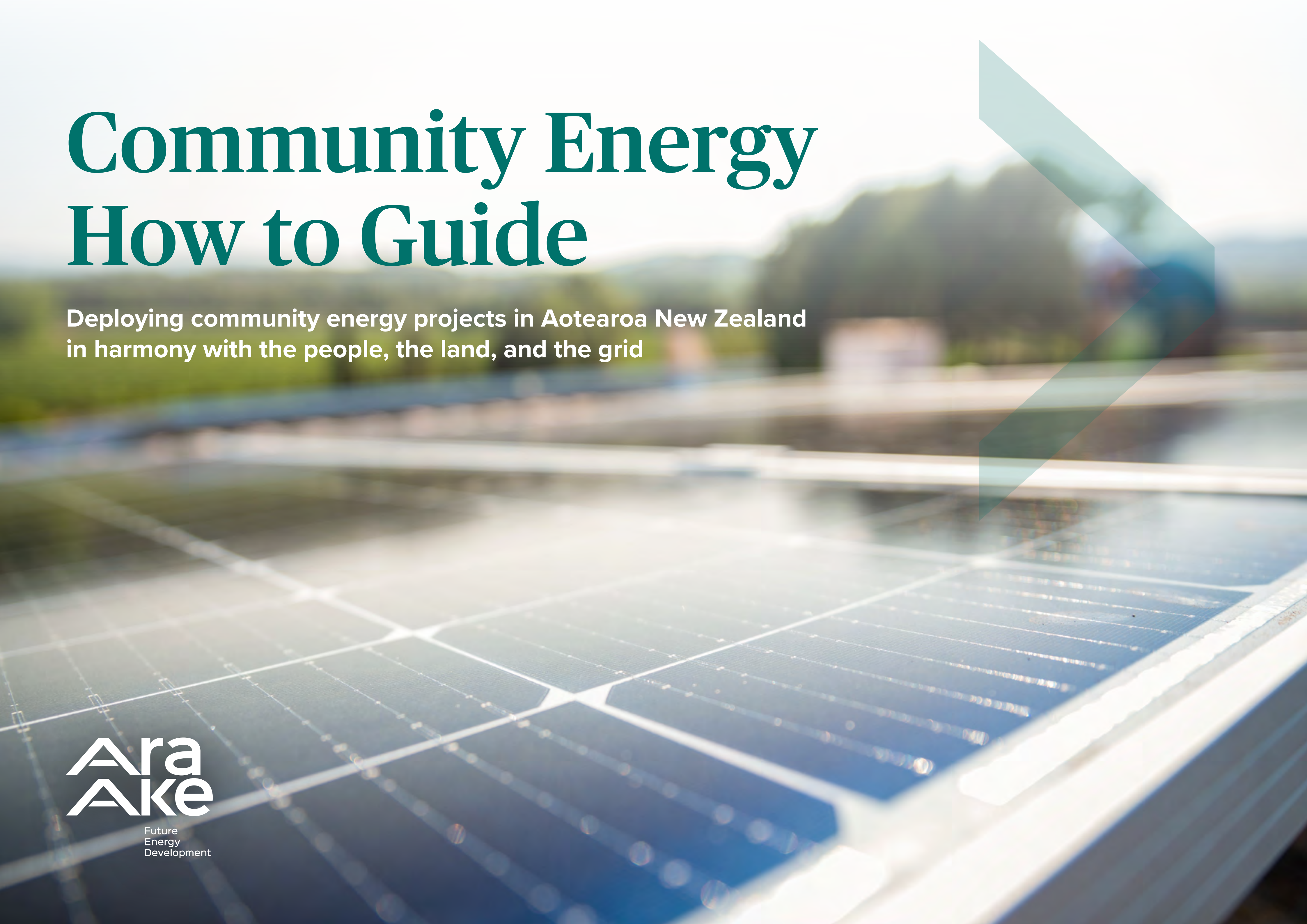


Community Energy How to Guide

Deploying community energy projects in Aotearoa New Zealand in harmony with the people, the land, and the grid

Ara Ake
Future Energy Development

Table of Contents

Acknowledgements

Many people have contributed to this guide with their timeand energy so that others would have an easier time developing their own community energy projects.

Below is the list of people who have contributed to the guide.

Astad Kapadia DSO and Network transformation lead at Counties Energy

Ben Armstrong Nau Mae Ra

Blair and Julie MacKinnon 26 Arohoa

Brendan Winitana Chair of SEANZ

Brian Vass Ministry Business Innovation and Employment

Caroline Gunn Ara Ake

Charlotte Yeats

Chase Hancock Ara Ake

Chris Lambourne leading Manaaki Energy

Daniel Brown Ministry Business Innovation and Employment

Delaraine Armstrong leader of the Te Orewai in Tai Tokerau community energy project

Dr. Anna Berka Massey University

Dr. Cristiano Marantes CEO of Ara Ake

Dr. Jarra Hicks Founding Director of Community Power Agency (Australia)

Dr. Steve Batstone Whiteboard Energy

Dr. Will Edwards Ara Ake board member

Ed Robinson and Steve Heinen Vector

Eric Pellicer General Manager Business Development at Powerco

Eric Pyle Solar Zero

Garth Dibley CEO of WEL Networks

Gavin Bonnet Orion Energy

Graeme Everton leader of the Kia Whitingia community energy project

Guy Penny Principal environment Advisor, Kainga Ora

Hermione Keepa, Nick Price Tenco

Huia Burt Electric Kiwi

Jack Sherratt Solar Bay

James Grant BNZ

James Lyver leader at the Waingākau Housing Development

Jason Patrick Chief Investment Officer at NZGIF

Jeff Suddens BNZ

Jenny van der Merwe Kainga Ora lead for renewables on shared housing

Joey Au, Alastair Dixon NZ Electricity Authority

John Campbell CEO of Our Energy

Jonathan Young Ara Ake

Katie Brown, Laura Lynch and Andrea Espinosa State of Victoria DELWP

Katie Fendall Simply Energy

Keith Scoles Orion Energy

Leah Sibley Counties Energy

Leigh Ramsey, Gael Ferguson Ōtaki Charitable Trust community energy project

Leslie van Gelder

Lingsong Zheng WEL Networks head of DSO and Network transformation

Manu Barrett Solar Sense

Matiu Taurau CEO of Tu Mae Ra

Michelle Allfrey WEL Networks head of Commercial

Mike Casey, Rebecca Casey Forest Lodge Orchard

Nigel Hancock Community Power Agency (Australia)

Nina Campbell Electricity Efficiency and Conservation Authority

Paul Brainerd, Debbi Brainerd Camp Glenorchy Microgrid

Richard Le Gros Electricity Networks Association

Rogier Simons General Manager of Vector Powersmart

Rupert Holbrook Head of customer connections at Transpower

Ryno Verster General Manager Asset Strategy and Investment at Powerco

Shay Brazier Revolve Energy

Steven Follows Eastland Group, Tairawhiti

Stu Innes EMH Trade

Tama Toki Aotea

Thom Gill, Josh Yeats Cohaus

Vanessa Whiu, Te Aroha Hohaia leaders of the Parihaka PapaKāinga Trust

Abbreviations commonly used in this guide

CEP	Community Energy Project
DER	Distributed Energy Resource
EDB	Electricity Distribution Business (Lines company)
ICP	Installation Control Point (meter)
kW	Kilowatt – A measure of power
kWh	Kilowatt hour – A measure of energy
MW	Megawatt – 1,000 kW
kVA	Kilovolt-amps – this is the same magnitude as kilowatts but includes reactive power
EA	Electricity Authority
MBIE	Ministry of Business, Innovation and Employment
EECA	Energy Efficiency and Conservation Authority
GXP	Grid exit point
EIPC	Electricity Industry Participation Code or "The Code"
PPA	Power purchase agreement
GHG	Greenhouse Gas (emissions)
TOU	Time of Use rate
ENO	Embedded network owner
RAB	Regulated asset base
VAR	Volt-amps reactive

Defining success

The world of energy may seem complex and daunting. Like anything complex, if we can set aside the time and go about it methodically, creating a community energy project (CEP) can be achieved and be rewarding. Being in control of your own energy is a continuous journey. This guide is intended to be a first step.

From the title of the guide, it may seem like success would be measured by whether or not you end up building a CEP. While each new CEP would be celebrated, even if you decide that building a CEP is not right for you now, you will have developed a better understanding of your community and their energy needs and may even have developed an energy plan. That would be success.

About the guide

Why was the guide created?

As Aotearoa New Zealand is home to people from many cultures, the guide serves everyone. Several of the projects developed by Māori have informed the guide and some have been included as cases studies.

There are many communities and individuals who would like to have better control over their electricity. Equally, projects at community scale can act in harmony with the grid to improve resiliency, reduce costs and reduce greenhouse gas (GHG) emissions for all. This guide is intended to provide information to get enthusiastic communities started so that they can create projects as cost effectively as possible in collaboration with the electricity ecosystem. It is intended to help navigate a complex world so that you can maximise the positive impact for your community however you define it.

Who made the guide?

The guide is published and maintained by Ara Ake, New Zealand's future energy development centre, for the benefit of everyone.

This is a living guide where contributions and comments are welcome. If you do contribute, then the answer to the question "Who made the guide?" will be "You made the guide!"

Who is the guide for?

In a community project of any kind (a community garden, building a playground, etc.) there is typically a core group shepherding the project through while others contribute special skills from time to time, help out where they can, or support passively.

The people in the core team of a project will likely use this guide the most. The guide will also be a good reference for supporters and interested parties to help understand how they can participate.

How to use the "How to Guide."

Like most energy projects, community energy projects can be complex. There are four options:

1 Be willing to learn how to do the project - build skills and common goals and create something of lasting value for your community. This is the most challenging and yet most rewarding.

2 Hire someone to do all the work – relatively easy though typically expensive. This is effectively a commercial transaction with an energy project developer.

3 Develop a plan that incorporates a mixture of both above points 1 and 2, where local learning, planning and implementation is supported by professional advice and contractual components to the project.

