Throughout all 11 interviews and the 65 SRs, only KIs 2 and 11 made specific mention of how solar farms could impact ancestral or mana whenua associations with place. Practitioner KI 11 conveyed that he provided a link of relationship between mana whenua and the developer while drafting the Naseby Solar Farm resource consent. Technical expert KI 2 stated the planning considerations: "Are you actually looking at cultural constraints, heritage constraints? [...] You have to really [think] through a site-specific location, if you're within those environments." Community interviewees made no direct mention of mana whenua engagement in the solar farm planning process. Nor did survey participants explicitly state that their concerns about landscape interruption arrived from, or were influenced by, a tākata whenua standpoint. Further results about mana whenua engagement in the planning process are presented at Section 7.5.3.

7.5 Council and Planning Processes

Elements of the CODC's approach to the emerging interest in the Central Otago District for grid-scale solar development were discussed throughout interviews. Significant themes included the CODC's decision-making framework, mana whenua and community engagement, and gaps.

7.5.1 Developers Take a Lead Role

(a) "We're bringing a lot of experience from overseas, to the New Zealand market"

Of the technical experts interviewed, KI 2 worked on behalf of a developer. They described how their company was able to bring experience and expertise from overseas markets, elaborating that "it's interesting being [in the United Kingdom] where the market is so developed and solar has been part of the landscape for 15 years. ... you're on a train and you just see fields of solar." For KI 2, the developer had to take a lead in consciousness-raising with Aotearoa-New Zealand communities:

> *"We don't have anything of scale in New Zealand at all. But this is all happening quite quickly. It's a lot about taking people on the journey of what will this look like? [...] That's a lot of my role [at Developer]. My role spans the whole development process, right from first site selection."*

Similar to the sense of relationship expounded by KI 6, KI 2 conveyed that "we want to be a good neighbour," which could be supported through a CBA. For Central Otago, KI 2 emphasised that:

> *"we haven't announced a project yet because we had taken the time to do due diligence. […] It would be helpful, just so that [we can be] authentic, in terms of [what is] central in the relationship there."*

(b) "We're not one of the established big energy companies in New Zealand. We're a disruptor."

As shown in Table 15, KI 2 underlined the advantages to the public of the solar farm industry being run in the private sector, and explained how their company could be a 'disruptor' for the established energy market in Aotearoa-New Zealand. KI 2 added that:

> *"*[the UK] *solar farm industry isn't subsidised either. Local or national government. It's all privately funded, so there's no additional obligations on the community or tax on the*

rate base or anything like that as part of a solar farm, especially as the community or rate base would not be burdened by costs of development."

Table 15. The role of developers in the energy market: A Naseby landowner's experience, contrasted with one developer's position.

Landowner experience (KI 6)	Developer position (KI 2)
*"The other guy from Australia, he was the guy - so **we're talking to the man that made the decisions**."*	*"I'd also reiterate, with more of this large scale solar coming on board will mean more energy supply, which means the prices will come down of power."* ***"We're not a generator, we're not one of the established [...] big energy companies in New Zealand. We're a disruptor** [...] we're bringing additional power onto the grid.* *So, you really should see that impact that the price is lower as more of these larger systems come online."*

(c) Developer discretion in planning

Key Informants 2, 4, 6, and 11 explained the lead role taken by developers in bringing solar farms to the fore. In particular, KI 4 referred to the discretion available to developers in certain aspects of solar resource consenting. This latitude related to decommission plans for solar farms, which KI 4 conceded was a potential concern for community-members:

> *"It is definitely an issue on the radar of solar panel manufacturers, and I haven't yet seen a consent condition for solar farm consented in New Zealand which includes a decommission plan. Maybe I've seen one, which mentions the need for decommissioning plan, but you know that's not something for which you need to supply straightaway. But it is something needed at the time of commissioning, as decommissioning is as big a job as actually building the thing."*

Another planning practitioner, KI 11, conveyed broad scepticism about the 'lead role' taken by developers and how that played out in the planning process.

> "[District Councils need to] *make sure that they have some levers in the policy in their decision-making framework to ensure that these external parties have some accountability to the local community beyond during the construction period. You know, they come in,*

they make a mess. They kind of tidy up the mess. But then they run away with the money, and they are occupying our space, and what could that space be used for. Quite often, it's in the private ownership anyway so it's a commercial decision."

Key Informant 11 advocated for District Plans to enact policy levers for Councils engaging with private developers: "levers that are based on community aspirations." They observed:

> *"Developers operate against one particular model and District Plans don't really resist that model that much, and they don't really protect their community as much as they could, should do. That is possibly because of the climate that those plans were constructed in 10-20 years ago. The times are different now, the engagement process needs to be different now."*

7.5.2 Policy Gaps

According to KI 11, loopholes in the District Plan are permitting developers to compromise the landscape character and visual amenity. Key Informant 11 points out that this worked in favour of the Naseby Solar Farm as rural amenity was already compromised by the radar and substation on Fennessy Road. However, when considering future solar developments, these loopholes create dangerous territory for poorly planned and consulted applications (KI 11).

The lack of preparation for REG throughout the District Plan is further discussed by KI 11. It is acknowledged throughout interviews that hydro and wind REG are occurring in the district, however, Naseby Solar Farm will be the first of its kind. Though the district planning process is currently set up to cater for these other methods of REG, "they're not set up for solar or other technologies [...] And there's now a push to bring the policy up to speed" (KI 11). Key Informant 11 applied this sentiment to national policy as well: "It gets tricky when you're going through the RMA process [...] You can get really bogged down through interpretation and plans that haven't been set up to deal with renewable energy in the form of solar."

7.5.3 Mana Whenua Engagement

Within the planning system, KI 11 drew a general contrast between the transient, project-focussed perspective of developers as compared to the ancestral connections of mana whenua. Key

Informant 11 prefaced that while they were not mana whenua for this rohe – and did not intend to speak on their behalf – they could express that:

> *"[developers] just want to build stuff, make it fast, get the money, get on their CVs, and move on. But mana whenua, it's a different story. It's their whakapapa, their place – a longer-term involvement, and connection to this space."*

Key Informant 11 was supportive of mana whenua having a broader role in engagement: "Mana whenua need to be at the table with the community, alongside the community, and explore what they what their aspirations are." However, KI 11 expressed scepticism about the level of involvement that mana whenua have in current planning processes and the "willingness of the decision makers […] to acknowledge the mana of mana whenua in these local government sort of processes: decision making processes, engagement processes."

For KIs 2, 4, and 11, mana whenua engagement was conceived as a component of the statutory planning process. Furthermore, they each identified how relationship-building underpinned the private sector's approach to iwi engagement.

Key Informant 4 drew analogy with the recently consented Tauhei solar farm in Waikato, explaining that "18 different iwi who were potentially interested in the site and surrounds", leading the developer to "[start] off slowly, as they should, forming relationships." Key Informant 4 explained that the engagement process with mana whenua, through the consultancy iwi advisor, helped the developer identify over time those "couple of iwi, who would have agreed mana whenua. And eventually, the Cultural Impact Assessment was prepared in relation to that." Key Informant 4 described how engagement with mana whenua, and other professionals, led to a rounded process for the design of the solar farm proposal:

> *"At one point, in the early stage, we got the iwi reps, our ecologists, our landscape architect and our planner on-site, with the client as well, for a site visit. And just the cross-fertilisation of ideas about what was trying to be achieved, and what the issues were really, really helpful, which fed back into the design."*

This was similar to the experience of KI 11 while preparing the Naseby Solar Farm application:

"I was having dialogue with [the developer], *passing on the message basically, 'mana whenua wants some sort of native plants,' and then we start talking, 'how might this this encourage bird life besides the screening effect,' things like that. That's kind of how I get mana whenua outcomes in, just almost trying to be a conduit or intermediary.* […] *I'm communicating things that I know for sure and that I've confirmed* [with mana whenua] *and nothing more, besides my professional perspective. You don't want to speak on their behalf, so it's tricky."*

On behalf of developer, KI 2 explained how their community-oriented approach to engagement could apply to engaging with mana whenua for CBAs, as in some cases "it might be that there's a local marae nearby and we can assist by paying a proportion of the power bill."

7.5.4 Community Engagement

Community engagement was discussed through the lens of Naseby Solar Farm, and engagement more broadly with the community. When asked to share their thoughts on how Council approached the consented development, some locals expressed feelings of distrust and hopelessness around the Council's engagement in general. Quotations from these KIs can be seen in Table 16. While it was acknowledged by KI 10 that consultation does occur between the Council and special interest groups, it was voiced that "it's hard work because [Interest Group] is a pretty stable entity. The Council's not". This raised the wider issue of the difficulty to build relationships when there is rapid staff turnover at the Council.

Table 16. Quotations from Key Informants expressing hopelessness on CODC's engagement with the community.

Key Informant	Quotation
KI 8	*"We can't do anything about it. I don't take any notice anymore, I have more input here, whatever I do here is useful. My voice is not heard anywhere else. No one else is interested. If we really, really want things to happen, we speak up and make a lot of noise. Or we just do it ourselves. And that's been done for generations."*
KI 9	*"I don't know if Council will be looking out for us…* [the CODC] *definitely need to take an interest in us on the same level as they do in other areas."*
KI 10	*"…we find that a small community dealing with centralised institutions like* [CODC] *it's fairly hard to get your voice heard cause we're a small voice in the whole of CODC and we have very little representation."*

In relation to Naseby Solar Farm, KI 10 stated there had been "some instances the Council hasn't always been completely transparent with some of their planning decisions. But in this instance, would've been nice to know it was happening but it's being viewed as a positive thing at least by the people I've spoken to anyway." These uncertain yet optimistic attitudes were echoed throughout the community as discussed in Section 7.2, and KI 5 stated that "most of [the community] won't care. They won't engage unless it's really big." While local residents shared this positive perspective, KI 11 endorsed greater communication and transparency between the CODC and community. For KI 11, the CODC's approach to Naseby Solar Farm may set precedent for future solar developments:

> *"...They should have said 'hey guys this is what we are looking to do, this is how we propose to mitigate the associated effects that we have been asked to mitigate, is there anything we are missing? You don't need to be concerned'."*

7.5.5 Community Understanding of Planning Processes

Most local residents who participated in this study were aware of Naseby Solar Farm. However, this was primarily attributed to word-of-mouth, rather than engagement with the planning process. Key Informant 3 commented "I don't know if this application was actually notified, I didn't see it advertised anywhere." Although some participants did not know enough about the process, others voiced preferences for CODC take the notification route for developments at this scale. Key Informant 10 thought the "way forward is to have a notified consent on it", whilst KI 8 expressed "I think it's only polite." This suggestion was rebutted by planning practitioner KI 11:

> *"I think in this case it is not a sensitive receiving environment, so it is an appropriate development there. Notification wouldn't be in my perspective, because that introduces a whole lot of costs and uncertainty and opportunities for the process to be manipulated by external parties who might have competing interests and things like that. I don't believe that notification would have been appropriate* [for Naseby Solar Farm].*"*

Contrastingly, KI 5 relayed concerns about how the planning process appeared to be more permissive to solar farms than for other local community aspirations which were perceived as lower impact. He compared the recent non-notified consent for Naseby Solar Farm, with a situation experienced by a local business owner seeking to erect a temporary structure: "I just want to make sure we have all those balances because [a local resident] got to go through hoops […] but even the 50 hectares of visual pollution of course is on the energy component."

The juxtaposition of these recommendations suggests that community desire fairness in the planning system, but they lack understanding about the conditions for, and consequences of, notifying such consent applications.

7.5.6 Council Gaps

Interview responses revealed gaps within Council processes, and between the Council and external stakeholders. Lack of resourcing was identified by KI 2 as a significant limitation upon Council:

> *"You also have to remember: solar farms are happening in rural districts. Because that's where all those criteria come together. Rural councils are really low resource: they don't have a lot of planners. They don't have a lot of ability too. You don't have specialists in house. They're all overworked.* [...] *They have to look at parts of the Plan that they've never looked at. They've got to consider National Policy they've never looked at. So that's quite a lot to take on."*

This lack of resource exacerbates a seemingly widespread policy gap for sustainable development of REG like grid-scale solar. Key Informant 12 commented "the balancing act will be very much around how what sort of level of detail is required at the Councils as the consenting authority", as currently, developers need to provide little information.

These loopholes, as discussed by KI 11 in Section 7.5.5, could become a significant issue if not addressed in the review of the District Plan as Central Otago continues to be scouted for grid-scale solar developments. It is important to require technical information like how the developer plans to connect to a substation, or how the council will rate operations like this, but it this is also relevant to how Councils may enable CBAs. As acknowledged by KI 5, Council could leverage for clear community benefits given the common understanding that solar developments will be profitable for developers: "how do we tap that so the benefit goes to the whole community? Through rates we can do that – we have target rates for grants."