4 Decide not to do the project, if the community decides that the status quo is the preferable option.

The guide is useful for each of these four options:

1 Reading the guide might help you decide whether or not a community energy project is for you.

2 The guide should help understand who and how to hire, and help you manage them and the expectations of the community.

3 The guide will be most helpful for those who end up building a project, or at least doing parts of it yourselves. Even so, it should be viewed as a starting point and a reference rather than a comprehensive manual.

While writing this document many people were interviewed including a wide array of industry participants, financiers and people who are currently or have been building community energy projects. Their responses are the basis of this guide and have informed the topics in the guide, the challenges presented, and the ways to approach them.

In instances where information appears subjective, it has generally come directly from, or been supported by, one or more of those conversations. Where possible, to limit bias, several views have been triangulated to reflect a balanced perspective.

Rather than being prescriptive with a set of steps, the guide presents as much information as practical so that the reader can design their own creative solutions.

How difficult is the guide to read?

Any guide must be simple enough to understand, easy to follow, pleasing to engage with and yet enable people to deliver on a project that is reasonably complex. To address this complexity, the guide must cover a wide range of topics in enough detail to illustrate what needs to be done. For this reason, there are some sections that get into reasonable depth using industry terms and concepts. The more you know, the more likely you are to succeed.

The guide does not make assumptions about the reader's technical capacity for comprehension, instead it presents the information believing in the readers ability, imagination, and ingenuity to use the information to create the energy project that best serves their community.

Read the sections you find interesting. Leave sections that don't apply. Return to relevant parts as you need them.

What is community energy?

The idea of community energy predates the invention of electricity systems. Read more about the evolution of community energy in the Appendix "Guide to understanding Energy."

Community energy includes the local production, delivery, and use of energy within a community, in a project initiated by the community, which delivers benefits to that community. Community energy encompasses all the different ways in which communities around the world are engaging in the energy transition: the shift from carbon-based sources of energy to renewable sources of energy. This ranges from bulk purchase of solar panels to energy efficiency, to renewable energy, storage, flexibility and ancillary services or distribution and supply. This guide focuses primarily on electricity self-generation and energy storage projects. Community energy delivers social value (e.g. increased accessibility, energy equity, community empowerment) to the environmental outcomes of renewable energy and electrification projects.

For the purpose of this guide, a Community Energy Project (CEP) means an electricity self-generation and/or electricity storage project that is owned by, and serves, a defined community that is either separate from the grid or has a distinct interconnection point to the main grid. The electricity generation is usually from renewable resources and there is typically a clear social or community purpose or benefit. Energy is a much broader term that includes heat and work in a variety of forms. Because they are related, the guide will sometimes use the terms energy, power, and electricity interchangeably.

A useful definition comes from Dr. Anna Berka: *"Any clean energy activity that is i) managed in an open and participatory way, and ii) that has positive local and collective outcomes."*

Why do communities develop energy projects?

There are many reasons that communities seek to create a community energy project (CEP):

Growth of energy citizenship

With increasing distributed energy resources available, community awareness of options for ‘behind the meter’ electricity generation and usage is growing. Governments also see community energy projects as part of the solution of increasing renewable electricity generation while potentially not increasing load on our networks.

Building community

We should not underestimate the power of a project to build community and the power of community to have a positive impact on people’s lives. Many people like to be part of a community project. This could be a community garden, a playground, a skate park or, in this case, a community energy project (CEP).

Whatever the reasons for building a community energy project, they should be clearly stated and agreed. They don’t need to be the same for everyone, but it is important that you understand why each person is involved and what motivates them. This reduces the risk of missed expectations, conflict, and loss of motivation along the journey.

See more in the appendix “Building Community Engagement and Participation.”

It is important to have clarity on whether all the different motivations are symbiotic and can be accommodated. For example, if the goals are to achieve a high rate of return on community funds, high wage jobs to build and maintain the system, and a low cost of electricity, you will probably find that you can’t have all three – or even two of the three.

This will also draw out motivations of the participants such as a landowner is being willing to effectively donate the use of the land to the community through a peppercorn lease of $1 per year for the duration of the project, or, if a local contractor seeks to do the work at cost as a service to the community.

Understanding the motivations may also determine the type of funding and funding organisations that would be interested in the project. (More about this in the funding section.)

Electricity is needed

Some communities are not on the grid and need electricity. This was the case for Mayor Island off the East Cape, a project developed by Māori for Māori with funding from the Ministry of Business, Innovation and Employment (MBIE). Other communities may be in other parts of Aotearoa New Zealand and not be connected to the grid either by choice or geography.

Additional electricity is needed

Some communities have an electrical connection, but they need more power than the connection can supply. In some cases, it may be more cost effective to supplement the energy needs with a community energy project than to upgrade the power line to carry more power.

Electricity Supply Resiliency

Some distribution lines, might be frail or vulnerable and residents at the end of these lines experience frequent outages. In some cases, businesses or communities generate and store their own electricity while still being connected to the grid. When the grid fails, they can continue to operate, albeit at a reduced capacity.

Independence and agency over your electricity

The drivers for agency range from practical to ideological. For many communities, having control over their basic needs such as water, education or electricity is essential. Sometimes energy independence can be driven by other factors such as resiliency or simply to feel that the community is not beholden to an entity that does not share its values. Some communities like to be independent of mainstream infrastructure or the organisations that control it.

Full energy independence can be more expensive upfront and on-going than being part of the grid and it requires a set of skills that the community needs to possess, learn or outsource.

Economic payback or return on investment

All energy projects, large or small need to be financially viable for them be sustained. Payback can be measured is several ways. The simplest way is to take the capital cost, divide it by the annual savings to see how many years it would take to pay back the capital cost. Interestingly this results in some very strange logic. At present, if you are paying for electricity every month you will never pay off the grid. There won't be a moment (say 67 years from now) when the grid will send you a letter and say you have paid enough. Therefore, even if your community generation system took 50 years to pay off, you would still be ahead. People may get very animated about whether the payback is 5, 10 or 15 years – However, so long as it is less than 25 years, the life of most projects, you should be ahead financially. It is more complicated than that, but it is good to go into this with some perspective. Also consider the other things you buy in life - a boat, a BBQ, a bicycle, a car, or a kitchen. Do you consciously calculate the payback of any of these?

Building local capacity, upskilling, job training and new business opportunities

Some build energy projects so that members of the community can learn new skills. Sometimes people find that they are really good at building energy projects, and this becomes the start of a new career or business, with organisations and communities developing new resources, processes and abilities. Energy projects can deliver long-term revenues to the local community, in some cases enabling local investment in critical infrastructure, education, and economic activity. It may also build community understanding and skills that can be transferred to other projects that improve the community.

Learning about electricity

By doing a community energy project you may learn more about electricity than you ever wanted to know. This is a great motivation for several reasons. (1) the greater the challenges, the more you learn which keeps you motivated, and (2) a CEP will last for the next 25 to 50 years, and (3) how you manage electricity in your own home will carry through the rest of your life, so it is good to understand it well.

Defining success for your project

We ask these questions not to deter you before you start, but for you to bear them in mind as you go through the planning process and before you get over committed on money, time, and expectations.

To help understand your community's motivations and to define success, imagine that your project is complete. You have just finished taking that group picture in front of the energy project installation. Someone important has cut a ribbon. Someone little has just flicked a big switch and electricity started flowing. Everyone cheered as the meter clocked the first unit of electricity delivered. Now what?

What does your CEP provide that you didn't previously have?

What were your reasons for creating the CEP and did it meet them? Did it meet the goals and aspirations of your community?

Are your stakeholders satisfied?

Did others in the community and those that supported and championed the project get what they wanted? Did the customer end up paying the price they wanted to for the electricity? Did they get carbon credits or at least carbon kudos?

Who is reliant on you?

Are you supplying electricity to a group of people who now rely on the CEP for power? If the CEP stops working, what are the consequences?

What is the promise and who must keep it?

Is the promise that prices will be lower, that prices will be stable or that the power will be more reliable? Who in the community is responsible for keeping that promise? Who will be responsible for keeping the CEP running?

If the CEP breaks or degrades in output, who will fix it?

If the project is too complex for the community to run and they can't afford to pay someone to run it, then was it the right project to build?

Project plan and approach

Some like to dive headfirst into developing a project. However, it is worth developing a plan with stage gates so that you can manage the time, effort and money that go into the project and track your progress.

Initial scoping and project feasibility assessment

The initial scoping or feasibility assessment should be comprehensive and include paying someone to do the work. A reasonable amount for this work might be approximately 10% of the project cost. However, with the right skills in your network and considerable effort, this cost could be reduced. The initial scoping and assessment is time and money well spent, particularly if you realize early that the project could be done differently, should not be done, or is better delayed.

There are seven key elements to a successful scoping and feasibility assessment:

1 Community

- Identifying the objectives and required outcomes
- The links between community activities and energy (e.g. commercial, agricultural);
- Did the project come from the community or was it brought to the community?
- Is the community generally positive on the project?
- What types of support can be expected?
- How will the community want to be involved long term (e.g. customers or investors?)
- Are there any stakeholders who might be reluctant to allow the project to succeed?

- Will it be a net positive for the community?

2 Sizing and siting:

- Understanding the basics of the situation including the location, topography, utility connections, community systems etc.
- Are there energy saving and energy efficiency measures that can be made to reduce energy demand?
- What scale of project is required? Is the system going to be sized to local energy demand, or sized for maximum commercial benefit?
- If the project is to be connected to the grid, is this physically possible at a reasonable cost? i.e., is there an existing or nearby connection point?
- Can the grid, at the point of interconnect, cope with the peak capacity or will upgrades be required?
- What are legal requirements related to use of the land? Lease, purchase, community agreement?

3 Project type:

- Identify feasible energy generation and storage options, matching these to the community energy demand and ability to import/export surplus and deficiency quantities.
- Identify the current and potential energy use in the community
- What kind of generation technology will be used?
- How much power will you generate and what is your power generation profile and capacity to deliver services to the grid such as VAR support?
- What will the relationship be to the grid in terms of visibility and control? i.e., will the lines company have access to the data on the project and will they be allowed to control the level of electricity export or import at certain times?

- What is the current and future infrastructure used to distribute the electricity?

4 What will you do with the electricity you create?

- Use it on site?
- Sell to a retailer or the wholesale market?
- Sell it to an end user under a power purchase agreement?
- Deliver under a peer-to-peer arrangement?

5 Consents and studies required:

- Outlining potential constraints such as consents and regulations, geotechnical, heritage and other considerations
- Council and resource consents
- Environmental impact assessment
- Grid integration study

6 Project economics and funding:

- Undertaking options analysis, identifying a short list of credible options (including 'do nothing')
- In rough numbers, will enough electricity be produced with sufficient value per unit to cover the cost of the project development, installation and operations?
- Is there a path to funding and can you fund the feasibility assessment? What costs could be covered by voluntary and in-kind contributions, and which will require cash? How will you fund capital costs and on-going operations and maintenance?
- Who will benefit financially from the project? Will this benefit be reduced energy prices, a distribution of surplus/ 'dividends', grants?

7 People: Do you have the skill sets in your community or can you afford to hire them?

- Some degree of technical capability
- Commercial acumen
- Community leadership and community engagement
- Project management
- Legal knowledge
- Accounting

There are likely a wide array of project specific information to gather before these questions can be answered. Scoping can save you a lot of time and energy and motivate you to start the project or tell you early that it will not pan out so that you can change your plan.

He Tangata, He Tangata, He Tangata

People are the heart and soul of a community, and they are vital to the success of your CEP.

A legal entity to develop, build, operate and own the CEP

To build a CEP you will need to bring money in, pay money out and contract with various parties and manage tax, risk, and legal obligations. To do all of this you will need a legal entity like a company, cooperative or trust. Most communities gravitate toward a non-profit structure as it sounds egalitarian. But there are some good reasons why it might be helpful to include all options when considering the type of entity. Even if your community has an existing entity, it is worth considering a separate entity for the CEP.

It is always best to consult with someone who understands the law, tax and accounting implications of the various entities as well as understands the characteristics of your community and the project. Often a group will include people who know a little bit about the various structures, be attached to a given approach or have anecdotes about what works and what does not. As with all decisions, it is important to keep an open mind. This link communitytoolkit.org.nz has some helpful information to get you started.

Factors to consider include:

- How much liability the members are prepared to take on?
- How will the benefits will be allocated?
- Will you be applying for grants for all or some of the project cost? Will you need to seek funding from members or investors?
- How will decisions be made?
- What will the balance be between control versus consensus?
- Who wants or needs to own the project, or have a controlling interest?

While there might be some initial discomfort in answering these questions, it is better to get agreement early on regarding how the project will be structured, owned, and delivered, than have disagreement later in the project. Below is a summary of the options to start the discussion. *Note that this does not constitute legal, tax or accounting advice.*

Limited Liability Company (LLC)

Directors do still have liability – it is limited, not zero. This structure allows for just a few people to be in control. That makes it easier to make decisions. Benefits can be distributed separately from management by allocating shares to reflect the intention of the project. In this way many people can benefit economically through shareholding while a small number of people can manage the project. Voting power is allocated per share, so people with more shares have greater voting power.

Co-operative company

This is a specific type of Limited Liability Company where the ownership is more broadly distributed among members who are trading with the company. In this case, trading would likely mean buying electricity; this may limit the ability to bring in outside investment. Is it worth noting that cooperatives are democratic organisations, where each member has one vote in major decisions. Co-operatives form a strong part of New Zealand's economy. For example, New Zealand's top 30 co-operatives' total gross revenue represents approximately 20 per cent of the country's GDP with over 50,000 people are employed by co-operatives.

Incorporated Societies

Incorporated societies are often set up to promote a community activity like sport, art, social services, or philanthropy. Many are charities – this requires the additional step of registering as a charity. Some of the features of an incorporated society are:

- the members can change, and the society continues
- the members are only responsible for the liabilities of the society if they breached a rule
- The society must exist for some reason other than making a profit. In fact, it cannot operate for financial gain or distribute surplus to its members. This might prove limiting when seeking investment for the project.
- The society must have at least 15 members.

Incorporated societies are inclusive, but they can make management of the project burdensome and close off some avenues to financing.

Charitable Trust

In the context of a CEP, the charitable trust must exist principally for purposes of benefit to the community. The trust board can operate almost exactly like an individual, but it must follow the rules of its trust deed. The trust is permitted to make a profit, but the profit must be used for charitable purposes and cannot be distributed to the members.

Trusts should be set up by someone with specialist knowledge and an understanding of the project (preferably a trust lawyer).

In all this, professional legal and financial advice should be sought on the type of legal entity which will own the project and the governance structure for decision making and how the community can participate in the entity and its governance processes.

Entities that may be unique to Māori

Many Māori businesses and trusts operate under some combination of the structures above. There are some tax benefits to being a Māori organisation, but this status must be applied for and awarded separately. Some Māori land is held under a structure managed by the Māori land court. This structure is seen by some as restrictive and cumbersome but there are some benefits. The common title of a large piece of land with many separate leaseholds may allow for peer-to-peer trading. A customer or embedded network would not be possible if all the houses were on separate titles. Decision making is more communal and that comes with benefits and challenges.

Governance of the entity and the project

Governance in its widest sense refers to how any organisation is run. It includes all the processes, systems, and controls that are used to safeguard and grow assets.

There are three key elements:

- Ensuring that you meet the legal requirements based on the type of entity you selected
- Promoting fairness, transparency and accountability
- Directing and controlling the organisation according to the values of the community it serves.

Te Puni Kōkiri (Ministry of Māori Development) has this to say about governance: *"Tikanga principles are often included in governance. Tikanga can easily fit alongside governance best practice. Many Māori organisations are explicitly driven by tikanga, kawa and values (for example in employment, tangihanga and cultural leave policies) that consider the aspirations of whanau, hapu and iwi. Māori organisations may also have a Māori dimension in procedure such as the use of Te Reo, mihi, karakia, koha, hospitality for manuhiri, manaakitanga, whanaungatanga, consensus decision-making and regular consultation hui. These elements should support the general principles of good governance."*

Management of the project

In contrast to governance, management is responsible for the daily operations and tasks. In short, management makes sure that the strategies and plans are executed in a timely manner, within budget. Management orchestrates the work of all the individual contributors to complete their sub tasks on time and on budget. It is common in a CEP for an individual to contribute in all three roles of governance, management and individual contributor at different times of a given day.

Assembling the team

Community energy projects have many of the same characteristics as commercial energy projects. Therefore, a similar set of skills is required. Commercial energy projects are typically created by professionals with years of experience; therefore your odds of success increase dramatically if you can assemble a team with the requisite skill sets. Any skills that the group is missing will likely show up as increased costs, lost revenue, or time.

You can still do the projects without all the skills sets, it will likely take longer, cost more, include more risk and be more difficult for all concerned. It is common for one person to serve in several roles and to change roles over the life of the project.

Roles to include:

Legal and Governance Advisor. Someone with professional experience to advise the community energy project group on their legal obligations and which different types of governance arrangements are suitable. (i.e. the different advantages and limitations of a limited liability company versus an incorporated society, the legal requirements and accountabilities of each.)

Community Engagement Manager: To ensure there are opportunities for community participation and input into project design, delivery and decision-making.

Champion to hold and promote the vision: Someone is the champion and the face of the project. They often communicate with the outside world, raise the money and lead key negotiations. They engage others in the idea and keep things moving along particularly after setbacks. They would lead community outreach, education, stalls, events and celebrations that can help bring the project to life in the community.

Project Manager: It really helps to have someone who has been a project manager either in their profession or informally on other community projects. Although project managers don't require formal training, they need to be able to make sure that things get done in the right order, on time and on budget. They can organize, manage, and motivate people. This person is often key to getting funding because the funders will want to know that the money will be spent wisely. They should also be aware that project managing a CEP is a specialized skill and if they have not done one before they will need plenty of support, tenacity, and patience.

Financier and Accountant: When energy projects generate electricity, it can either be sold or used to offset higher electricity costs to create savings – these are revenue streams. On the other hand, there is a capital cost to the project and there are ongoing operational costs. The finance person relates revenue streams to the capital and operational costs. They don't need to be an accountant, but they should have three skills: (1) be able to create and run a financial model in a spreadsheet like Excel (2) be able to translate the work activities into monetary terms and (3) be able to explain the economic value to each counter party and the team.

Technical Expert: There are many reasons to have someone on the team who understands energy systems, the electrical grid, the market, and the other participants. They should also have technical modelling experience so that they can illustrate the amount of electricity and generation profile that the system is likely to generate and to create a system that meets the needs of the community and the grid. This set of skills would often be embodied in more than one person. This role is critically important during negotiations so that the counter party knows that they are dealing with someone who understands them and can hold them to account. Often this skill set needs to be hired and paid for but even finding out who to select requires knowledge, not merely trust.

Commercial Engagement Manager: To most counter parties, community energy projects are about money - money they will stand to gain or forego. Almost every cost or revenue opportunity is negotiable in some way. Since the margins in energy projects are thin, few projects can afford to leave money on the table unnecessarily. Regardless of the prevailing status quo, passion and values, there needs to be someone who is adept at negotiations, dealing with contracts, personalities, and relationships with counter parties, including commercial entities.

Storyteller: This is an often overlooked but a vital skill. The community energy project will be fitting into an existing landscape, and everyone will see it from their own viewpoint. Someone needs to be able tell the story to multiple audiences, framing it in a way that clearly communicates the value and opportunity the community energy project represents. Story telling could include getting articles in local press or publishing updates on the project on the website. It is important that the narrative be consciously managed from the start.

Community Leader: This role can be completely unrelated to the physical elements of the project. Someone with strong standing in the community needs to be on the team to ensure that the community is, and feels, heard, and involved all the way through the project.