Staff retention was another gap identified within Council. This perceived lack of institutional knowledge frames a gap between the community and CODC, as displayed by the comments in Figure 36. In KI 10's view:

> *"*[CODC] *change their staff on an almost daily basis it seems.* [...] *They have a lot of academic knowledge, but very little on-the-ground, institutionalised knowledge about anything they're administering 'cause their staff changes so regularly. That can be frustrating when you're looking at it from our end."*

Key Informants 11 and 12 placed significance on how CODC coordinates with external stakeholders including technical experts, government entities, and the local community. Key Informant 12 identified Waka Kotahi as an important external stakeholder, with respect to possible conflicts between the *Road to Zero* initiative and development of the grid network. For KI 12:

> *"I think it is very much a coordination piece. The likes of Waka Kotahi have to be involved in that, the roading people within the councils have to have more active engagement, particularly around where the solar farm is going to be placed. To a certain extent, the Council has to ask 'how are you going to connect to' or 'what are you going to connect to?'"*

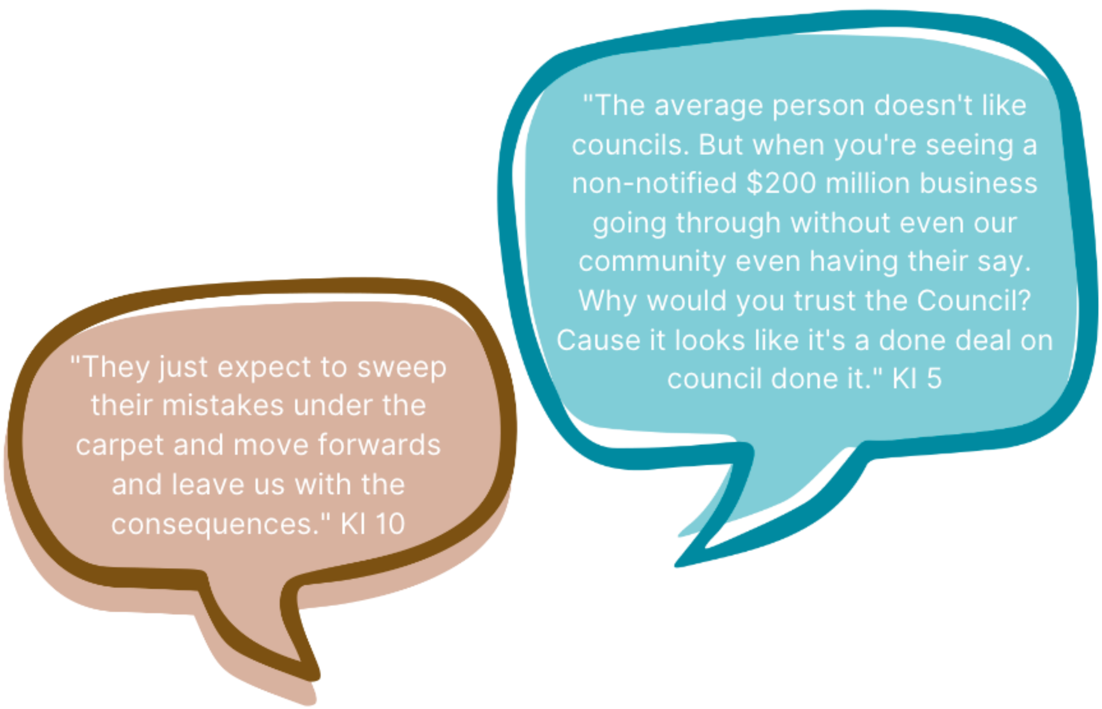


Figure 36. Key Informants commenting on the disconnect between CODC and the community.

7.6 Summary

This section displayed the mosaic of primary results gathered from KI interviews and surveys. Planning practitioners and technical experts provided details on the key siting considerations associated with grid-scale solar farms, and the environmental and economic impacts that these developments could attract. On these results, a sense of uncertainty dominates community perceptions about solar farms. Industry professionals echoed the lack of local precedent for these types of developments in Aotearoa-New Zealand. Yet local residents conveyed their sense of optimism about solar energy, with many relating these to the broad-scale ‘goods’ of transitioning to renewable energies, or to positive opinion on agrivoltaic systems.

Local residents emphasised the notion of Central Otago’s identity, which was often linked with the landscape. Yet KI 5 was particularly concerned that national environmental problems would become the burden of rural communities, and other community-members sought to protect their small-town lifeways. Planning practitioners advocated for District Plan levers that could regulate and enable solar developments, particularly due to National Policy updates since the last plan review. One KI acknowledged few levers for considering social impacts, and advocated for better planning levers to promote partnership with mana whenua.

One should note that these results are not considered to be representative of all views or demographics in Māniatoto and Central Otago. Findings are limited by the number of survey responses and KIs that were able to be captured through distribution and snowball sampling, as discussed in Chapter 5. The following chapter discusses the implications of these results.

8.0 Discussion

This chapter addresses in turn the four Research Objectives. The first Research Objective was fulfilled by the domestic and international case-studies that are incorporated in Chapter 3. Section 8.1 discusses the environmental conditions, infrastructure, and physical resources required for grid-scale solar developments to be viable in Central Otago. Section 8.2 addresses positive and negative impacts of grid-scale solar, focussing on environmental and economic impacts at the Ward-scale. Section 8.3 discusses the potential impacts on a rural community by looking at social impacts, acceptance, and a Social License framework for grid-scale solar farms.

8.1 Environmental Conditions, Infrastructure, and Physical Resources for Grid-Scale Solar Developments

A key objective of this research is to understand the environmental conditions, infrastructure, and physical resources needed to make grid-scale energy developments viable in Central Otago. The results presented in Chapters 6 and 7 highlight the preferred siting conditions for grid-scale solar farms. The following section analyses the feasibility of pursuing grid-scale solar developments in Central Otago District.

8.1.1 Environmental Conditions

The primary environmental condition identified in scholarship and primary data was the importance of sufficient insolation to ensure that the solar array was energetically and economically effective. As in India's Bhadla Park case-study, KI's identified Central Otago's high insolation, low rainfall, and minimal cloud cover as favourable climatic conditions for solar farm developments (B. R. Kumar, 2022; Rajaram & Balamurugan, 2020). Māniatoto's topography provides minimal shade and low slope-angle, further enhancing access to solar radiance as well as an appropriate aspect for laying out an array of PV panels on a utility-scale (Misra, 2023).

Another vital condition is the existing land uses of the land identified for, and surrounding, a solar farm development. Key Informants made clear that unproductive land, such as low quality pasture, is ideal for grid-scale solar farms as it provides an alternative land-use to what might have been deemed otherwise "uncultivable" (H. Kumar et al., 2012). Key Informant 6 highlighted that the area consented for Naseby Solar Farm was their least-productive paddock, though sheep-grazing could still be co-located amongst the panels. The NPS-HPL provides clear national direction on the protection of "inappropriate" use and development of highly-productive soils. Through GIS mapping of Central Otago, it is illustrated that a large proportion of land that would otherwise meet solar farm development criteria could be excluded by accounting for the NPS-HPL. The suitability of areas of the Māniatoto, such as Naseby and Wedderburn, were largely unaffected when GIS mapping provided for HPL. However, as highlighted by Dhar et al. (2020), water stress may become a more probative issue depending on cleaning processes for the panels, or should a developer propose to undertake agrivoltaic cropping. The issue of water stress could therefore intersect the NPS-HPL with the NPS-FM, and its implementation through the Proposed Otago Regional Policy Statement (2021).

The natural features on the land have a significant impact on the potential for development of solar farms. Natural shelter belts are highly sought after as they can restrict sight-lines to solar farms. Visual amenity elicited concern from KIs and SRs, and while Naseby Solar Farm was consented in an area with existing industry uses – the space radar and forestry operation – other local residents like KIs 8 and 9 raised concerns that future developments ought to be sited "sensitively." Without the presence of shelter belts, developers need to plant screening vegetation. This was a point of benefit for Naseby Solar Farm, as the native planting was proposed after engagement with mana whenua.

8.1.2 Infrastructure and Physical Resources

Transportation and connection to the national grid were highlighted as vital infrastructure components for grid-scale solar developments. Technical experts pointed out that during the construction phase, the roading network would be trafficked with heavy machinery. Hence, transport planning was necessary to avoid conflicts between construction personnel and other road-users. Furthermore, some local residents expressed concerns about how the character of their rural community could be disrupted by increased vehicle movements. While social impacts are explored in detail later in this Chapter, these concerns highlight the need for careful planning and assessment of the existing road conditions. According to KI 12, travel management plans had relevance to Waka Kotahi's *Road To Zero* initiative, and could be included in resource consent applications or requested as a condition of approval. For instance, time restrictions can be implemented to prevent heavy vehicles from traveling through residential areas during peak school pick-up or drop-off times, reducing potential safety hazards and traffic congestion.

Additionally, the availability of accessible connections to the national grid network is crucial for grid-scale solar developments. Proximity to substations plays a significant role in site selection, as constructing power infrastructure over long distances can be prohibitively expensive for developers and also introduce amenity concerns. As shown by KIs 2 and 12, developers often set a 5 kilometre 'radius' as a site-selection criterion for solar farm development, beyond which they may refrain from building due to the substantial costs involved. Apart from grid distance, the installation of power lines to transmit the generated energy is another important consideration. The recent pylon upgrades in Māniatoto, facilitated by a Fast Track Order (2020), provided significant public investment in grid-capacity. Although, other studies note that concern about their visual impact can vary among communities. It should be remembered that developers commit to investing in power line infrastructure, rather than the burden falling to the municipal rate-base. This can present a challenge for developers, as they seek to balance cost-effective aerial options, against the more expensive but more discreet underground trenching. Moreover, this study presented no explicit evidence from developers as to how underground trenching could impact soil quality, erosion, dust, or biodiversity – all factors that conflict with the policy intention of the NPS-HPL.

8.1.3 Summary

In conclusion the research undertaken has identified Central Otago has many of the early requirements for grid scale solar farm developments to be implemented throughout the region. These requirements are supported by GIS mapping which together can assist in developing the technology in the region. Although the research was not exhaustive, it provides a foundation for the CODC to develop a better understanding of the technology and the processes involved.

8.2 Positive and Negative Aspects of Grid-Scale Solar Developments

The Naseby Solar Farm, and future developments, could produce numerous positive and negative effects for Central Otago's economy and broader environment. This section will focus on the environmental and economic impacts from grid-scale solar developments, by analysing impacts at the scale of Vincent and Māniatoto Wards. The Ward-scale is relevant to economic and environmental considerations because, under the RMA, these factors are integral to the District Council's consenting framework for land-uses, as well as zoning and land-use patterns. Employment and other economic inputs will also flow beyond a small rural setting. Economic and environmental outcomes will be explored through each stage of the lifecycle of solar developments.

8.2.1 Construction phase cost and benefits

Within the lifecycle of a grid-scale solar development, the construction phase may be the most impactful in terms of costs and benefits. It is important to note that the degree at which these costs and benefits are experienced is heavily dependent on the choice to implement strategies to prevent costs and amplify benefits, as well as site location, and other related factors (Dhar et al., 2020).

For the construction phase, SRs and KIs tended to focus on potential economic benefits such as employment and servicing. Consonant with Dhar et al. (2020) and Hernandez et al. (2014), it was identified that during the construction phase, positive economic outcomes could include opportunity for employment, circulation of secondary spending, local community upskill, and the potential for more local development and investment. Importantly, the latter three economic impacts can be hard to quantify as they rely on indirect and induced spending from *consumer-to-business* and *business-to-business* interactions, rather than primary spending by the developer (Jones et al., 2015; Tuck, 2021).

Short-term benefits from the construction phase may remain impactful for Central Otago, even if employment numbers contract once construction is complete (Jones et al., 2015). The scale of economic benefits is also relevant. It is unclear the extent that significant jobs will be taken up by small townships like Naseby. Key Informant 5 acknowledged that workers might need to be brought in from centres like Cromwell, meaning that there is potential for economic benefit to impact at regional and national levels through the construction and energy sectors (Tuck, 2021). Notwithstanding this factor, the small-town scale might mean that secondary spending has the potential to be impactful – in the words of KI 7, "it's always good to have those workers coming to town [...] it's all good for the town." The results also suggested that economic costs during construction would largely be borne by the developer themselves (Tuck, 2021). Indeed, KI 2 affirmed that it was advantageous for private developers to lead the process, as it would not place pressures on municipal revenues or the low "rate base" of Central Otago.

The negative implications during the construction phase of a solar development are heavily directed towards the effect it has on the environment, which is evident through literature. Through our study, results showed environmental concern for the unique landscape. Dhar et al. (2020) comments on some of these concerns which have the potential to impact upon natural landscapes, such as land fragmentation. This leads to issues such as habitat decline and the displacement of certain species (Dhar et al., 2020). Due to the construction phase being heavily focussed on clearing and grading land, soil quality, erosion, and habitat loss are expected environmental concerns at this stage (Dhar et al., 2020). The removal of vegetation during the clearing of land can result in the production of dust, ultimately changing the land cover and effecting the dynamics of the land (Hernandez et al., 2014). These factors may be important in the dryland and tussock grassland ecosystems that characterise Māniatoto and the wider district (LINZ, 2002).

8.2.2 Operational phase cost and benefits

During the operational phase of grid-scale solar developments, the positive and negative effects for environment and economy have frequently been described as less impactful than in the construction and decommissioning phases, as noted in the literature and research results (Dhar et al., 2020; Hernandez et al., 2014; Tawalbeh et al., 2021). However, the extent of environmental and economic costs and benefits that are experienced during the operational phase of solar developments depends on a variety of factors. Implementing agrivoltaic systems, for example, can significantly influence the type of environmental and economic effects encountered during the operational phase of solar development (Nordberg et al., 2021).

For the most part, the potential outcomes of a solar development have been widely noted as having more positive than negative economic and environmental impacts during the operational phase. Some of the economic impacts identified in the results, in relation to this phase, included employment opportunities, potential tourism, investment in developments and infrastructure upgrades, and economic diversification. These findings align with the findings of studies elsewhere (Dhar et al., 2020; Hernandez et al., 2014; Tuck 2021). Notably, economic diversification is particularly significant as it could contribute to the resilience of rural communities in the Māniatoto and Vincent Wards. For instance, Partridge (2020) demonstrated that agricultural farmers diversify their income streams by becoming energy producers through the implementation of solar farms, reducing rural economic and energy vulnerability. In Central Otago, the income stream for farmers can be diversified by leasing farmland to the energy companies for solar farms. This same opportunity was emphasised in the present research. Considering this positive aspect of grid-scale solar developments is crucial as it encourages economic and energy resilience, especially in the face of the challenge of climate variability on agriculture and energy production. However, it was noted by some participants that energy resilience may not end up being specific to the rural community where the solar farm is located, depending on whether all the energy is fed back to the grid or not. Similarly, the income received by contracting landowners may only have a modest 'ripple-effect' for local community-members (Fraser & Chapman, 2018). Even so, at the national level, solar developments will be instrumental in increasing energy resilience in Aotearoa-New Zealand and contribute towards the country's renewable energy goals.

When examining employment opportunities through the operational phase of solar developments, it may initially seem that these opportunities are minimal compared to the construction phase. While this is somewhat true, employment opportunities may increase with the implementation of agrivoltaic systems (Nordberg et al., 2021). Despite this fact, the research participants made little mention of the economic aspects that agrivoltaic systems would no doubt produce, and no mention of the employment prospects. This may be because the land where the Naseby Solar Farm is to be built was deemed by many participants as not being suitable for crops, and only suitable for sheep grazing. However, it has been noted that land productivity can increase from agrivoltaic systems with crops and regenerative farming (Nordberg et al., 2021; Pascaris et al., 2022). Therefore, further research is needed to determine if this holds true for the land in the Vincent and Māniatoto Wards where future solar developments are most likely to be situated. The research results suggest a lack of public awareness regarding the economic opportunities presented by agrivoltaic systems. Consequently, it is imperative for knowledge about agrivoltaic systems to become more widespread, to fully capture and utilise all the potential economic benefits of solar developments during the operational phase.

The environmental concerns regarding the operational phase of solar developments, as illustrated in the findings of this study, did not entirely align with what has been demonstrated in relevant literature. For instance, other researchers have explained that key environmental issues during the operational phase include land fragmentation, which leads to habitat loss and threatens biodiversity, as well as water stress concerns (Dhar et al., 2020; Hernandez et al., 2014; Nordberg et al., 2021; Sánchez-Pantoja et al., 2018; Tawalbeh et al., 2021). However, these matters were not raised by our participants, except for a brief comment on water usage for crop irrigation in relation to agrivoltaic systems. It remains unclear whether this absence of discussion by our participants regarding environmental impacts is due to a lack of awareness of potential effects or the irrelevance of the common environmental concerns elsewhere to the Māniatoto and Vincent Wards. Additionally, since these environmental problems were not mentioned, there was no exploration by participants regarding how agrivoltaic systems might mitigate these issues, despite the emphasis in the literature on agrivoltaic systems as a mechanism for not only mitigation but also environmental benefits (Nordberg et al., 2021). Regardless, it was indicated by a participant that solar developments during their operational phase would improve environmental prospects when compared to current practices on the land. For that reason, it would be valuable for potential environmental issues and their solutions during the operational phase to be more thoroughly considered moving forward.

Jamil et al. (2023) explain that as the demand for renewable energy sources such as solar power grows, the allocation of land for solar developments often raises concerns regarding the competing uses of land and potential conflicts with existing land uses. However, when examining the specific context of Central Otago, particularly the Māniatoto and Vincent Wards, the primary concern does not revolve around a lack of space for large-scale solar developments. Instead, some participants expressed a desire for the land beneath the solar panels to be utilised effectively, perhaps recognising the potential benefits of combining renewable energy production with agricultural productivity. Considering agrivoltaic systems, therefore, is crucial because not only do these systems ensure the best potential environmental and economic outcomes, but they also allow for the mitigation of many issues related to land-use conflicts (Jamil et al., 2023; Nordberg et al., 2021). This argument further reinforces the value of agrivoltaic systems, emphasising their potential to deliver both environmental and economic benefits.

8.2.3 Decommissioning phase costs and benefits

There were limited results directly addressing the anticipated costs and benefits of decommissioning a solar development. Both residents and professionals expressed uncertainty and a lack of knowledge surrounding compliance measures once a large-scale solar development has completed its lease. The operational lifespan of a solar energy plant is around 20 to 30 years, after which infrastructure is either decommissioned or upgraded (Dhar et al., 2020). Environmental concerns during decommissioning were briefly explored, however study participants did not directly mention economic or environmental aspects that could adduce cost or benefit effects. Only KI 4 acknowledged that decommissioning would be as big a task as the construction phase.

The key environmental concern that was demonstrated by participants in relation to the decommissioning phase was that of the waste from panels and batteries. This finding aligns with research that discusses hazardous waste from solar farm decommissioning as the main potential negative environmental effect (Dhar et al., 2020; Hernandez et al., 2014). Hence, Dhar et al. (2020) place significance on planning for decommissioning from the inception of a solar development. Technical experts in our study did comment on the some of the ways in which waste issues may be addressed. Even so, this was not specific to a certain solar development therefore may not always be applicable. Furthermore, both the technical experts from our study and Dhar et al. (2020) highlight that technology, laws, and environmental conditions are likely to have changed by the time of decommissioning, due to new research. Therefore, new and more effective decommissioning techniques may arise. This does not negate the need for appropriate mitigation and compliance planning, particularly as regards returning land to its original condition.

The economically focussed costs and benefits during the decommissioning phase were not commented on within the present results, but this lack of response reflects the uncertainties within other academic studies. For example, Dhar et al. (2020) state that to date, reclamation-planning has not received enough attention, leading to a large gap in knowledge surrounding the decommissioning of solar energy developments and how decommissioning could affect ecosystem restoration. As the PV market grows, the amount of waste material also grows, thus justifying circular economy principles to maintain the value throughout the whole lifecycle of a solar development (Invernizzi et al., 2020; Trypolska et al., 2022; Welsh, 2023). Welsh (2023) mentions that questions have been raised regarding who is accountable for restoring previous land conditions, what will evidently occur economically, and rather whom this responsibility falls on. Trypolska et al. (2022) showed that extended manufacturer responsibility could be a pathway forward. The overall concerns of Welsh (2023) and Invernizzi et al. (2020) have not been addressed directly by the results of the present research. The concern that community-members demonstrated about solar waste, in addition to KI 11's critique that current planning regulations do not require much information from developers, indicates that resource consent conditions could act as 'levers' at the decommission stage.

8.2.4 Summary

There are various positive and negative impacts which can arise in the different phases of a grid-scale solar development. There was an economic and environmental focus that was specific to the impacts anticipated for the Vincent and Māniatoto Wards. In summary, the construction phase is where most positive economic impacts are experienced, and where the environmental effects may be the most pronounced. Employment, economic circulation, and diversification would be at their peak during the construction phase, where environmental consequences like land fragmentation and erosion would also have the greatest effect. Due to the passiveness of solar farm operation, economic and environmental impacts are less pronounced in comparison to alternate stages. International studies suggest that the operation phase contains the most potential for further economic investment, greater economic resilience, and agrivoltaic-related employment. It is during the decommissioning phase where waste from solar panels could pose an environmental concern. Scholars have suggested that waste from solar panels and batteries will proliferate as more solar farms are rolled out. To mitigate against environmental and economic uncertainties, this analysis suggests that regulatory levers, such as consent conditions and information requirements, would be beneficial.

8.3 Impact of Grid-Scale Solar Developments on a Small Rural Community

This subsection addresses the potential impacts of grid-scale solar developments on a small Central Otago settlement, using the case-study of Naseby. As discussed above, environmental and economic impacts could be impactful at the Ward-scale. To complement the prior section, this section analyses social impacts at the community-level, to identify affected 'publics' and "local priority values" (Berka & Creamer, 2018, pp.3401).

Drawing from literature on SIA and SLO, this section first comments on the key relationships and 'stakeholder' groups that underpinned solar farm development in the Naseby "social impact setting" (after Burdge, 1987, p.141). The Naseby case-study shows how CBAs 'localise' economic gains. Second, social impacts are classified against the eight-factor typology adopted by Vanclay (2003). Third, a SLO framework is applied to discuss Naseby residents' acceptance of the Naseby Solar Farm, drawing attention to procedural aspects that fostered community's sense of the project's legitimacy and credibility (Parsons & Moffat, 2014; Thomson & Boutilier, 2011). The section concludes by applying Hall's (2014) Traffic Light System to distinguish costs, benefits, and 'game-changing' impacts for SLO in Central Otago's rural communities.

8.3.1 The 'Social Impact Setting': Key Relationships Surrounding Solar Farms

After Harvey and Bice (2014), the community-scale focussed down on social impacts that would affect the priorities and values of the local Naseby community. Key Informants from Naseby described how access and use of electricity created particular energy attitudes in the small-town setting. This led "local priority values and needs" to underpin community-members' perception of social impacts, as well as what commitments they might expect from developers (Berka & Creamer, 2018, pp.3401-3403).

Private investors, particular emerging companies such as Solar Bay, can act as what KI 2 called "disruptors" in the established energy market. For Naseby, the private sector initiated and led the process of community engagement, with an "absence of levers" (KI 11) that mandated particular social outcomes in consenting conditions. However, it was explained that the developers had worked alongside kā rūnaka to identify cultural associations with Naseby site-area, and from there developed appropriate mitigations (a visual buffer comprising native plantings) that went beyond minimum conditions for the resource consent.

Whilst CODC is responsible under the RMA for land-use zoning, certain infrastructure, and planning consistent with NPSs, it is clear that the current District Plan did not anticipate the frequency or scale of private investment in solar farm infrastructure in the district. One can therefore anticipate that until finalisation of the PORPS 2021, and review of the District Plan, solar developers will continue to lead land-use change and economic development for Central Otago's small towns.

The heuristic in Figure 37 attempts to capture these emerging relationships for Central Otago's small towns. Figure 37 represents a point of departure from del Río & Burguillo's (2008) web of 'stakeholder' relationships for renewable energy developments. Crucially, the present report integrates mana whenua alongside the domain of local government, in recognition of their Treaty partnership as well as the diverse ways in which private investors, communities and other groups may interact with mana whenua as regards solar farms.

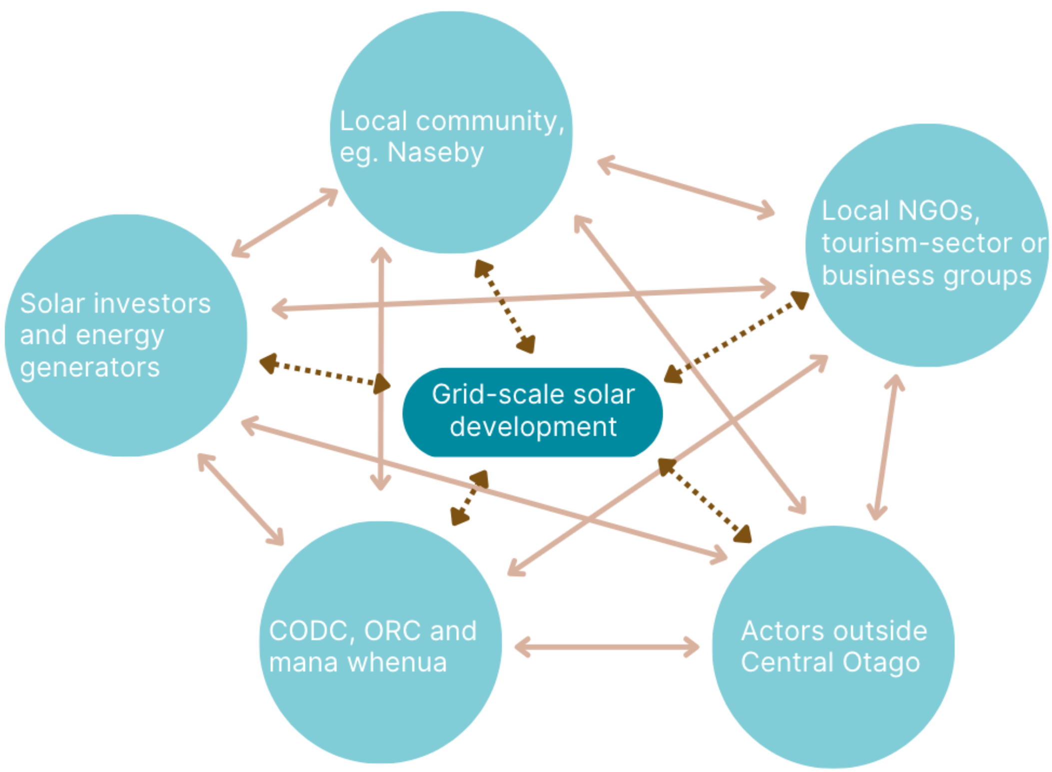


Figure 37. Heuristic for the web of 'stakeholder' interactions and relationships pertaining to grid-scale solar developments in Central Otago (Adapted from del Río & Burguillo, 2008).