Paid staff and volunteers

Generally, when the project starts off, everyone is volunteering their time or doing it as part of their main work. Over time it becomes clear that a small number of people are carrying most of the load. Unless they happen to be retired, wealthy or overly generous, they will, at some point decide that they either need to get paid or reduce the amount of time they spend on the project. It is best to have a plan in place to compensate key people in some way. This could be deferred income, a shareholding in the project, free electricity, or something less tangible. The project will at some point generate cash or at least electricity so there will be a value to allocate. There is nothing wrong with people being compensated for work. After all, there are professionals who develop similar energy projects who are paid.

Partnering for skills and influence

There are a variety of organisations and business that may benefit obliquely from the CEP or be willing to support it. Some of them may have skills or resources that they could be willing to share or donate. In some cases, partnering will mean handing over project management to a renewable energy developer entirely, with the community primarily acting as an advisor and investor. It is worth thinking about who to include in the broader outreach program to attract support.

The electricity landscape in Aotearoa New Zealand

It is important to understand the other participants in the electricity landscape in Aotearoa New Zealand because they are not only vital to the success of your project but in many cases hold most of the cards. It is worth understanding their business model and regulatory constraints as this drives their behaviour and gives clues as to how CEPs can collaborate. This overview provides context for rest of the guide.

Generation: Gentailers, IPPs and small-scale generators

Most (about 90%) of the power in Aotearoa New Zealand is generated by the gentailers, five companies that generate power and sell (retail) power to residents. The remainder of the power is generated by a few independent generators called Independent Power Producers (IPPs) and people with small scale projects like CEPs and home generation.

Transpower – Transmission Grid and Electricity Market

Transpower is a state-owned enterprise that owns and operates the transmission grid. As the System Operator, Transpower manages the real-time operation of the grid and the physical operation of the electricity market. The system operator's function is primarily to ensure real time security by balancing supply and demand. An output from the system operator's supply and demand schedules is the wholesale market spot price.

If you have a large project, then you might need to connect directly to Transpower's transmission grid. Most CEPs would not engage with Transpower directly and would rely on their commercial relationships with an EDB and electricity retailers to manage any transmission level issues.

Lines company, distributor or EDB (Electricity Distribution Businesses)

Local lines companies, also called distributors or EDBs (Electricity Distribution Businesses) can be one of the most important relationships for a community energy project. Some of the later sections and the Appendix "Guide to harmonious grid connection" describe this relationship more fully.

EDBs are responsible for delivering power from the Transpower transmission network through a distribution network to businesses, communities, and residences. An EDB's primary job is to transport electricity safely and reliably to consumers. Or more simply to "make sure that the lights stay on".

There are 29 EDBs in Aotearoa New Zealand. They are diverse in size, ownership structure and approach. Some, such as Vector in Auckland, serve over one million people in urban and rural areas. Others serve a much smaller set of customers such as Buller Electricity serving less than 5,000 people in a West Coast rural community.

EDBs are responsible for connecting many of the smaller commercial, and community energy projects to the grid. Most EDBs understand that community energy projects and distributed energy resources (DER) can be beneficial.

**See more in the later sections on EDB's and in the Appendix "Guide to integrating CEPs to the grid."*

Retailers

Gentailers account for about 90% of the electricity sold (retailed). The remaining 10% of all electricity is sold by independent retailers. This means that many independent retailers are small and therefore struggle to achieve economies of scale. Retailers that don't own generation, must purchase electricity from the market or a generator and then resell it to consumers. Some lack the market power or sophistication to gain access to electricity supply (via hedging contracts) at affordable rates.

Hedging contracts allow retailers and large business to effectively lock in the price of power for a period, typically up to three years. If the retailer cannot do this, and the wholesale price of power increases dramatically, they can find themselves having to sell power for less than they buy it for.

When selecting a retailer, it is important to consider whether they have the capability and capital to manage this complex market. Further, selecting a retailer that understands the value of your project and is willing to get you market access at a fair price is key to the economic viability of the project.

The Central Government

The central government has a stake in some of the gentailers such that about 60% of all electricity produced and sold in New Zealand generates a dividend for the central government. The government also collects GST on electricity sales. Furthermore, Transpower is fully owned by the central government and operates as a state-owned enterprise.

As described below, central government agencies also regulate the electricity market and provide services to the market. They investigate claims of market manipulation or excessive prices.

Local Government

In cases where EDBs are partly owned by a local council (through a holding company), the council relies on the EDB for part of their income. This dynamic should be considered when approaching the local council about selling them electricity, particularly behind the meter. They are managed at arm's length by separate legal structures to limit the blending economic interests of EDBs and the councils that own them.

Government Agencies

The key government agencies that impact the electric sector are described below. We will refer to these agencies throughout the guide.

The Electricity Authority (EA) ea.govt.nz

The EA is responsible for the regulation of the New Zealand electricity market. They do this under a directive to serve the long-term benefit of consumers. They develop, monitor, and enforce the Electricity Industry Participation Code (EIPC) simply known as "the Code" which defines the rules for industry participants.

It is worth understanding the Code well as there are all manner of ways that knowing the Code would be helping in discussions with counter-parties from fees to response times. The most relevant part of the EA Code for CEP is called the Electricity Industry Participation Code 2010 Section 6.

Your CEP, if it participated in the wholesale market, would do so under the Code. Operationally, the EA publishes the wholesale market prices. The EA provides a list of information that you can request from your retailer and provides the rules specific to a DER connection.

The Government has recently established a Consumer Advisory Council and an Energy hardship expert panel and reference group

The Commerce Commission (ComCom)
comcom.govt.nz

The Commerce Commission (ComCom) is a government agency with responsibility for enforcing the Fair Trading and Commerce Acts, which help promote competition in the electricity sector. Additionally, ComCom has enforcement powers regarding competition and consumer laws that apply to all New Zealand businesses. Further, ComCom has a role in regulating the transmission and distribution businesses because there is little or no competition in the markets for these services. If you believe there has been a breach of the competitive rules or the legislation that ComCom is responsible for, then you would approach ComCom.

Ministry of Business, Innovation and Employment (MBIE) mbie.govt.nz

MBIE is the ministry that serves the electricity sector, among 18 other sectors. They serve the electricity sector by taking on initiatives that the other authorities do not, such as promoting innovation, reporting on issues, and sometimes providing grants and funding for projects or studies. They run forums and provide education on the sector. For example, MBIE recently provided grants for Māori communities to build CEPs some of which are described in the case studies in this guide. The guide was written with input from several of project leaders whose CEPs were funded by MBIE grants. MBIE collaborated on the guide, and through its funding of Ara Ake, indirectly funded the creation of this guide.

Your CEP might be able to get funding or other assistance from MBIE depending on whether they have initiatives that fit your profile at the time. MBIE's website and reports are a helpful source of information.

Energy Efficiency and Conservation Authority (EECA)
eeca.govt.nz

EECA is a government agency that was set up to encourage, support and promote energy efficiency, energy conservation, and the use of renewable sources of energy. Since establishment in 1992, most of their programmes have focussed on delivering energy efficiency for low-income homeowners and businesses, but they also implement electric/low emission vehicle funds, some technology demonstration funds, and set standards for energy efficiency of residential, commercial, and industrial products sold in New Zealand. They provide some information on renewable energy, but they generally do not provide direct financial assistance to CEPs.

Utility Disputes (utilitiesdisputes.co.nz)
udl.co.nz

While more focused on classic utility disputes such as unfair billing practices or customer service, one path for escalation might be the Utility Disputes Commission. Their tagline is that they are free, fair and independent. It would be worth trying this out as a possible escalation path if you are unable to come to agreement with a particular industry player.

Becoming fluent in electricity speak

Just like learning a language, becoming familiar with the terminology related to electricity and CEP's can be extremely helpful. It helps everyone on your team describe the same thing in the same way, it helps with communication with outside parties and will enable the project to be more successful.

This section has some of the key concepts with much more about this in the appendix "Guide to understanding energy". There is also an endless supply of information on the internet.

First, your Community Energy Project (CEP) will often be referred to as a DER which stands for Distributed Energy Resource. This just means that your CEP is something other than a giant conventional utility scale power plant. Unlike these large power projects that are typically connected to the ransmission grid, a DER is typically connected to the distribution grid. Following is a technically accurate definition – DER (*Distributed Energy Resource): A resource sited close to customers that can provide all or some of their immediate electric and power needs and can also be used by the electricity system to either reduce demand or provide supply to satisfy the energy, capacity, or ancillary service needs of the distribution grid. The resources are small in scale, connected to the distribution system, and close to load. – Source US DOE Department of Energy*

Power and Energy

Power is the ability to do work. Energy is the amount of work done over time.

In electricity we use the metric term for power which is Watts (W), Kilowatt (kW) (1,000 Watts) and Megawatts (MW) (1,000,000 Watts). In the electricity industry, kWh is simply called "units." An efficient light bulb can be 6W, a large heat pump can be 6kW (a 1,000 times larger) and a medium sized industrial load might be 6 MW.

There are two important measures for any project:

- The power – The maximum power you could put in or take out the grid measured in kW.
- The Energy – How much power you use for how long measured in kWh or MWh

More about this in the Appendix "Guide to understanding energy."

The four major categories of Distributed Energy Resources (DER)

DERs, or energy assets more generally, fall into four basic categories: Efficiency, Controllable Load, Storage and Generation. When conceiving a CEP, most people go straight to generation, some consider storage, and fewer still consider controllable load and efficiency. In many ways the order should be reversed. We will consider these in the order of impact i.e., start with the one that impacts the others first and then work your way down the list. You will likely have to iterate a few times to settle on the final design.

Energy Efficiency: Typically, a one-off reduction in the amount of energy needed. Energy efficiency is enabled by substituting energy intensive devices for more efficient ones, such as LED lights or heat pumps or installing insulation.

Controllable and Flexible load: Smart appliances, hot water heaters, pumps or electric vehicles (EVs) are all loads which you can turn on or up when power is cheap and turn off or down when power is expensive, or you can't generate.

Generation: Solar, wind, biogas, small hydro, or fuel cells that generate electricity.

Storage: Batteries, hot water storage, or pumped storage – pumping water up to a dam and then letting it run back through a turbine later to generate electricity when you need it.

Even before you pick a technology like solar or wind, it is good to figure out what mix of energy efficiency, controllable load, generation, and storage that will lead to your best outcome.

Industry specialists and energy modelling tools can help support this journey. The greater the complexity, the more likely it is that you will need to consider using an energy modelling tool yourself or involving a specialist to do the analysis. The tools will provide a good benchmark and aid in the investment decision to test the performance of the energy systems once operational.

Energy Efficiency – the lowest cost energy

Energy efficiency often delivers the most cost-effective outcome as it impacts all your other decisions and is an option on nearly every device that uses electricity. This could be lighting, insulation, heat pumps instead of heaters, heat pump hot water cylinders or solar hot water instead of conventional hot water, ... the list is nearly endless. Every kWh of energy that you don't use, doesn't need to be generated, transmitted, or stored.

It is almost always far more cost effective to optimise your energy use first by deploying energy efficiency measures than it is to generate or store energy. There are some exceptions to this, but usually money is much better spent insulating the ceiling than putting solar on the roof.

There are three components to energy efficiency:

- How big is the load – hot water is a big load compared to lighting.
- How easy is it to adopt – changing light bulbs or insulating the ceiling can be relatively easy. You can change the bulbs when they burn out for new energy efficient LEDs, or you can add insulation to the ceiling without any construction activities.
- How much does it cost upfront – A heat pump would save you money in the long term but could be $3,000 to $5,000 installed.

Which you choose to do, and in what order, will depend on your circumstance, but it is worth creating a master list of all the possibilities. Particularly because some energy efficiency measures also enable the loads to be controllable and this might move them up the priority stack.

In a few cases, it may be cost effective to not implement energy efficiency measures if you happen to have cheap source of generation or storage or if the load can be shifted to off-peak.

Controllable load

Controllable load refers to appliances and other loads that use energy that can be automatically or manually adjusted to reduce their energy use or shift their energy use to a different time. Controllable loads used to be the sole domain of large industrial companies with megawatt scale loads whose energy use could be ramped up and down to maintain grid stability. This involved a contract between the company and the EDB or gentailer along with a dedicated energy manager who could be called on to manage the controllable load.

Today, with DER aggregators and software, controllable loads can be small and numerous and remotely controlled. A simple example is a washing machine. If you have solar PV, the best time to run the washing machine is in the middle of the day so that you could consume solar power, or late at night when grid energy costs the least which is typically between 11pm and 5am. You could do this manually, or if your washing machine has timer, you could automate it. Most modern appliances have functionality that can aid in managing times when they operate. Some have timers, some can respond to price signals, and some can be remotely managed.

Controllable loads that can be automated can be internally controlled (by you) or remotely controlled by an external party (either your EDB or a DER aggregator). Which of these two options you prefer will depend on the trade-off you're prepared to accept in limiting your access to electricity for a time in lieu of cost savings or wanting more personal control.

The best of both is when your electricity reductions are not noticeable. Ripple control is a great example of this. It allows the EDB to control when the hot water cylinder runs in your house. EDBs in New Zealand use this when they, or Transpower, have too much load at a major substation or line (forecast or real time). They will turn sectors off for short periods of time and then go to the next and will ripple through the neighbourhood to keep the overall energy draw on that part of the grid below a certain level. Most people don't even know that they are on ripple control and very few experience any inconvenience. It may only be used a few times a year and might only reduce the temperature of hot water by a few degrees. But for the EDB and Transpower, being able to reduce those peak loads is very valuable and enables them to keep the power on.

Although ripple control represents about 15% of New Zealand's peak load, is a bit of a blunt instrument because EDBs can only control it in sectors rather than at the individual Installation Control Point (ICP) level. This means that it can be used for bulk control but not for managing constraints at the individual distribution transformer level. This limits its value for managing DERs. Although, with modification to the IT systems, it might become more useful at a more granular level and become part of the flexibility value stack so that it can be used to maximise its value to the grid in concert with other controllable DERs.

Controllable loads should not be used at the expense of safety, productivity, or comfort. Only using your lights during the day when you are producing energy from solar would be impractical, or only turning the heater on after 9pm when the price was low might not be worth sacrificing your health and comfort.

If you are purchasing an EV and a dedicated EV charger it is worth considering how you want the charging to be managed. Installing a charger that has the capability to communicate with the outside world would enable the CEP, DER aggregators or EDB to manage the charge time and rate in the future.

See more about EVs as a controllable load in the Appendix "Maximising the utility of EVs."

As with energy efficiency, which loads you choose to control and in what order is up to you. Be aware that today nearly every new appliance has a version that can be fully controlled internally or externally and this should be a factor when considering replacement or new build.

Finally, there are some very big controllable loads that are not associated with building appliances, but with industrial or commercial appliances that you could incorporate in your CEP project. These include water pumping, many agricultural loads or charging of electric tools and vehicles. One of the big differentiators between a CEP and a home energy project is that CEP is at more of a commercial or industrial scale which allows for aggregation of heat and power and therefore economies of scale for cost reduction, in negotiation with third parties.

This brings us to the shift to electrification. If you will be generating your own energy or will be actively optimising for lowest cost use of grid power, then shifting from tools and vehicles that run on fossil fuel to batteries can make a lot of sense. The batteries can be charged at times of day when energy is lowest cost or most abundance. Economically (and environmentally) this usually makes the most sense when replacing tools or vehicles rather than throwing out perfectly good fossil fuel powered tools.

The other consideration is supply resilience. If you shift all your appliances to electric, you would be less diversified in terms of fuel risk and so would need to be sure that your electrical system is sufficiently resilient to meet your needs.

Electricity Generation

There are many ways to generate electricity and there is no way this guide could cover all of them in sufficient depth. Fortunately, there is no shortage of information on each one on the internet.

We will look at each of the major established technologies briefly and then spend most of the time on solar PV. We do this because solar PV is the most common and the most likely technology to be used in a CEP. The guide does not cover emerging technologies because they compound the risk of the project and make financing difficult. Communities are welcome to research and use these technologies and apply relevant elements of the guide to working with them.

Solar PV: PV stands for photovoltaic which just means that the electricity is created because of a photon of light striking the solar panel. You don't really need to understand any of the science only that if the panel is in sunlight, electricity will come out the other end. The brighter and more direct the sunlight, the more electricity will be produced. Even if it is cloudy, you can still generate substantial electricity. If the panel is shaded (even partially) the electricity production drops dramatically and if it is dark the electricity production is zero. Therefore, the daily solar production profile follows the sun. It slowly ramps up in the morning, peaks around midday and then tails off in the evening. It varies depending on the frequency and density of cloud cover. Over the year, solar generally peaks in summer and is at a low in mid-winter but this depends on local conditions. Areas that get summer fog and clear cold winter days may see less of a difference between summer and winter production rates. Your specific daily and annual profile will be important when matching production to controllable load. It may also impact your priority of energy efficiency projects. There is more information about solar in the Appendices "Guide to understanding energy" and "Guide for new users of solar."

Solar thermal for hot water: For direct heating of hot water this can be low cost and effective. This is a simple technology in that cold water runs through tubes that are heated by the sun. Often some supplemental heat is needed to get the hot water up to the desired temperature, but this is a low-cost approach to hot water heating.

Wind: With the exception of solar PV and fuel cells, most electricity is generated by rotating a generator. How that generator is rotated, is determined by the energy source. With wind energy, the wind rotates the blades of the rotor, and this turns the generator to generate electricity. There are small wind turbines (enough to power a house) and big wind turbines (enough to power 3,000 houses) and not much in between. Small wind turbines (up to 5kW) can seldom compete economically with solar, however they do operate at different times than solar such as during the night and therefore can be very useful in your energy mix particularly to charge batteries or pump water. Large wind turbines are most economic when they are part of a large wind farm because operating and maintaining (O&M) them requires specialist skills and equipment that is best amortized over a large

number (50 to 100) large wind turbines. Unless you happen to be near a large windfarm and can negotiate an acceptable arrangement for operation and maintenance (O&M) services, it is unlikely that one, or even a few, large wind turbines will make sense.

The wind must be strong and consistent. In fact, it must be so strong and consistent that people find it unpleasant to live in the area. Often people will think they live in a very windy area, but when the wind is measured it turns out to be a modest resource. Ideally, before deciding to get a wind turbine you would measure the wind resource by deploying a met mast at several locations on your site for at least two years. This would give you the data you need to figure out the economics with some accuracy. Alternatively, you could engage in a specialist who can hindcast that data for the previous two years or more.

Hydro: With hydro power it is water that turns a rotor (or impeller) that turns the generator to create electricity. There can be several benefits to hydro. If the river or source of water is consistent (like a spring) then it can provide constant power. If the water is stored in a dam, then power can be generated when you need it. In the very rare case where you have a reservoir above and below, and the right type of equipment, you can store electricity by pumping water to the upper dam and use it later to generate electricity when you need it.

There are several challenges with hydro. You need a lot of water with consistent flow and fall to make it economically viable. For the system to be robust and withstand flood conditions and debris management it can become expensive to build. You need to get the power from the generation site to the point of use (load). All these factors favour building larger systems and with scale come greater capital cost and impact to the river ecosystem and environment. As with wind, it would be best to measure the water flow over at least a year or two to determine the resource and look at historical flood events.

In addition, since such a large proportion of electricity comes from large scale hydro, it is likely that your hydro scheme will experience water shortages at the same time as the rest of the country does. In dry years when lake levels become low, hydro generation can be low and this effect drives significant seasonal volatility in the wholesale electricity price. Therefore, you could find yourself in a position of having to purchase electricity at times when the prices are high and having excess generation when prices are low. It would be worth carefully considering how you would sell your electricity. Before undertaking a hydro project, it would be worth doing a high-level assessment of the feasibility in terms of location to the point of use (load) or interconnect, along with the economics.

Biodiesel Generator: In some cases, a diesel generator is helpful because the fuel can be stored for a long time. To ensure it is renewable, a generator that uses biodiesel can be used. There is some conversion required and you will need a fuel source as well as managing that fuel to prevent bacterial growth and degradation. This is very much a back-up option rather than a primary source of generation. Many large buildings or critical operations like hospitals would have a diesel generator as back up. Converting these to biodiesel would be beneficial from a greenhouse gas (GHG) emissions reduction perspective. If you are near an entity that has a diesel generator for backup, finding a way to include it as one of your energy assets could help your projects resiliency.