8.3.2 Economic Impacts and the Role of CBAs

The foregoing section discussed economic impacts on the Ward-scale, showing potential for large employment gains and secondary spending during the construction of Naseby Solar Farm. Yet local employment gains were only speculative, and KI 2 suggested that the number of local FTE positions could be low. Naseby's demographics may play a role in this: Naseby's permanent population is predominantly retired, with no school or young workforce. This suggests that job opportunities for construction workers are likely to displace employment revenues to elsewhere in the district. Moreover, though residents hoped for cheaper electricity, several KIs explained that reduced costs would need to be negotiated with the developer – proximity alone would not cause national-grid prices to decrease. These factors recall the local/national split in benefits from REG development (Fraser, 2020; Harvey & Bice, 2014; Larsen et al., 2018). Analogy can be drawn with the low employment gains from mega-solar projects in Japan, as portrayed in Table 17 (Fraser & Chapman, 2018; Fraser, 2020).

Despite these limitations, the Naseby example provides a clear case-study on how CBAs can function to 'localise' community benefits. The developer Solar Bay engaged with community-members beyond the minimum constraints of the planning system in order to design a CBA that was beneficial to permanent residents and bach-owners. Here, this took the form of installing solar panels on the Curling Rink. The Naseby Solar Farm may only produce a "one-off" CBA (KI 6), but another KI explained that electrical apprenticeships, local upskilling, and power-bill payments could form components of an ongoing CBA. This pathway to developing a CBA is analogous to examples from Australia (Hall, 2014) and elsewhere in Aotearoa-New Zealand (MacArthur & Matthewman, 2018).

Table 17. Comparing social equity impacts between Naseby and a Japanese case-study.

Japan solar farm study (from Fraser & Chapman, 2018)	**Naseby solar farm case-study**
Minimal or no social impacts for host communities, with low municipal revenue or employment gains.	Most of the anticipated negative social impacts related to inclusion and participation in the planning/siting process. There may be positive social impacts during the construction phase from secondary spending in Naseby.

	Effects on “daily life” for Naseby were anticipated to be minimal; direct employment gains (FTE) would be low, and municipal revenues are currently unclear as the land-zoning remains fixed under the District Plan.
Increase in stable tax revenue in the under-invested rural sector	Study participants emphasised that solar energy would provide a chance for energy diversification in the district and landowner’s income diversification on agricultural land. No participants cited tax revenues as an auxiliary income stream.
Revenue for individual landholders, from rental of otherwise under-utilised land	Land-related revenues to the landowner would be stable for duration of 35-year lease. The Naseby Solar Farm is to be sited on their least productive land.
Negative social impacts, including; • *aesthetic issues;* • *negative effects of erosion and water runoff on nearby agriculture; and* • *‘freezing’ of land for the solar farm lease period.*	Anticipated negative social impacts: • Impact on visual amenity if the solar farm was sited inappropriately; • Effects on individuals were able to benefit from CBA, compensation, or land rental, while others might not. Erosion and water runoffs were not identified to be socially significant for Naseby Solar Farm as the site does not border other cultivated land.

8.3.3 Social impacts in Naseby

As laid out in Chapter 7, social impacts in Naseby range across the planning, construction, operation, and decommissioning phases. Impacts can be further distinguished against the eight spheres of social impact as adopted by Vanclay (2003) and Larsen et al. (2013). Against these eight spheres, the analysis in Table 18 suggests that *health, personal and property rights* and *fear and aspirations* are the least determinative social impact categories for the Naseby Solar Farm example. Social impacts concerning *way of life*, *community*, *political systems*, and *environment* were uncertain in some instances, and traversed matters of procedural fairness, participation in the planning system, ideological position on energy ownership, and equity concerns (consistent with Fraser & Chapman, 2018; Roddis et al., 2020).

Table 18. Analysing the eight spheres of social impact in planning, construction, operation, and decommission for Naseby Solar Farm.

Planning phase			
Social impact sphere	**Evidence from community participants**	**Positive, negative, or unknown**	**Duration**
Way of life	Contracting landowners can access another income stream, particularly in uncertain post-Covid economic conditions	+	Variable
Culture*	Community participants emphasised the importance of built heritage in Naseby, as in other "parochial" Central Otago settlements. Some participants were concerned for safeguarding that heritage but were unsure whether solar farms would have an impact.	U	*Long-term*
Community	Developers and community may negotiate favourable CBAs	+	Variable
	Negotiating CBAs for small communities may not always be straightforward, as Naseby is regarded by a resident as a "very diverse community" (KI 8).	U	*Short-term*
	Concern for community cohesion and fairness where landowners may receive different opportunities from private developers	-	Long-term
	Some residents commented that they preferred a community-ownership model, rather than private developer and contracting landowner	-	Long-term
Political system(s)	Naseby residents expressed that low-impact renewable energy infrastructures like solar, aligned with their political standpoint for Central Otago	+	Long-term
	Some residents voiced concern for the political expediency of 'problem-shifting' to rural towns	-	Long-term
Environment (including quality and access)	Naseby residents expressed that low-impact renewable energy infrastructures like solar, aligned with their environmental values for Central Otago – particularly positive about agrivoltaic co-location	+	Long-term
Health			
Personal and property rights	Naseby residents had a sense of natural justice to be consulted in the planning process	U	*Long-term*
Fears and aspirations	Naseby residents expressed uncertainty about the reality of the development due to lack of information or understanding, and related this fear to their concern for poorly planned development in Queenstown	U	*Long-term*

<table>
<tr><th colspan="4">Construction phase</th></tr>
<tr><th>Social impact sphere</th><th>Evidence from community participants</th><th>Positive, negative, or unknown</th><th>Duration</th></tr>
<tr><td>Way of life</td><td rowspan="2">There is the potential for positive accommodation impacts from an influx of construction workers to the local community, across way of life, local culture, and community social impact spheres.</td><td rowspan="2">+</td><td rowspan="2">Short-term, variable</td></tr>
<tr><td rowspan="2">Culture*</td></tr>
<tr><td rowspan="2">There may be negative trade-offs associated with accommodating or serving workers during the construction period, such as:
- undesired changes to local culture and community;
- a shortage of able-bodied workers (due to a small, predominantly retired local population); and
- the potential that workers may instead be accommodated in a different town to the host community.</td><td rowspan="2">–</td><td rowspan="2">Short-term, variable</td></tr>
<tr><td>Community</td></tr>
<tr><td>Political system(s)</td><td></td><td></td><td></td></tr>
<tr><td>Environment (including quality and access)</td><td>Impacts on the transport network due to introduction of construction materials, equipment, and workers.</td><td>–</td><td>Short-term, variable</td></tr>
<tr><td>Health</td><td>Impacts of construction could include noise and production of dust. However, these may be negligible depending on the site location and its proximity to facilities used by local residents.</td><td>U</td><td>Short-term</td></tr>
<tr><td>Personal and property rights</td><td></td><td></td><td></td></tr>
<tr><td>Fears and aspirations</td><td></td><td></td><td></td></tr>
</table>

Operational phase			
Social impact sphere	**Evidence from community participants**	**Positive, negative, or unknown**	**Duration**
Way of life	Potential for improved access to solar electricity technologies through CBA	+	Variable
	Some participants believed that the operation of the solar farm would have little impact on their day-to-day life	U	*Variable*
	Expectations of significant social benefits may not eventuate; some community-members thought that solar farms could introduce a significant number of jobs – but individual solar developments will produce few FTE positions. This factor may be a source of disappointment for community, and affect their sense of 'buy-in'	–	Variable
Culture*			
Community	Potential for tourist interest in viewing the solar farm	+	Variable
	Tourist interest in solar farms, may interact or conflict with other aspects of the tourist experience (e.g., open landscapes)	U	*Variable*
Political system(s)			
Environment (including quality and access)	The operation of the solar farm is low-impact upon the environment, and will not affect existing access rights due to being on private land	+	Long-term
	Agrivoltaic systems are congruent with community-members' environmental values, but may exacerbate water demands in an historically water-stressed district	U	*Variable*
Health	Some community-members expressed concern for health and safety risks from electrical fires, and the community's capacity to mitigate those risks	–	Variable
Personal and property rights			
Fears and aspirations	The term of operation is fixed under a lease; individual or community aspirations for the host area, may change during the lease period, which may introduce reverse sensitivity concerns	U	*Variable*

Decommissioning phase			
Social impact sphere	**Evidence from community participants**	**Positive, negative, or unknown**	**Duration**
Way of life	Accommodation and other ancillary impacts associated with the construction period, may repeat, as an influx of workers is again required	U	*Variable*
Culture*			
Community			
Political system(s)			
Environment (including quality and access)	Land will be returned to its original state after the solar development is decommissioned. Environmental benefits – such as native plantings – may endure.	+	Variable
	Community-members expressed concerns about solar e-waste, and how such waste would be incongruent with their environmental values.	U	*Variable*
Health	There are uncertain health risks of solar e-waste, such as hazards from any toxic chemicals or heavy metals contained in the panels.	U	*Variable*
Personal and property rights			
Fears and aspirations			

8.3.4 Social Equity Impacts

In the case of Naseby and Māniatoto, several participants questioned the social equity implications of solar farms. Social equity matters were expressed in terms of favouring a community-ownership model; questioning the dynamic a "singular winner" in solar farm development; or raising concerns that private commercial decisions would affect community cohesion, equitable compensation for all community-members, or cultural values. Similar to previous academic studies (Fraser & Chapman, 2018; Morrison & Lodwick, 1981), impacts on social equity were challenging to interpret and quantify in the Naseby context. They were inherently relational and were sometimes conveyed through the participants' sense that they lacked information.

For Naseby, another important social equity concern related to environmental 'problem-shifting' – that small rural towns would be assigned the burden of meeting urban energy demands and GHG emission-targets, through new energy infrastructures. Though Roddis et al. (2020) also questioned the fairness of siting REG infrastructures in small rural communities, the survey and photo-elicitation showed strong community support for renewable and solar infrastructure in Māniatoto and Vincent Wards. Residents also made favourable comparison between Naseby Solar Farm and the divisive Project Hayes proposal. On balance, social equity concerns remain probative, but Naseby "local values" appear to concord with those "public 'green' values" that support renewable energy development (Berka & Creamer, 2018). The positive community feedback about opportunity for income diversification, along with a sense that agrivoltaic technologies were sympathetic to rural identity in Māniatoto, suggest important opportunities for the highly-seasonal agricultural sector of Central Otago (del Río & Burguillo, 2008).

8.3.5 Limitations to ascertaining cultural impacts in Naseby

The authors of the present report have taken a cautious approach to identification of cultural impacts from solar farm development in small towns. Whilst the results showed that rūnaka engagement had occurred for Naseby Solar Farm, the researchers did not engage directly with mana whenua. The process of ascertaining cultural impacts, similar to gauging social impacts, recalls the tensions of "insider/outsider" dynamics for SIA (Ahmadvand & Karami, 2017, p.40), and thus the sensitivity that 'outsider' researchers should have when assessing impacts.

Importantly, CIAs have a particular purpose and function within the context of Treaty partnership in Otago (Ruckstuhl et al., 2014).

The existing statutory 'levers' to support recognition of cultural values and impacts, reside primarily in the RMA (Table 19). They can be "provided for" through a CIA on a site-specific basis, and through longer-term relationship building that may support social license with Indigenous communities (Ruckstuhl et al., 2014). Given the sometimes "contested" nature of renewable energy transitions in a Tiriti o Waitangi context (MacArthur & Matthewman, 2018), this report advocates an IA and SLO framework that can affirm Treaty-partnership between mana whenua and local government in energy transitions.