Biomass – Burn biomass to make steam: This is essentially firing a boiler with wood waste to create steam to turn a turbine-drvien generator to make electricity. A steady supply of biomass is required for the lifetime of the project.

Biomass digestor: A biomass digestor consists of a large tank in which bacteria eat the biomass to produce biogas which is similar to natural gas. This biogas is then used in a fuel cell or burned to create electricity. It can also produce fertilizer. Since the feedstock is typically animal waste, crops and food waste it is most appropriate in a rural setting or landfill sites.

Hydrogen: Hydrogen is a way to store energy. It must be created by using energy either (1) electricity to convert water or (2) to strip the hydrogen from a fossil fuel. Creating "green hydrogen" requires electricity from renewable resources. Currently this is more expensive than stripping it from oil or natural gas. Hydrogen is a way to store energy, as is referred to as an energy vector.

Storage

Pumped Hydro: As described in the generation section, if you have a reservoir above and below the hydro turbine you could have a pumped hydro storage system – using solar to pump the water up during the day and running the hydro turbine at night. This is a complex system and only likely to be applicable in unique circumstances.

Water Pumping: If one of your larger loads is irrigation, you could pump the water to an elevation during the day with solar and then have gravity irrigate when the sun is not shining. This could also be considered a controllable load.

Hot Water: If you have a large central hot water system, you can store energy as heat in the hot water during times of low-cost grid power or self-generation. It cannot be converted back to electricity, but it can avoid needing electricity for water heating during peaks.

Batteries: It used to be that guides like this would describe the different types of batteries. Now, for the most part the choice ends up being lithium ion. Sometimes people use second life car batteries but most often they go for lithium ion phosphate because it is typically lower cost, less toxic and has a longer life cycle. Although it is less power dense (power per kg) than other lithium ion batteries, it is applicable to stationary applications because weight is not a factor. Lithium ion phosphate is also more chemically stable, reducing the risk of thermal run-away and fire.

The choice of generation type matters to the community and the grid

Each generation source has its own value to the network and has its own deficiencies that need to be accommodated by other power sources on the network.

For example: some hydro projects are "run of river". That means that if the river is running (in the winter and spring) then they can generate power, but toward the end of summer there might not be enough water to run the turbines to generate power. Other hydro projects may be supplied by large dams so that they can run year-round and ramp up and down to match the load.

Another example is geothermal projects generally like to run at the same rate all the time so at night, when very little power is being used, geothermal projects could be "over generating." This excess geothermal could be used to pump water back to the top of a hydro dam to be released to generate electricity during the day.

Wind and solar projects only generate when that resource is available, and the power fluctuates according to the strength of solar irradiation or wind at any given moment. Hydro can be used to balance the demand and supply equation for wind and solar.

This does not mean that one generation source is good, and another is bad. In theory, the greater the number of generation sources and the greater the variety, the more likely it is to be able to have a resilient grid. However, each new generation source requires consideration of how it fits in with the overall mix. If the grid were run by a benevolent technocrat, then each new generator could be assigned its full time and location-specific value on the grid and the grid could maximise harmony and resilience. At present this must be done through negotiation with your EDB (see the Appendix "Guide to harmonious grid connection").

Creating a CEP that is right for your community

Sometimes communities build an energy project that fits their budget or fits available land or roof space. The result can be a system that doesn't adequately meet the needs of the community, and this can have a negative impact on the economics and the level of satisfaction. It is helpful to figure out the type and size system you will need to fit your purpose. There are two key steps to take (1) perform an energy audit (balance) and (2) take an inventory of your current energy assets and system.

Energy Balance

An energy balance simply means comparing the energy you use to the energy that you generate or store. Doing an energy balance is:

- Really important to understand your energy requirements.
- Gives you real control in negotiations with all the other parties.
- Possible to do yourself with some time and effort

It is important to understand your current and projected power and energy usage so that you can select the correct type and size of generation.

The three most valuable parts of the energy project are:

1 Discovering ways to save energy

2 Discovering ways to shift energy use to a different time

3 Discovering the most economically viable amount energy to produce and store.

Once you have completed your energy balance, you should have a long list of opportunities for energy efficiency and controllable load. More details can be found in the Appendix "Energy Balance and Energy Inventory."

Energy inventory of your current system

Often there are energy assets in your community or in adjacent communities that are underutilized and can be integrated into a CEP project. This may be roof space at a local school, heating for the community pool or back up generation for a clinic or hospital. These are all resources that should be considered when planning a CEP.

An inventory of your current system can be as simple as starting with a blank sheet of paper and a pencil or printing a map and building a spreadsheet.

More details can be found in the appendix "Energy Balance and Energy Inventory." Once you understand the energy you need and the assets you already have, you can proceed to the next step: determining your generation and storage options.

How to choose generation and storage options

There may appear to be a dizzying array of choices and combinations. Fortunately, in Aotearoa New Zealand there is an easy button. Simply start with solar to test out the economics.

Once you have the solar model in place, then you can look at swapping out, or adding in, your generation and storage options. The simplest storage option to model, and likely the most cost effective at community scale, is lithium ion phosphate batteries. When looking to add to the mix, consider generation sources that complement solar when your solar system production is lower than your load.

Given the structure of the market in Aotearoa New Zealand, exporting to the grid typically has lower economic merit than self-consumption, and so should be minimized to maximise economic value. In some circumstances storage may make sense if you cannot use the power when it is generated. In other cases, you may have a unique set of resources such as strong, consistent wind in a region with low solar irradiation. But for the most part, if the economics don't work out with solar PV and batteries, they are unlikely to work for other technologies. On the flip side, if the economics work for solar, then other technologies can be explored to increase the economic return, supply resilience or other factors important to your community.

Is it better to have solar PV on multiple house roofs, on one big community roof, or ground mounted? Typically, the larger the solar array, the lower the overall cost per kWh produced. However, this decision depends on the site and how the energy will be shared and used. For small scale systems, ground mounted arrays are generally more costly per kWh than roof top systems. This is driven by the cost of design, civil works and building the structure to support the panels. Ground mounted solar becomes more economic at large scale as costs are amortized over a larger project. For a 10kW system or below, you could spend as much as double on a ground mounted system as a roof top system.

One of the biggest reasons to start with solar and lithium ion phosphate battery storage is that they are generally modular, and you can model the impacts relatively accurately (less guess work). This has several advantages:

1 You can size the system precisely to your needs

2 If you are off on your original budget estimate you can reduce or increase the quantity of each to get back into the budget envelope.

3 You can add to the system over time as your energy consumption changes.

With the basic energy system specification determined, it is time to understand what to do with the electricity you will generate.

What to do with the electricity you generate?

The professional term for selling your electricity is "power marketing." Essentially it is how you get compensated for the electricity you generate. It is a vital part of the equation because the higher and more predictable the income stream from your electricity, the easier it will be to get financing for the project. Some of the approaches to selling electricity are well established and fully supported by the current regulatory framework, while others are more experimental in nature and may require some work on the regulatory side to gain support.

Self-consume your electricity behind your meter

This approach is well tested and supported by the current regulatory regime. You can consume the electricity behind the meter as it is generated. The phrase "behind the meter" means that because the electricity is used before it gets to the meter on your property, it is not measured by the meter or accounted for by any external party like a retailer or lines company. The meter does not know how much electricity you were using or generating. It only reads the net electricity that flows through the meter.

Using the electricity behind the meter is by far the simplest and has lowest impact on the grid or anyone else. But this does require that you match your loads as much as possible to when your generation occurs. If you have solar, this typically means shifting loads like water pumping or running the dryer to the sunniest part of the day. If you have hydro or geothermal, your loads can be more spread out through the day. Even so, you will very likely end up exporting electricity to the grid and drawing electricity from the grid. The grid effectively acts as a giant battery. Afterall, that is the point of the grid, it is why there is a national grid rather than thousands of separate community energy projects.

A typical household with solar would be doing well if it self-consumed 50% of the solar it generated. A commercial or community installation would be doing well if it self-consumed 75% or more.

Sometimes the solar installation is oversized for other reasons such as low incremental cost, in which case the self-consumption numbers will be lower.

Sell your electricity to a retailer

Selling your electricity to an electricity retailer is well tested and supported by the current regulatory regime and is likely the easiest to manage. This is sometimes called "selling the power back to the grid" even though the grid is not an entity that buys or sells power.

Currently, you can only have one retailer so if you are selling electricity that you generate to them you must purchase the electricity you use from them. There are two prices to consider. The price you are paid for electricity you produce and the price you must pay for the supplemental electricity you need to buy. The lowest risk approach is to have both prices fixed. This also helps when seeking financing as this provides some stability in revenue and costs.

If the price you are paid and price you pay for electricity varies with the spot market price you are taking on considerable market risk and would need to carefully analyse if this makes economic sense.

There are generally four options that retailers offer:

Time of Use (ToU) spot. This rate provides full exposure to the wholesale market spot price. The price you buy and sell electricity is determined by the real time price in the spot market. The retailer will typically take a fee for providing access to the spot market (~10% of the value of the trades). You really have to be on your game to be on this structure as periodic price spikes can quickly erode savings and expose your project to significant financial risk. More about this below and in the appendix "How to access the spot market."

Time of Use (ToU) Fixed. The day is divided into six 4-hour slots starting midnight to 4am, 4am to 8am, etc., each 4-hour slot can have a different price, but it is the same price for that slot every day and is locked in for a defined period such as two or three years and it is typically purchased several months in advance. Usually, the lowest price is midnight to 4am. It ramps up toward 8am. It is moderate in the middle of the day, and it may increase for the evening peak before declining toward midnight. The value of this structure is that the rates are known, and you are rewarded for shifting electricity use from high to low pricing periods. EDBs typically reserve this for larger users with connection capacities above approximately 300kVA to 500kVA and/or annual usage above 300 MWhrs per year (roughly the equivalent of 45 houses.) Smaller entities can request to be on this rate; however, the associated lines charge may be too high for smaller users. This lines charge might be negotiable depending on the circumstance, so it is worth checking. TOU fixed contracts are typically only fixed for two to three years at a time after which they need to be renegotiated at a new price. It is important to check with your EDB when their TOU charging applies as not every EDB has the same time reference for TOU charges.