Table 19. Key 'levers' in the RMA 1991 for recognising Indigenous cultural impacts and values

Section 6(e) of the RMA requires public authorities to *"recognise and provide for"* the relationship of Māori and Māori culture with "*their ancestral lands, water, sites, waahi tapu, and other taonga"* as a matter of "*national importance*".
Section 7(a) requires public authorities to *"have regard to"* kaitiakitaka.
Section 8 requires public authorities to *"take into account the principles of the Treaty of Waitangi"*.

8.3.6 The role of uncertainty in identifying social impacts

As introduced above, participants' uncertainty about the impacts of the Naseby Solar Farm meant there were methodological constraints in assessing the scope and significance of social impacts. First, several community-members conveyed that they did not have enough information to feel prepared to comment on how solar developments might affect them. Second, community optimism about "massive" economic benefits was somewhat mismatched with evidence from technical experts and practitioners, who indicated that CBAs were more likely to be the source of longer-term benefits in rural communities. It is important to recognise that disjunction between expectations and reality could affect residents' sense of both *substantive* and *procedural* fairness for solar farm developments, in turn changing the level of local acceptance (Parsons & Moffat, 2014; Roddis et al., 2020).

Though Naseby residents seemed satisfied with the Naseby Solar Farm and the associated CBA, the issue of uncertainty seems likely to persist. As explained by one KI, several Māniatoto landowners have been approached by solar investors. Landowners, such as KI 6, may have a sense of direct contact with solar developers; but the corollary is that communities may continue to experience uncertainty around positive and negative impacts. This could inadvertently lead local governments to manifest what Walker (1995, p.57) called the *decide-announce-defend* approach to renewable energy developments. The GIS results indicate Wedderburn, Ranfurly, Ōmākau, and Ranfurly as suitable areas for solar farms, and they could also be considered "communities of relevance" for IA and SLO (Brewer et al., 2015; Roddis et al., 2020). Since uncertainty appears to be a crucial consideration in assessing social impacts, the following paragraphs integrate uncertainty into a framework for understanding acceptance, approval, and Social License for solar farm developments.

8.3.7 From Impact Assessment to Social License

(a) Factors within social acceptance and approval of the Naseby solar farm

The survey results show that community support for low-impact renewable energy was a likely predictor of their moderate or strong support for development of solar farms in Central Otago. Yet the Naseby case-study illustrates how community-members can move from "abstract" support, through to approving of a development with "particular character" (Walker, 1995, p.50). To interpret the Naseby results, Figure 38 applies Thomson and Boutilier's (2011) SLO continuum.

First, KIs came to view the project as *legitimate* due to its low environmental impact, seeing solar on a utility-scale as "one of the viable options going forwards" (KI 10). Second, the Naseby solar farm drew *credibility* through being "sensitively" sited away from important view-shafts that would disrupt the community's attachment to the landscape. Their *acceptance* was further supported through negotiation of a CBA that would reduce energy bills for the community's Curling Rink. Third, community-members *trusted* the judgment of the landowner in entering into the agreement, as his judgment was "very long term" (KI 8). Similarly, KI 6 himself expressed that trust and open communication with the developer underpinned his decision to enter into the lease arrangement.

The SLO continuum provides a useful heuristic to understand how a rural host community, like Naseby, may come to not only *accept*, but *approve* of a solar farm development. Whilst Thomson and Boutilier's (2011) continuum suggests that communities may come to *identify* with a proposal, it may be some time before the Naseby community is able to develop a view, because the Naseby Solar Farm has yet to be constructed. It is also important to note that Naseby residents, alike others in Māniatoto, have prior experience with renewable energy proposals in the area. Study participants compared solar energy favourably to the divisive Project Hayes proposal. This is important because windfarms have often generated strong public opposition (de Sena et al., 2016; Larsen et al., 2018). This suggests that solar seemed *preferable* to wind- or hydro-power. To borrow from Lovins (1978), impacts from solar farms could therefore be considered a 'softer' energy path.

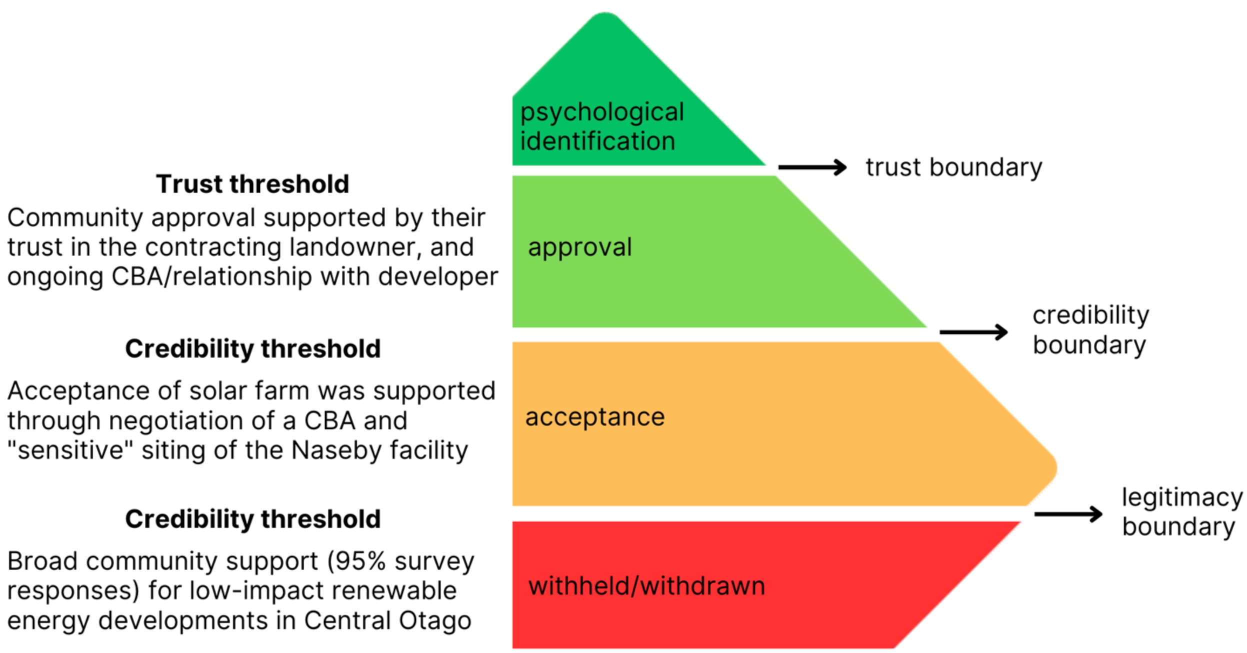


Figure 38. Thresholds for project legitimacy, credibility, and trust in Naseby solar farm case-study (Adapted from Thomson & Boutilier, 2011).

(b) A Traffic Light Framework for solar farm SLO: costs, benefits and 'game-changers'

Under Thomson and Boutilier's (2011) concept, 'identification' remains the last threshold regarding a SLO for solar farms. To determine which factors could manifest a degree of 'buy-in' for Naseby, the present report applies Hall's (2014) Traffic Light Framework. The analysis in Table 20 displays impacts and perceptions as *Costs*, *Benefits* and *'Game-changers.'*

Table 20. Traffic Light Framework for solar farm SLO in Naseby: Costs, benefits and 'game-changers'.

Category	Status	Observation in wind-farm case-study
Contextual	A *Game-changer*	**Engagement and access to the planning system** Several participants in Naseby expressed how planning system does not adequately consider contribution from individuals and communities
	A *Game-changer*	**Community uncertainty and education around solar farm interest in Central Otago** Many community-members were uncertain around the potential impacts, costs, and benefits of solar farms, which affected their ability to engage meaningfully with the present research. It also affected their perceptions about the magnitude and nature of perceive benefits or costs – presumptions which could affect their ideological standpoint
	A *Game-changer*	**Mana whenua aspirations and intentions** Concerns and aspirations of mana whenua, in relation to private-sector led energy generation and the RMA-system, require further attention (beyond the scope of the present report).
Physical	G *Benefit*	**Broad environmental 'gains'** Environmental gains include low-carbon and low-impact electricity generation; compatibility with farming; and potential to improve biodiversity through native tree planting in visual buffers
	G *Benefit*	**Compatible with Naseby Dark Sky Zone** Solar farming is sympathetic to the Naseby Dark Sky Zone; and glare is unlikely to produce more than minor adverse impact.
	A *Game-changer*	**Visual impact: Design and layout** The layout, number and location of the utility-scale solar array can minimise community perceptions of negative visual impact if done "sensitively" (KI 8)
	G *Benefit*	**Agrivoltaic** Agrivoltaic systems (livestock, e.g., sheep) were positively viewed by study participants as "making sense" for the agricultural landscape setting
	A Game-changer	**Agrivoltaic** Agrivoltaic systems (cropping) were viewed positively, but raised questions about water-use in a predominantly water-stressed district
	R *Cost*	**Risk and mitigation for electrical fire** Risks and mitigation associated with electrical fire are not clearly understood and questions remain about the availability of an appliance for Naseby/Māniatoto
	R *Cost*	**Fixed land-use**

		Siting a solar farm means no option of alternative land-use for the duration of the solar farm lease.
Economic	A *Game-changer*	**Tourism** Solar farms can attract tourism, yet this may conflict with other aspects of Central Otago tourism (e.g., wide-open vistas along the Rail Trail)
	A *Game-changer*	**Economic perceptions versus reality** Participants had a range of perceptions around the number of jobs that solar farms could create for the district. For those who perceived that a significant number of jobs would be created, the understanding that few FTE positions would result, could impact their sense of buy-in to solar development.
	A *Game-changer*	**Public revenues** Private developers sell solar-generated electricity back to the grid, via Transpower; profits may hence accrue outside of Māniatoto or Central Otago district. The extent that local revenues can be retained – through taxation, rating, or development contributions – is a matter for local government.
Social	G *Benefit*	**Developer-led engagement and CBAs** Developers acting beyond required compliance, including willingly engaging outside the formal resource consent process, leads to better-acceptance for utility-scale solar farms: - Community Benefit Agreements - Community engagement and trust-building
	R *Cost*	**Compatibility with individual and community worldview** Some participants expressed ideological and cultural opposition to proposed solar farms – opposition that may be immutable despite engagement, education or trust-building as regards specific developments. Such underlying concerns related to: - The sense that rural areas were the subject of environmental 'problem-shifting' from urban areas, in terms of urban energy demands or national GHG emissions; - The sense that small-town or rural areas were neglected in the planning or local government systems; - Individual or community commitment to an anti-development stance, bolstered by aversion to the phenotype of development in Queenstown

Key *'Game-changing'* factors relate to participation in the planning system; recognition of mana whenua interests and values; and site-specific design, layout, and land-use conflict. Similar to Hall (2014), one should observe that the ideological standpoint of community-members may be immutable as regards urban/rural tensions, or commitment to 'green' technologies. However, the present results showed that technological advances, such as agrivoltaic systems, could be a '*Game-*

changer,' as community-members viewed them as complementary to rural lifeways. Similarly, access to favourable CBAs was a substantive *Benefit* towards SLO in Naseby case-study. It remains to be seen whether CBAs may need to be managed as a '*Game-changer'* for future solar developments in Central Otago.

8.4 Summary

This chapter analysed the series of environmental, economic, and social factors that determine the viability of grid-scale solar farms in Central Otago District. Through high solar radiance and gentle topography, many parts of the district receive the combination of environmental factors that indicate the land's suitability for siting a solar farm, and proximity to substations is a determinative factor. Lines-connection and transport-planning remain key infrastructure considerations. Importantly, the NPS-HPL may impose constraints on site-selection should solar farms be considered an "inappropriate" use or development.

Economic and environmental impacts are likely to accrue at the Ward- or district-scale. Economic benefits include employment opportunities during the construction phase, and secondary spending associated with accommodation and hospitality. Environmental costs are most concentrated in the construction phase due to noise, soil gradation, dust, and road-movements. However, there are few environmental costs during the operational phase, with the district (and wider region) benefitting from divestment to renewable energy. Agrivoltaic systems generate strong community support and enable productive land to be utilised according to the purpose of the NPS-HPL. For local communities, social impacts upon their *way of life* and *personal rights* will be minimally impacted during solar farm operation. However, local communities also experience little in the way of direct economic benefit from having a solar farm operating nearby, raising social equity concerns. Community Benefit Agreements become a way of 'localising' economic benefits and social gains that would not otherwise occur during the lifespan of a solar development. A SLO framework can identify community perceptions and uncertainty towards environmental, social, and economic impacts from solar farms. Through the SLO lens, planning practitioners may focus on managing *'game-changing'* factors for community engagement in the solar planning process.

9.0 Recommendations

9.1 Recommendation 1: Enable and Manage Solar Developments Through a Policy Framework

The authors recommend that CODC manage current applications for solar developments through existing resource consent levers such as consent conditions. The District Plan Review, and development of a non-regulatory strategy, can enable and manage future utility-scale solar developments.