Fixed and flat. The price is a flat rate regardless of the time of day. Essentially it would be based on the demand weighted average of the time of use rates. As with TOU fixed, "fixed and flat" is locked in for a defined period such as three years and can be purchased several months in advance. The value of this rate is that you are protected from market price fluctuations and don't have to spend much time thinking about when you use your electricity. However, it doesn't provide much scope for reward for being able to shift your electricity use or generation.

Non-half hourly: The phrase "non-half hourly" refer to the fact that monthly meter reads are used to calculate your bill rather than half hourly meter reads. This is the flat rate that most household consumers would be on. While it is a flat rate there is no long-term contract so from time to time the rate will increase or decrease (but mostly increase.)

Select the plan that is best for you overall

The goal is to select the rate that offers the best overall value (price they pay for your electricity versus price they sell electricity to you) for your specific circumstance. In addition to the retail energy rate, you will also need to consider the lines charge structure in your area for both Transpower and your EDB as each may have time of use structures that could amplify or neutralize gains from your energy rate decision.

It is important that you don't just select the same plan as someone else you know or read about. They may be in a part of the grid that has a high congestion charge and energy prices in the middle of the day and therefore may report very positive gains with their solar generation. In your part of the grid, peak prices for lines charges and energy may be at a time when you have no solar generation.

The first step is to figure out what your generation, usage and net electricity profile will look like under at least two scenarios: (1) no change in behaviour and (2) using controllable load to shift usage toward generation periods.

If you are considering a Time of Use (ToU) rate, the second step would be to look at the historical pricing data for the specific pricing node for your location and determine, based on your electricity profile, what your net annual bill would have been historically. While the past is no guarantee of the future, you will at least have a better understanding of the trade-offs. This will take some effort. See more about pricing at nodes in the appendix "How to access the spot market".

Sources for good information are energynews.co.nz Energy News | New Zealand Energy Sector which requires a subscription and energylink.co.nz Energy Link – Plan and Execute your Energy Strategy with Confidence. Both will give you access to data, but you may need to retain an expert or you, or someone on your team, will need to know where to find the data and how to do the analysis.

Once you understand your anticipated profile in relation to the anticipated market price, then you can consider scenarios that might cause you to lose money and plan a mitigation strategy.

With this information in hand, you are ready to have a discussion with retailers about the options they offer. Some retailers will seek to have a short conversation and sign you up to a standard rate. Other retailers will seek to understand what you are looking to achieve and the specifics of your situation.

When negotiating a rate plan with a retailer consider the retailer's situation. The retailer needs to balance their book. For example, if you are exporting solar during the day but drawing from the grid during non-solar hours, the retailer will need to procure electricity to sell to you during the morning and evening peak and late at night. This electricity is more expensive so they will need some way to pass that through to their customers. Retailers that pay more for solar may require you to shift to a Time of Use (TOU) rate (Fixed or Spot) to allow them to pass through the higher peak prices or their flat rate charge may be higher.

In Aotearoa New Zealand consumers pay about 25 to 34 cents per kWh all-in for grid electricity. This includes an energy charge, lines charges (which includes transmission and distribution) and smaller charges that add up like a metering charge, billing, fees and taxes. For electricity generated locally and consumed in a local part of the grid, it is worth exploring which of these charges might be reduced or not apply.

The energy charge

The energy charge is based on the price of energy that the retailer pays for the energy plus a mark-up. The price they pay could be the wholesale market spot price or it may be more or less if they have a long-term contract (hedge contract) or if they own generation assets.

At the time of writing, the price that retailers would pay for solar was typically lower than the demand weighted average spot price.

It is quite common for retailers to pay 8 or 9 cents per kWh (with a max of 12 cents / kWh) for the electricity you sell to them. In a report from Concept Consulting titled "Review of the Generation Investment Environment" they show that the contract prices for 2022, '23 and '24 were 14 cents, 13 cents and 12 cents respectively. That same report shows the cost of supply at around 8 cents. Concept asserts that the difference is due to a lack of supply. Economic theory would suggest that if supply was the constraint, then each new incremental DER project should be compensated at closer to the average wholesale spot price than the average cost of supply.

Another indicator that the solar buy back rate might be due for reconsideration is that commercial contracts for energy that had been at 8 or 9 cents a few years ago are now at 18 to 20 cents. Yet over the same period the solar buy back rate has remained about the same.

There is an explanation for this. The demand average weighted price includes peak pricing when there is a high volume of demand and lower pricing during the night and middle of the day when demand is lower relative to production. The narrative is that while the peaks have risen dramatically pulling up the average, prices in the middle of the day have not risen as much. This trend of the morning and evening peaks rising faster than midday prices could be expected to continue as industries that use electricity during the working day (9am to 5pm factories) are in decline in and more solar is set to come online.

This would indicate that batteries will become increasingly valuable as will generation sources that can deliver electricity during peak times such as wind (unevenly) and small hydro. It also indicates that a CEP with solar should consider selling their solar direct under a Power Purchase Agreement (PPA) to commercial entities who have seen a dramatic rise in their rates. (More on PPAs below.)

CEP and DER owners would be well advised to review the average day time rates for their particular pricing node to determine how it relates to the buy-back rate they are being offered and then review this periodically over the life of the project in order to strengthen their negotiation position with the retailer.

The other variable is if there is a sustained spread between the price you are being paid for your solar and the price that retailer traders are paying for daytime power in the spot market then at some point some entity will look to aggregate solar and pay a higher rate.

For larger projects that are associated with entities that are large net electricity users, retailers might be willing to pay more for solar as part of an overall electricity supply deal.

Lines charges

Lines charges are made up of transmission charges and distribution charges. While these appear on the bill from the retailer, they are determined by Transpower and the EDB respectively.

Electricity generated and consumed locally can be more valuable to the grid because it does not need to be transmitted over long distances. Generally, the transmission charge is a flat rate intended to recover the cost of maintaining and upgrading the transmission system. If one CEP or industrial user reduces their transmission charge, then Transpower would eventually need to increase the charge for other users.

The transmission charge is a pass-through and is often part of the overall lines charge. Thus, to have the discussion you would need to coordinate with your retailer, the EDB and Transpower. The EDB would need to explain to Transpower why the transmission charge should be reduced or not apply and use data from their network assets to support the argument.

Some retailers will be supportive and help you in this negotiation. The less you pay for electricity all-in, the more you would have to invest in further electrification. In addition, customers are more likely to stay with a retailer that finds creative ways to save them money.

Transpower is exploring the possibility of a Transitional Congestion Charge (TCC). The TCC would rise when transmission constraints or congestion occurs during certain hours of the day. Depending on where your generation is produced and consumed in the local network, you might be able to argue that some of your electricity should not be subject to the TCC particularly if you are generating during times of constraint as the electricity you inject would be easing the burden on the grid. Even though the TCC is intended for large users and EDBs, it is set up to incentivize reductions in the cost of managing or upgrading the transmission system, so seeking cost reductions for reducing congestion would be a legitimate.

Arguing for a reduction in the EDB's charges requires collaboration with the EDB because they would have to supply the data to support your argument. While it is true that your solar energy might be consumed by a local neighbour, the EDB still needs to have sufficient capacity to manage peaks and power quality so the savings can be difficult to quantify. In cases where your CEP enables the EDB to defer or avoid an upgrade, it is easier to calculate the value. Currently, electricity flows are not measured with sufficient accuracy or frequency at an ICP level, or in the rest of the low voltage network, to provide clear data that electricity produced locally is being consumed locally in real time. However, some EDBs are willing to accept that, on average, the energy flows will net out over the month or year.

At present, the four options for allocating this value are: (1) reducing your upgrade customer contribution charge, (2) reducing capacity or demand charge, and (3) a custom rate (needs to be done within the regulatory constraints) and (4) a bespoke procurement of flexibility services by the EDB. Currently, procurement of flexibility services is seldom at a scale at which an individual CEP can participate.

There may be barriers to having this level of discussion with the EDB. The economic value may not be sufficient for the EDB to allocate the resources to have the discussion. The EDB may not have, or be reluctant to release the data. The grid may not have a constraint or problem to solve, limiting the value of local generation.

Getting the best all-in electricity rate

Finding creative ways to increase your all-in (energy plus lines charges) sell rate or decrease your all-in buy rate is important to the economic success of your project. It is important not to be limited by the current perceptions of the incumbents. The world is changing, and your efforts can support that change.

To decarbonise effectively, the grid will need to operate with more cost-reflective pricing and that will mean a shift from an incumbent controlled world to a market and price-led world.

More on solar buy back rates for specific retailers can be found here Solar Power Buy Back Rates NZ **(mysolarquotes.co.nz)**

Sell your electricity directly into the wholesale spot market via your retailer

Selling electricity directly to the wholesale market is common for large customers in the Megawatt scale, but less tested in the sub 250kW scale. For installations above 1MW, it is supported by the current regulatory regime but is complex to navigate. If you sell your electricity in the wholesale spot market, then you get whatever the wholesale spot price is for the electricity at that time. Your retailer may manage this either for a subscription fee or for a percentage of the transacted value (10% is common). Even though you might be losing 10% off the top, this can garner you the most value for your electricity.

However, you will also need to buy your supplemental electricity (the electricity you use more than what you generate) in the wholesale market so you need to have a way to hedge against having to buy when prices spike, or your profits can be quickly reversed. This means having some way to be able to rapidly reduce demand during peaks either with very flexible load, storage, generation reserve or a combination of all three. If you do not have a way to shift your load or store electricity and/or have a very sophisticated trading strategy, you may be worse off being exposed to the wholesale market. Even if you are getting solar for free from a neighbour or your solar system was free because of a grant, the prices that you will pay on peak, morning, and evening, for the electricity that you use in excess of what you generate, could reduce or reverse your solar savings.