A key area of interest for practitioners revolved on the current District Plan levers available in order to regulate ad hoc development and land-use change for solar farms. The current iteration of the Plan does not contain any provisions that are specific to development of REG infrastructure on private agricultural land. The Plan provides district wide rules and performance standards to manage adverse effects on the receiving environment (such as environmental and amenity effects from construction and development). However, the Plan does not identify specific direction on activities such as solar-farm decommissioning. Therefore, CODC practitioners could activate existing resource consent levers such as consent conditions and section 92 requests under the RMA. Resource consent conditions could apply to a decommissioning plan; or to mandate financial contributions (per section 15 of the current District Plan). Where appropriate, applicants should also be compelled to provide further information about environmental, social, and cultural effects through section 92 of the RMA. The GIS outputs in the present report indicate 'communities of relevance' for SIA, which applicants may be compelled to provide (Brewer, et al. 2015). Information on cultural effects ought to be reflected via an applicant's engagement with kā rūnaka.

The District Plan Review should consider how it sets the activity status for certain land-uses in Central Otago. At first blush, the NPS-HPL stipulates a national policy direction to safeguard HPL for primary production purposes. Agrivoltaic co-location appears sympathetic to the intentions of the NPS-HPL, as sheep can be grazed or crops grown beneath solar panels. This indicates that it may not be pertinent to set a stringent activity status for grid-scale solar, particularly when aligning with NPS-REG. However, the report-writers note that the PORPS 2021 is yet to be finalised, so it remains to be seen how the Freshwater Parts will implement the NPS-FM's direction on water allocation, which may have relevance to agrivoltaic operations that require irrigation. The Plan Review may be aided by forthcoming national guidance on consenting for REG (MBIE, 2023a).

This report also advocates a non-regulatory strategy for grid-scale solar developments. Such a framework could be prepared as part of a Spatial Plan, or as an addendum to the *Economic Development Strategy 2019-2024*. Components could include spatial planning in 'hotspots' for grid-scale solar developments; strategy for managing land-use change and cumulative landscape effects; and guidance on consenting conditions, community engagement and CBAs. A non-regulatory framework should, alike the District Plan Review, provide for partnership with mana whenua. Yet it may be expedient to prepare a non-statutory strategy prior to reviewing the Plan, in order that CODC signal its policy direction on managing effects.

9.2 Recommendation 2: Facilitate Cross-Industry Opportunities for Education.

The authors recommend that CODC facilitate cross-industry workshops that support consciousness-raising and knowledge-building in the district.

Community-members in Central Otago did not have a clear image of the potential impacts of grid-scale solar developments, and how these developments might affect them. Many study participants highlighted their desire for further information in order to make informed engagement with the present study and future developments. Cross-industry workshops ought to be led and funded by representatives from solar farm developers who are actively expressing interest in Central Otago. By providing a council venue, or administrative support, the CODC can further signal its active involvement in planning for solar land-use change in Central Otago. Cross-industry workshops could first prioritise townships in Māniatoto and Vincent that are likely to be 'host communities' for solar developments.

Some study participants perceived that Council has a knowledge-gap regarding grid-scale solar developments. It is likely that landowners will continue to approached with offers from developers, but it is unclear how landowners might direct their queries to the Council. To aid Consent Officers, it may be useful for CODC staff to prepare an internal fact-sheet that describes the anticipated environmental, economic, and social considerations specific to utility-scale solar farm developments. This sheet could also include information about co-locating agriculture with solar panels, and the resource consent considerations that this may attract.

Though outside of the scope of the present report, there were several study participants who questioned the ethics of investor-led energy transitions. Community-ownership models may support energy resilience in Central Otago but it is key that members of the public feel that CODC processes are amenable to articulating and achieving such aspirations.

9.3 Recommendation 3: Promote Partnership with Mana Whenua and Transparency with the Wider Community.

The authors recommend that CODC continue to promote partnership with mana whenua and transparency with the wider community as regards planning and consenting for grid-scale solar developments.

Developing ongoing partnership and co-design with mana whenua will support the two foregoing recommendations. Though solar REG is considered a low-impact technology, CODC is still obliged to take into account Te Tiriti o Waitangi. It is important that CODC understand and embrace the expectations and intentions of kā rūnaka, particularly as private investors continue to dominate the solar farm sector.

10.0 Conclusion

The Central Otago District has been identified as an ideal location for future grid-scale solar developments. It is evident that communities are less familiar with solar developments as a form REG, and that solar developments are not comprehensively reflected in national direction on REG. The CODC devised a brief that invited the researchers to consider the implications and planning conditions for grid-scale solar developments in the district. The Research Objectives that guided the study were as follows:

1. To investigate examples of grid-sized solar energy developments in Aotearoa-New Zealand and overseas;
2. To understand what environmental conditions, infrastructure, and physical resources needed to make a grid-scale solar energy development viable in Central Otago;
3. To consider the benefits and costs of grid-scale solar developments;
4. To consider the impact of a grid-scale solar energy development on a small rural community.

The qualitative and quantitative methods focussed on the collection of primary and secondary data. Primary qualitative methods consisted of photo-elicitation, and semi-structured interviews with planning practitioners, community-members, landowners, and technical experts. Other primary methods included a quantitative and qualitative survey-questionnaire, as well as GIS mapping. Secondary methods included a literature review, which identified solar development case-studies. A policy analysis was also employed to become familiar with policies relevant to the research, while recognising gaps specific to the context of Central Otago's solar development potential.

The literature review and a policy summary answered the first Research Objective. The results from these methods illustrated examples from India, Japan, Germany, Edgecumbe, and Taupō. Furthermore, the policy summary indicated how development of solar farms can intersect and conflict with national direction that promotes REG but seeks to safeguard HPL.

In answering Research Objective 2, the study incorporated KI interviews as well as GIS mapping. Findings revealed that sufficient solar radiance, minimal shade from topography, minimal cloud cover or precipitation were all environmental conditions needed to ensure the greatest efficiency of a grid-scale solar development. Other site-selection criteria included proximity to the national grid, and identifying unproductive land that had no potential for alternate use. Infrastructure and physical resources needed for a viable solar development in Central Otago consisted of natural landscape character, cost of aerial lines versus trenching, as well as transport and road infrastructure considerations. The extent to which grid-scale solar developments will be considered "inappropriate use and development" of HPL, relies on how the District Plan sets an activity status for REG developments on this type of land.

Research Objective 3 was investigated through a combination of interviews, survey-questionnaires, and the literature review. The economic and environmental costs and benefits of grid-scale solar developments were explored on a Ward-scale, following the lifecycle of a solar development. Depending on how a development is carried out, there may be substantial economic benefits during the construction phase, and environmental effects such as erosion, dust, and visual impact must be managed appropriately. Agrivoltaic systems may be sympathetic to the Central Otago context due to the opportunity for the agricultural sector to diversify, which provides another source of benefit from solar developments.

The survey-questionnaire, interviews, and literature review were used to address the fourth Research Objective. The potential social impacts of solar developments on rural communities were examined in relation to Naseby. A SLO framework was utilised to address uncertainty in regard to what is perceived by communities, their acceptance, and what is deemed as legitimate and fair. Identified social impacts were classified into eight key spheres: way of life, culture, community, political systems, environment, health, personal and property rights, and fears and aspirations. The most apparent impacts were interrelated with aspects of way of life, local culture, and community. In addition, a Traffic Light Framework positioned key impacts into three groups: costs, benefits, and 'game-changers.' The 'game-changing' factors encompassed the engagement and access to the planning system, mana whenua aspirations, and community uncertainty and education.

In conclusion, this research project has illustrated numerous aspects of grid-scale solar developments that will be important for the CODC to consider in expanding the district's renewable energy capacity. The three recommendations, presented above, are crucial outcomes from this research that seek to aid CODC in successful future implementation of grid-scale solar developments. By targeting policy and implementation measures, cross-industry opportunities, and mana whenua partnership, the CODC may be well-positioned to approach land-use change and energy diversification in the district. This strategy can achieve the best range of outcomes for the local economy, environment, and community.

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Appendix A: Ethics B Approved Application

Form Updated: November 2021

UNIVERSITY OF OTAGO HUMAN ETHICS COMMITTEE
APPLICATION FORM: CATEGORY B

(Departmental Approval)

Please ensure you are using the latest application form available from: http://www.otago.ac.nz/council/committees/committees/HumanEthicsCommittees.html

1. **University of Otago staff member responsible for project:**
   Michelle Thompson-Fawcett

2. **Department/School:**
   School of Geography

3. **Contact details of staff member responsible** *(always include your email address)*:

   michelle.thompson-fawcett@otago.ac.nz

4. **Title of project:**

   Central Otago Grid-Scale Solar Developments

5. **Indicate type of project and names of other investigators and students**:

Staff Research Names	☐	N/a
Student Research Names	☐	Larissa Hinds, Emma Kuparinen, Daizy Thompson-Fawcett, Ella Walker-Smith, Corrigan Millar
Level of Study (e.g. PhD, Masters, Hons)		Masters
External Research/	☐	**Names**

Collaboration

Institute/Company | Central Otago District Council

6. **When will recruitment and data collection commence?**

1 May 2023

When will data collection be completed?

End of May 2023

7. **Brief description <u>in lay terms</u> of the aim of the project, and outline of the research questions that will be answered:**

The aim of this research is first to understand the conditions and infrastructure required to support grid-scale solar developments, and second to explore the environmental, social, and cultural costs and benefits of grid-scale solar developments in rural communities. This research is intended to assist in understanding the viability of New Zealand moving towards renewable energy.

The above aim will be achieved through the following research objectives:

1. To investigate examples of grid-sized solar energy developments in New Zealand and overseas.
2. To understand what environmental conditions, infrastructure and physical resources are needed to make grid-scale solar energy developments viable in Central Otago.
3. To consider the benefits and costs of grid-scale solar developments.
4. To consider the impact of grid-sized solar energy development on a small rural community.

8. **Brief description of the method.**

A multi-method approach will be used to carry out this research. Initially a desktop-based policy analysis will take place to contextualise the research area before interaction with technical experts and the public occur. Once sufficient knowledge of the legislative context and environmental, social, and historical context of the research area is reached, semi-structured interviews will take place with technical experts. These will include people from the industry such as Energy Bay Limited (Solar Bay) and Helios as well as planning practitioners from the district council. Interviews with technical experts will likely take place over Zoom or Teams platforms.

Public forums such as Facebook groups or various community groups and word of mouth will be used to recruit members of the public from the Naseby area to participate in interviews. Key Informants from the public might include local landowners that possibly have property near the proposed site, business owners that are interested in the implications this might have for their business, or public who want to have input in future developments. Local community members will be asked members of the questions regarding amenity values in and around the study area, thoughts on such developments in rural areas such as Naseby, and their understanding of large-scale solar farms. The data from these questions may be supplemented by the researchers investigating the viability the identified sites in relation to requirements for grid-scale solar by using Geographic Information Systems (GIS).

Interview participants will be asked a series of predetermined semi-structured questions, these interviews will not exceed one hour in duration. Attached in Appendix 1 is an interview schedule of the types of questions that will be asked and Appendix 2 detailing questions for our short survey. An information sheet will be shared with the participant outlining the purpose of the interview and what the data collected will be used for in the report. Consent forms will be required to be signed prior to the interview, ensuring that all parties are willing to participate and consenting to the interview being recorded and transcribed. The recorded audio files will be deleted following the completion of the project to ensure the security of our participants.

Information gathered throughout the project as well as data from key informant interviews will be stored securely on password protected devices, with sharing of information/ passwords outside of the students in the project group and the groups supervisor is strictly prohibited. Participants of the project will have the opportunity to not be named and if they wish all efforts will be taken to ensure that the participant remains anonymous throughout the project. All information from key informants will be deleted at the completion of the project in July. If key informants wish to participate in the research and have their contribution attributed to them, there will be the option on the Consent Form provided to them before conducting the interview. Their anonymity can also be altered after the interview or at any point before the July hand in date.

9. Disclose and discuss any potential problems and how they will be managed.

Participants involved in the research study will have their anonymity protected throughout the research and final presented report unless requested otherwise prior to the completion. No personal information will be kept following the completion of the study. Any recorded information including transcriptions will be held securely on password protected devices. If a participant feels uncomfortable throughout any stages of the interview process, the interview will be stopped upon request from the participant and all information gathered will be deleted if requested. Sought-after participants are individuals who have expert knowledge in the solar energy environment, planning practitioners from within the CODC, and those who express interests in the development of grid-scale solar farms in the Central Otago region.

Before the interview is undertaken it will be clearly explained to the participant that the responses recorded will be utilised by the research team in developing a report for the CODC. The report is intended to help the CODC understand the costs and benefits of developing grid-scale solar farms in the region. It will also be explained to participants that the report is not binding, and the CODC can use the research team's final recommendation in any way they deem appropriate.

Interviews will be conducted in a location agreed upon by both parties to ensure that both the research team and participants feel comfortable and safe. Throughout the interview process the research team will attempt to avoid conflicting information, however, if it is brought up the team will approach it with a neutral position and attempt to bring the conversation focus back to the research questions. The researchers will respect the differing values, opinions, and types of knowledge that come about when interviewing the participants by holding a neutral position throughout. The researchers have no prior conflicts of interest with the proposed developments or community of Naseby.

Consent will be sought prior to beginning any interviews, this will be achieved through the process of signing a consent form (provided in this application). Before signing of the consent form the researchers will provide the participant with a copy of the project's information sheet outlying the projects aim and the use of information gathered and recorded. Participants will have the ability to withdraw their contribution to the project at any time, with any saved data of their input deleted and no further questions asked.

The interviews will be attended by at least two members of the research team to ensure the researchers safety. Attendees will wear University of Otago ID's will be worn for the duration of the interview process and when engaging with members of the community, in order to address any concerns about the legitimacy of the research project.

***Applicant's Signature:**

Name (please print): Michelle Thompson-Fawcett

Date: 18 April 2023

**The signatory should be the staff member detailed at Question 1.*

ACTION TAKEN

☐ ☐ Approved by HOD Approved by Departmental Ethics Committee

☐ Referred to UO Human Ethics Committee

Signature of **Head of Department*: Douglas Hill

Name of HOD (please print): Assoc. Prof. Douglas Hill (on deputation)

Date: 30/04/2023

Departmental approval: *I have read this application and believe it to be valid research and ethically sound. I approve the research design. The research proposed in this application is compatible with the University of Otago policies and I give my approval and consent for the application to be forwarded to the University of Otago Human Ethics Committee (to be reported to the next meeting).*

Central Otago Grid-Scale Solar Developments
INFORMATION SHEET FOR PARTICIPANTS

Thank you for showing an interest in this project. Please read this information sheet carefully before deciding whether or not to participate. If you decide to participate, we thank you. If you decide not to take part, there will be no disadvantage to you and we thank you for considering our request.

What is the aim of the project?

This research aims to provide the Central Otago District Council with an assessment of the impacts of future grid-scale solar projects on rural communities. In doing this we aim to contribute to the socially and environmentally sustainable development of renewable electricity generation in the Central Otago area. This research is being undertaken by Larissa, Ella, Daizy, Corrigan, and Emma as a partial requirement for the completion of the Master of Planning at the University of Otago.

What types of participants are being sought?

To achieve our aim of better understanding how grid-scale solar developments will impact rural communities, we seek to interview people from the general public of the Central Otago area. If you wish to participate in this research and wish to receive a copy of the final report, this can also be arranged.

What will participants be asked to do?

Should you agree to take part in this project, you will be asked to participate in a semi-structured interview with two of our researchers. The types of questions that will be asked relate to the perceived costs and benefits of grid-scale solar developments in Central Otago. Interviews are expected to take 30 minutes and will not exceed 1 hour. If preferred, interviews can take place digitally over Zoom. The interviews will be recorded on audio devices for the purpose of correctly interpreting information and will be deleted after the completion of the project (21 July 2023). Please be aware that you may decide not to take part in the project at any point in the process and without any disadvantage to yourself.

What data or information will be collected and what use will be made of it?

We will be conducting recorded interviews with participants, but if they choose not to be recorded, their request will be honoured. The recorded interviews will be transcribed and analysed by the research team to identify key themes from all participants. To protect the confidentiality of the participants, their names will be replaced with aliases like Key Informant 1, unless they prefer to be named.

The research results will be shared with the Central Otago District Council via the final report, but any information that could be used to identify individual participants will be excluded, unless participants prefer to be named. Participants will have the option to protect their anonymity through the consent form.

During the interview process, semi-structured questions will be used to ensure that the conversation remains focused on the research questions, which pertain to the costs and benefits of grid-scale solar power in the Central Otago region. If the line of questioning becomes contentious, participants are free to decline to answer or withdraw from the project altogether.

Once the project is completed, the final report will be available for all participants to view if they choose to receive a copy.

Can participants change their mind and withdraw from the project?

Participants can change their mind and withdraw from the project at any time until the 30th of June 2023. All prior contributions and saved information will be deleted.

What if participants have any questions?

If you have any questions about our project, either now or in the future, please feel free to contact either:-

Larissa Hinds	and	*Michelle Thompson-Fawcett*
School of Geography		School of Geography
Larissa.Hinds@postgrad.otago.ac.nz		michelle.thompson-fawcett@otago.ac.nz

This study has been approved by the School of Geography. However, if you have any concerns about the ethical conduct of the research you may contact the University of Otago Human Ethics Committee through the Human Ethics Committee Administrator (ph +643 479 8256 or email gary.witte@otago.ac.nz). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.

Central Otago Grid-Scale Solar Developments
CONSENT FORM FOR PARTICIPANTS

I have read the Information Sheet concerning this project and understand what it is about. All my questions have been answered to my satisfaction. I understand that I am free to request further information at any stage.

I know that:

1. My participation in the project is entirely voluntary;
2. I am free to withdraw from the project before its completion (specify a date if necessary);
3. Personal identifying information identified in questionaries, audio recordings and associated transcripts will be destroyed at the conclusion of the project;
4. This project involves an open-questioning technique. The general line of questioning focuses of the costs and benefits of grid-scale solar farms in the Central Otago area. The precise nature of the questions that will be asked has not been determined in advance, but will depend on the way in which the interview develops and in the event that the line of questioning develops in such a way that I feel hesitant or uncomfortable I may decline to answer any particular question(s) and/or may withdraw from the project without any disadvantage of any kind;
5. The finalised results of this project will be presented in a report to Central Otago District Council
6. I, as the participant:

a) agree to being named in the research, ☐

b) would rather remain anonymous. ☐

I agree to take part in this project.

....
(Signature of participant) (Date)

....
(Printed Name)

Questions for Solar Power Professionals

1. How do you determine the suitability of sites to develop grid-scale solar farms?
2. Where do you want your workers to live? E.g. Alex? Naseby? Ranfurly?

Potential questions for CODC Staff or Councillors (after Fraser & Chapman, 2018)

1. What potential impacts will a grid-scale solar farm have on the local community? Please describe.
2. What kind of subsidies or revenues might CODC receive for hosting solar power infrastructure?
3. Please describe forms of municipal revenue that are expected from solar energy infrastructure.
4. What kinds of employment impacts are anticipated from grid-scale solar developments?
5. What kinds of considerations have been taken for siting arrangements?
    a. *Prompt:* what kinds of barriers have occurred during the planning process so far?
    b. *Follow-up:* which actors have been necessary for finding agreement to host the development?
6. During project construction, what social impacts are anticipated?
    a. *Prompt:* where will the construction workers be accommodated during development of the solar farm?
7. How does grid-scale solar development relate to your vision of Central Otago?

Interview Questions for General Public

Social and environmental impacts

1. What kinds of employment impacts will grid-scale solar farms have for your community?
2. How might a grid-scale solar farm influence tourism in your community?
3. What environmental impacts might occur from a grid-scale solar farm being constructed near your community?
4. How might a grid-scale solar farm influence existing or future land uses in your community?
5. How do you feel about agrivoltaic farming? (provide explanation of this if needed or photo?) Would it change your opinion on having a solar farm in any way? E.g. would there be more or less acceptance of the solar farm.

Community aspirations

1. How does grid-scale solar development relate to your vision of Central Otago?

Planning process

1. How did you first hear of this grid-scale solar development coming to your community?
2. What kind of involvement have you had in the planning process? What aspects would you want to be done differently?
3. For any future solar developments, what do you think are important considerations for CODC staff and decision-makers?

About you: ***My occupation*** **… (circle)**

Business owner. *Please specify:*	**Retired**
Farmer	**Seasonal worker**
Tradesperson *e.g. electrician.* *Please specify:*	**Education or healthcare industry** *e.g. teacher. Please specify:*
Tourism industry *e.g. accommodation provider.* *Please specify:*	**Another type of local resident.** ***P****lease specify:*

Effects of solar farming in Central Otago District

On the scales below, rate the extent to which you **agree or disagree** with the following statements:

Low-impact renewable energy developments would be a good thing for Central Otago:

Strongly agree with low-impact renewable energy developments	**Agree**	**Neutral/unsure**	**Disagree**	**Strongly disagree** with low-impact renewable energy developments

I support development of solar farms in Naseby:

Strongly agree with solar farm	**Agree**	**Neutral/unsure**	**Disagree**	**Strongly disagree** with solar farm

____

development in Naseby				development in Naseby

What **positive** or **negative** effects would you experience from solar farm development? *E.g. environmental effects, economic effects.*

____
____
____

Appendix B: GIS Maps

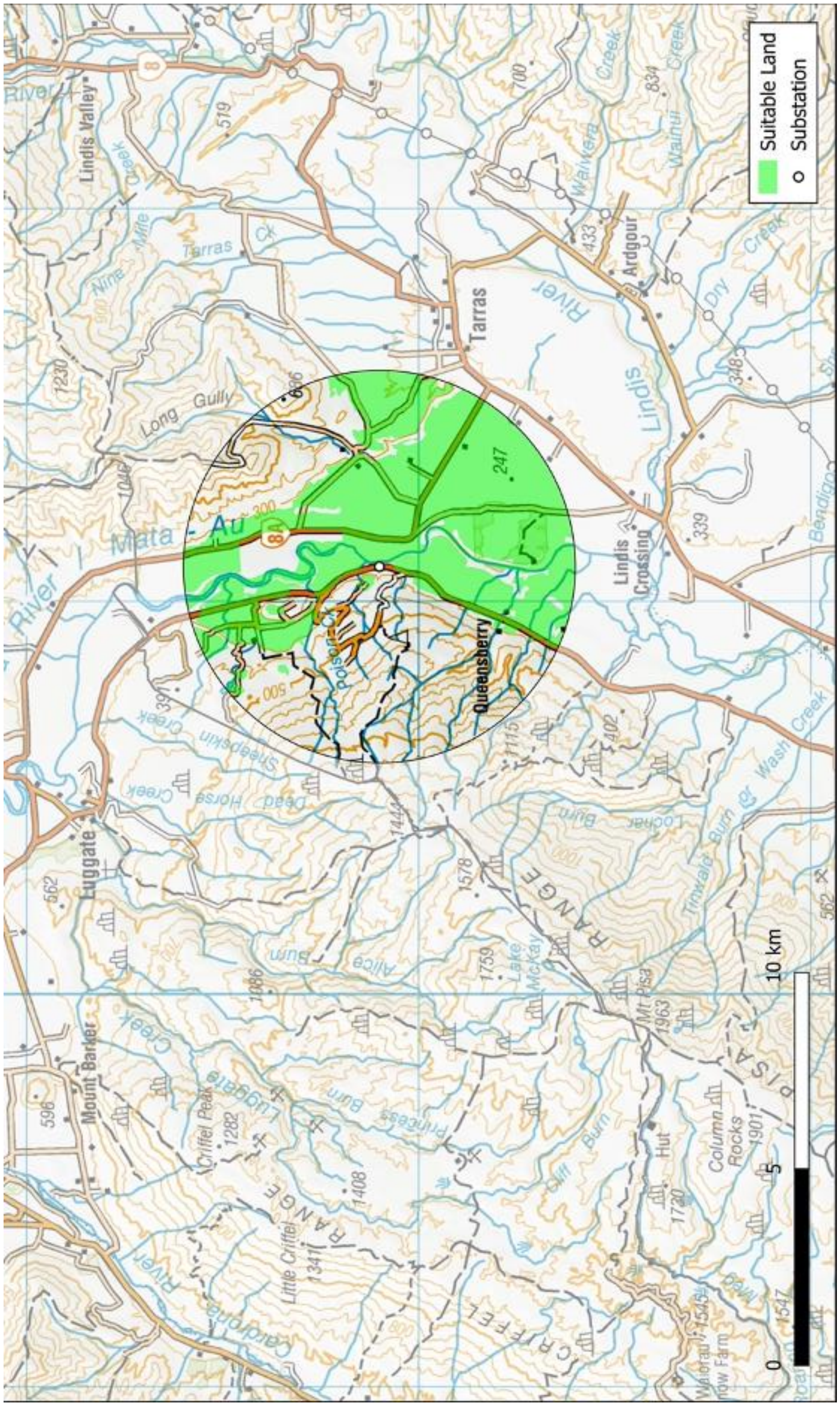

Figure 39. Tarras including HPL

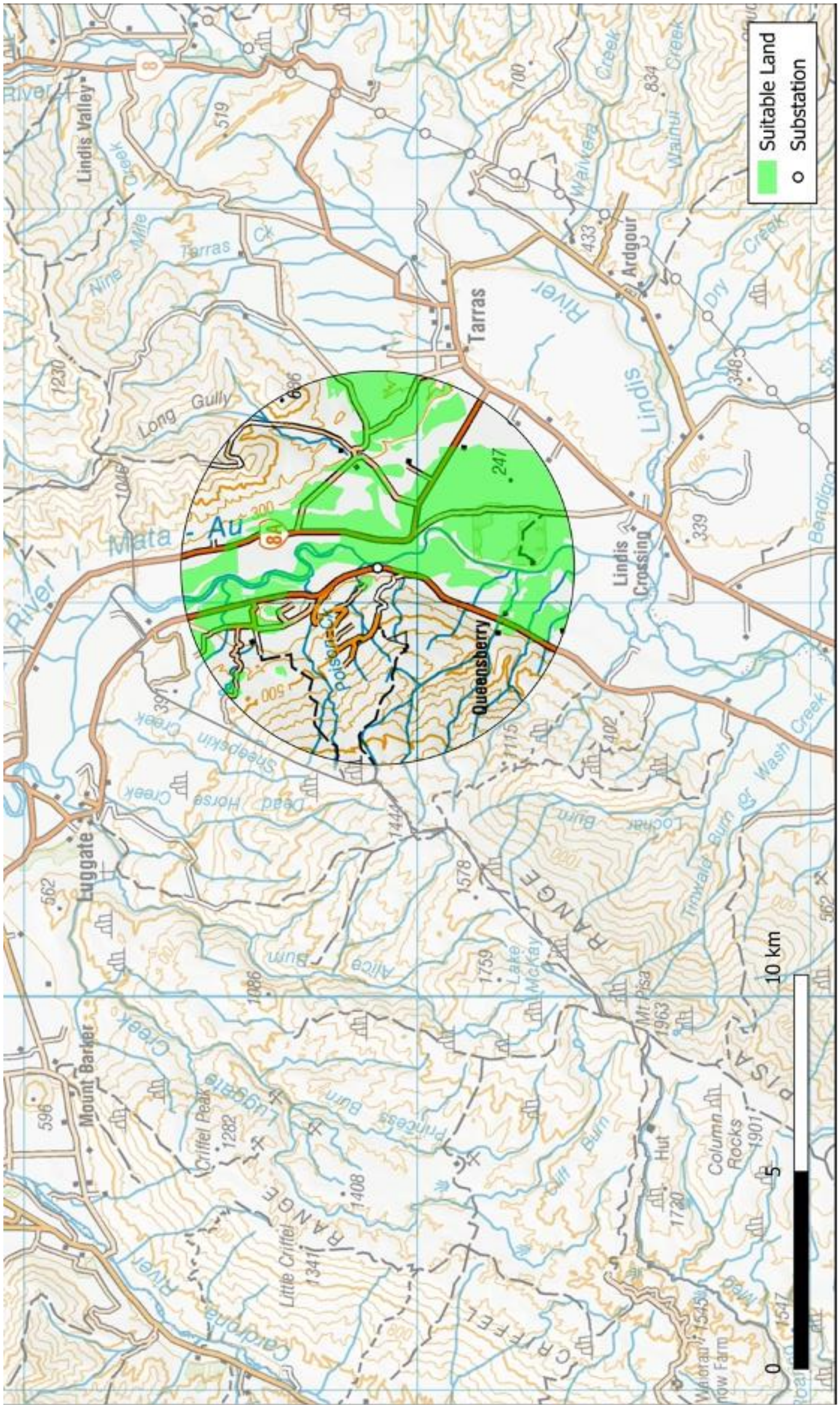

Figure 40. Tarras excluding HPL

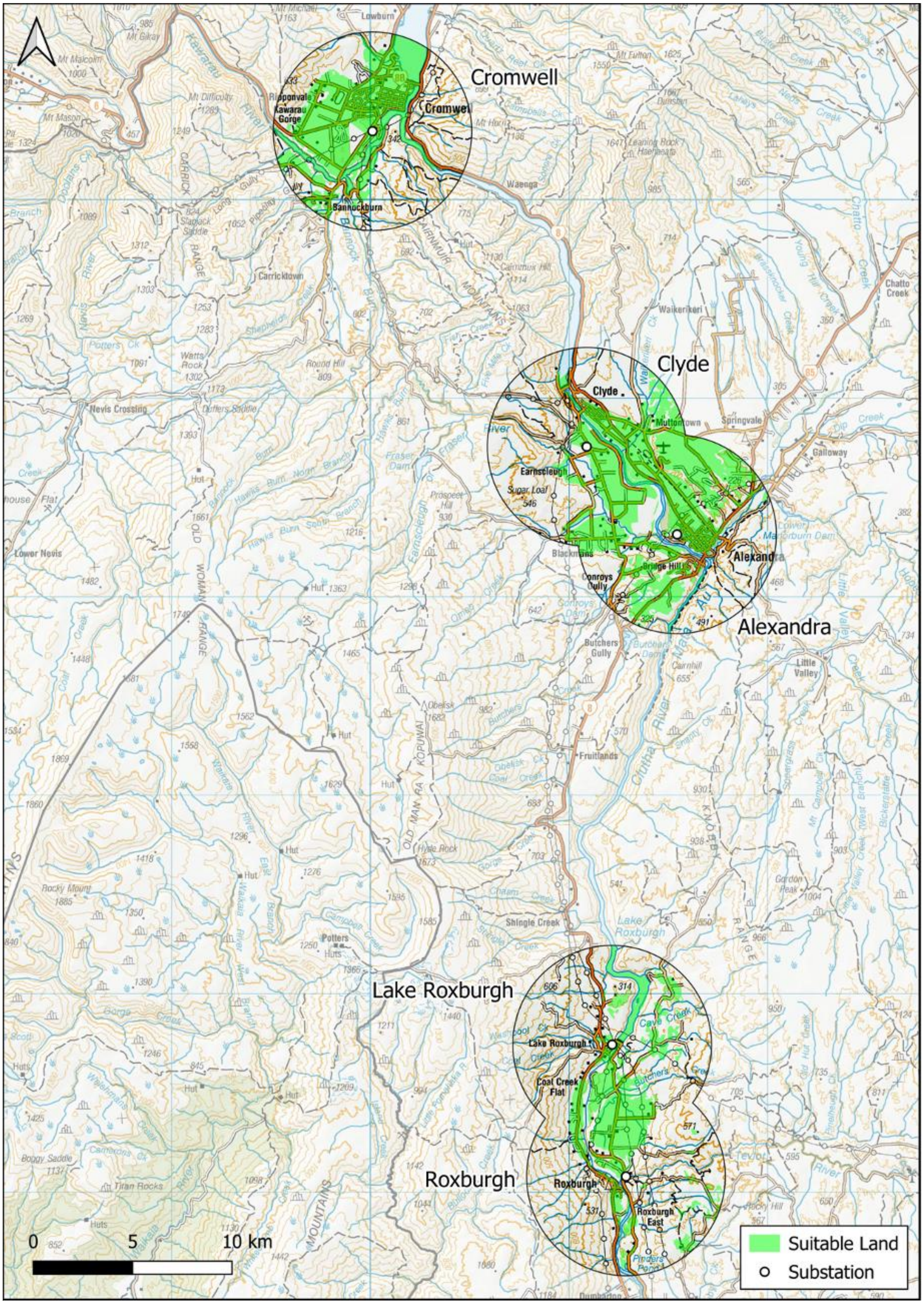

Figure 41. Cromwell and Alexandra including HPL

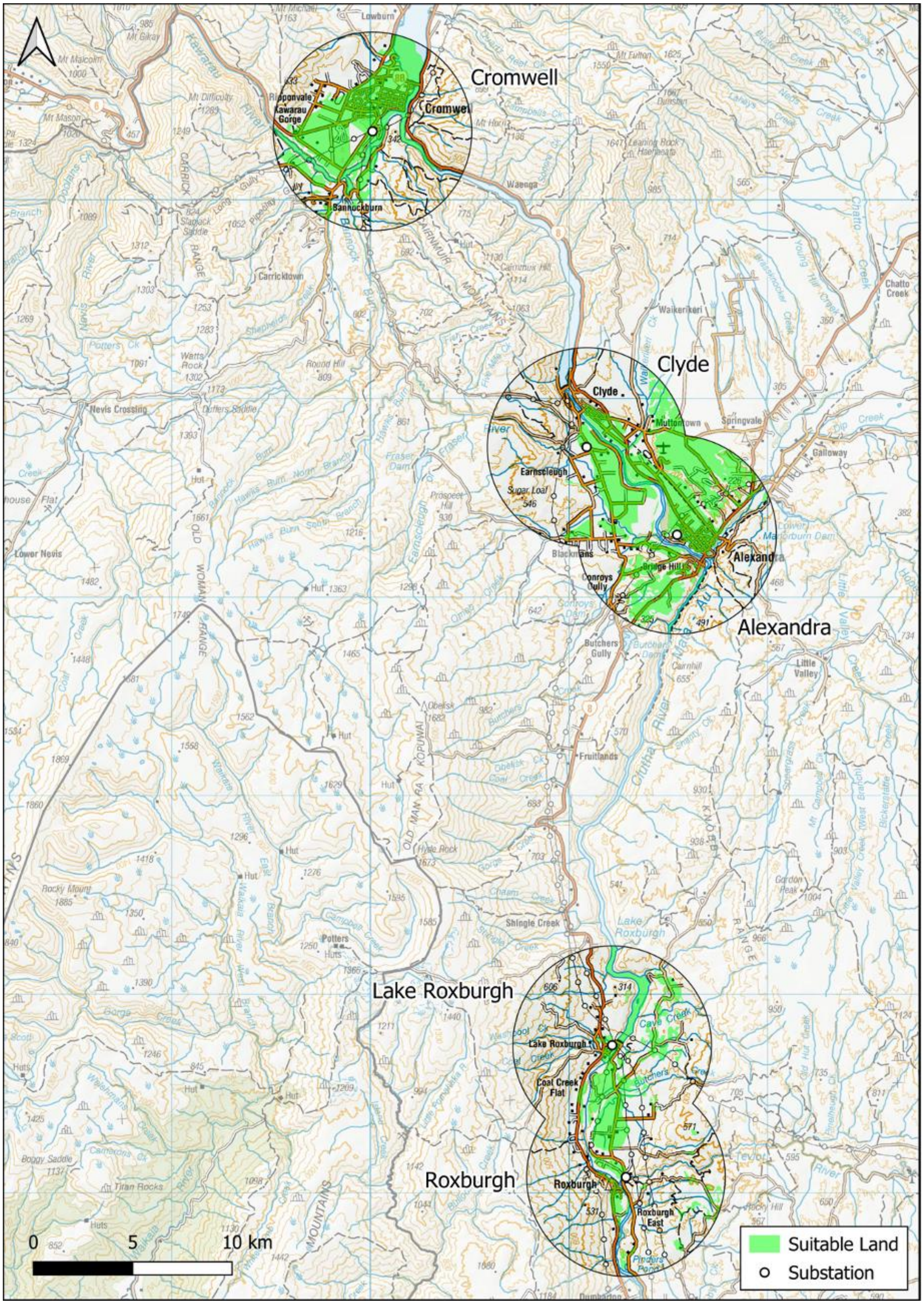

Figure 42. Cromwell and Alexandra excluding HPL

Appendix C: Breakdown of Survey Results and Statistical Analysis

Table 21. Summary of responses to question about participant occupation.

Occupation	Number of SRs	Percentage of responses
Business owner	9	15.0 %
Farmer	2	3.3 %
Tradesperson	3	5.5 %
Tourism industry	2	3.3 %
Retired	16	26.7 %
Seasonal worker	0	0 %
Education or healthcare industry	6	10 %
Another type (please specify)		
Hospitality & retail	2	3.3 %
Professional services	3	5.5 %
Other (unspecified)	17	28.3 %
TOTAL	**60**	**100 %**

Total question responses = 60

Total survey responses = 65

Table 22. Summary of survey responses for Likert-scale questions (A) and (B).

Survey question	Level of agreement (5-point Likert scale)				
	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
A	69.5 percent (41 responses)	25.5 percent (15 responses)	5 percent (3 responses)	0	0
B	51 percent (30 responses)	41 percent (24 responses)	7 percent (4 responses)	0	2 percent (1 response)

Table 23. Responses to question (C), coded by theme (up to 3 codes per response).

Theme code	Number of SRs	Percentage
Site selection factors	3	4.6 %
Environmental effect	5	7.7 %
Economic effect	12	18.5 %
Uncertain/ lacks knowledge	6	9.2 %
Uncertain but optimistic	8	12.3 %
Visual effect	21	32 %
Agricultural effect	2	3.1 %
Central Otago identity	6	9.2 %
Mana whenua association	0	0 %
Renewable energy transition	12	18.5 %
Economic resilience	2	3.1 %
Energy resilience	9	13.9 %
Rural lifeways	2	3.1 %
No response	2	3.1 %

Total question responses = 63

Total survey responses = 65

Table 24. Statistically significant correlation between survey questions A and B, using Spearman's rho correlation coefficient.

Correlation between survey respondents' answers to questions (A) and (B)		Question (B)
Question (A)	Spearman's *rho* correlation coefficient	.557**
	Sig. (2-tailed)	<.001
	N	59

**. Correlation is significant at the 0.01 level (2-tailed).

Null hypothesis: That there is no relationship between participants responses for questions (A) and (B) (i.e. that participants' attitude towards renewable energy transitions is unlikely to correlate with their support for solar farms in Central Otago).