Because of the financial risk that exposure to the spot market entails, the Electricity Authority has introduced a stress testing regime. The purpose of the regime is to make participants who purchase some or all their electricity at spot market prices more aware of the risks of assuming exposure to the spot market. Retailers are required to make consumers who are gaining access to the spot market aware of the regime. However, it is up to the consumer to ensure they understand the risks and they retain full responsibility for managing their exposure.

For example, the stress test notes that the spot price of electricity can go from a base of 10 cents/kWh to a spike of $10/kWh (a one-hundred-fold increase). You do not want to find yourself in a situation where you must buy from the spot market and pay 100 times more for energy than you expected.

There are five ingredients to mitigate the risk of having to buy when prices are high:

1. The ability to shift, curtail or limit your load
2. Electricity storage allows you to buy low (including self gen) and sell high
3. A control system that can read market signals and optimise when to trade
4. Negotiating a hedge contract that mitigates your exposure to extreme spot prices
5. The long-term enthusiasm and interest to manage it all.

Without these mitigations, there is a real possibility that, at some time, you might end up with a significantly higher electricity bill than paying fixed price from a retailer.

More information on the stress test is here Large scale consumer stress tests — Electricity Authority **(ea.govt.nz)** and more information about spot market is here Managing-electricity-spot-price-risk-guide.pdf **(ea.govt.nz)**

If this sounds too difficult, it is better not to be exposed to the spot market.

One aspect of getting the spot market price is that lenders will be less sure of the revenue and so lend a lower proportion of the overall cost of the project and/or require a higher coverage ratio than if the revenue stream was more assured.

See the appendix "How to access the spot market" for more information.

Sell your electricity to a third party under a PPA

The purpose of a Power Purchase Agreement (PPA) is to provide long-term surety of offtake and payment for electricity produced by a specific electricity generation project. This surety of offtake and payment helps the developer to finance the project. The buyer, who may be a gentailer or a private entity with a load, agrees to accept, and purchase, a specific amount of energy for a specific period at a specific price. Typically, the period would be 20 years, the price would be fixed with an annual escalation and usually the PPA covers all the energy that will be produced by the specific power project. A simple example would be if Spark built a data centre that needed 20 MW of power on a given section of land and then allowed a developer to build a 2 MW solar project on the same section. Spark could enter into a PPA with the 2 MW solar project to purchase all of the energy it produced and then procure the balance of its energy from the market. Since a data centre's power usage is consistent, they would always be using at least 2MW for at least 20 years. The price could be fixed with an annual escalation for say 20 years. If this PPA were in place prior to construction, then the project developer could use it as surety of revenue to borrow the money for construction from a bank.

If there was no direct physical connection between the generation and load, or if the solar project was on a different section of land, the PPA would need to be a little more sophisticated. The PPA would need to include a Contract for Difference (CfD) component. The CfD enables the transaction to be settled in the wholesale market but allows the buyer to pay to, or receive from, the generator an adjustment to cover the difference between the agreed fixed price and the spot price. This results in a fixed price to the power producer. However, the purchaser of the energy would have some residual exposure to the spot market and so could contract with a retailer to manage that exposure. While an entire mini guide can be written on this topic, suffice to say it is an approach worth considering because of the surety of payment it provides to the power producer.

At present gentailers tend to enter into PPAs under limited circumstances. One instance is where the PPA is part of an overall bilateral contract for electricity with an entity that has intermittent generation but a larger overall load. Under the PPA the gentailer may agree to purchase all the excess electricity that may arise during the day from a solar plant for example, 10 cents per kWh on an industrial site in exchange for being able to sell that industrial site all the supplemental energy it would need. This can be a good deal for both sides because the solar project can then be financed off balance sheet – they don't need to use company cash as they can borrow funds to build the project.

Note: That a PPA is a specific form of contract to provide surety of offtake and payment to a specific power project. A PPA is different from other forward contracts, bilateral agreements or energy supply agreements commonly used in Aotearoa New Zealand. For example: if an industrial company (such as the Tiwai refinery) buys power from a gentailer, the contract is focused on surety of supply to the load not on surety of offtake from a specific power project. Therefore, it is less useful as an instrument to finance a specific energy project.

When considering a PPA, recognise that this structure is new for energy projects in Aotearoa New Zealand and even experienced energy professionals may not be familiar with all the elements. It is advisable to engage someone who understands how the PPA should be structured to best enable financing.

Sell or donate your electricity to a separate and specific ICP

This approach is sometimes called Peer-to-Peer electricity trading.

Under current legislation, peer-to-peer at the consumer level between separate and specific ICPs is only supported when enabled by a registered retailer. The registered retailer ensures that the billing is accurate, that the transaction complies with regulations and that electricity can be supplied to both parties when the generation is not available. Both buyer and seller must be with the same retailer, and each can only have one retailer for all their electricity needs. Effectively, the buyer and seller establish a bi-lateral agreement for electricity sale-and-purchase that is outside of the wholesale market. If you were on different retailers, you could not have a bi-lateral agreement and the energy trade would be settled in the market.

Note: At the time or writing there were trials underway to enable more than one retailer to serve a given consumer. This would allow different retailers to sell different electricity products at different times of day to the same customer.

The more closely the peer-to-peer transaction maps to the physical grid, the more potential value there is to the electricity system as a whole and the more likely some of that value can be captured by the CEP. Once the electricity goes through your ICP meter, it is effectively part of the larger market. More about this in the Appendix "Peer to Peer Energy Trading"

Peer-to-peer trading, when combined with other cost savings like a bulk buy flat rate, can deliver value to both parties. However, when peer-to-peer is paired with exposure to the spot market for the supplemental

electricity, both end users can be exposed to price spikes particularly in the early morning and evening peaks when they would not have solar. See the section on spot pricing above and the appendix "How to access the spot market".

For financiers, peer-to-peer trading would require that the financier understand each of the buyer's creditworthiness in the peer-to-peer scheme and have surety that they would pay.

Sell flexibility services separately

In simple terms, from an EDB's perspective, any DER that can alter the amount of real or reactive power that it uses or consumes can be considered flexible. When flexibility can be provided at the EDB's request it enables the EDB to better balance the local grid. For example, if there is too much load on the grid, the EDB may call on the CEP to send power to the grid from its batteries or if the voltage is too high, the EDB might ask the CEP to adjust the power factor to bring down the voltage. Of course, this means that the CEP gives up the flexibility or control in exchange for being compensated in some way by the EDB. Demand response and other flexibility contracts or incentives for DERs are common in more mature markets but they are just being introduced in Aotearoa New Zealand. There are several features that should ideally be in place for this to work.

- The EDB needs to be able to value the flexibility – for example they need to have a constraint that the flexibility will ease and the value of easing the constraint needs to be calculable. They need to have an alternative for which they can calculate the value such as a line upgrade.
- The value also needs to be high enough to make it worthwhile for the CEP.
- The EDB needs to be able to make the opportunity visible to the CEP.
- Both parties need to agree the terms of when and how the flexibility can be invoked.
- The EDB needs to have the OPEX budget to pay for the service.
- The CEP needs to be able to perform the flexibility reliably from a technical and contractual perspective.

While Transpower has contracted for flexibility at the larger wholesale level, there are relatively few examples where this has been implemented at the distribution grid level. Today each opportunity is bespoke, generally limited to large-scale consumers or aggregated consumers and requires considerable negotiation between the two parties. In the future this should become more automated as the market matures. It is worth having a conversation with your EDB, retailer or flex traders about their approach to flexibility and setting your CEP up to be flexible so that it can participate in this value stream in the future.

Sell green credits separately

If you are selling your electricity to a third-party business, they may want the green or carbon credits or at least carbon kudos. These can be used to sweeten the deal or sold separately, and can present an additional value stream for your project.

These green attributes need to be trackable and show that they resulted in avoided emissions. Certified Energy certifiedenergy.co.nz has established the NZ Energy Certificate System (NZECS) to enable consumers to buy certificates from specific generation facilities. The value of these certificates roughly tracks the value of carbon credits.

Store your electricity and use or sell it later

Finally, with all these options you could also store the electricity in batteries or other storage technology and then use it in any of the ways above at a different time. As the peaks outside of solar periods become more extreme, batteries will become more valuable.

What type of energy system is best for you?

There are four key choices to make regarding the type of energy system. While it is easy to make this choice quickly based on pre-conceived ideas or advice, it is worth taking time to think them through and be willing to change your decision as you progress in your project.

On-Grid or Off-Grid

A key decision of any project is whether to be connected to the main grid, or separate from the main grid. Each community project needs to make this choice based on its unique circumstances.

Sometimes this choice is easy. If the grid is nowhere near your community such as on a small island or in a remote village far from a power line, then you would likely be building an off-grid system.

If you are already connected to the grid or close to it, then you likely would be better off economically with an on-grid system. There are several reasons for this:

1 The grid is a very cost-effective way to provide power to a large number of people. Therefore, it is unlikely that an off-grid system would be significantly lower cost.

2 The grid acts like a giant friendly neighbor -- even if you seldom use it, it is always there if your system goes down.

3 The grid also acts like a giant battery, absorbing electricity when you have too much and returning it when you have too little.

4 As the price of wholesale power changes, or if the market changes, and you may find the value of exported power to be much higher than it is today.

5 In the future, you might be in a position to be paid for flexibility (delivering electricity or capacity when needed) or for ancillary services – it helps to already be connected.

You may consider a hybrid set-up, with some parts of the property connected to the grid and other, more remote parts, off-grid. Some communities just love the idea of “being off-grid” but it is worth thinking through the advantages and disadvantages, rather than making this an emotional or ideological choice.

The grid is a collection of communities like yours, and the more CEPs that are a part of the grid the better it is for all.

Independent or Interdependent

Regardless of whether your CEP it is on- or off-grid, another question to answer is whether or not the energy system is only for a property that your community controls or if it is connected to other properties. Connectivity to other properties is easier in an on-grid system because the grid is already in place to connect the two systems. The reason this question is important is that it typically requires a sophisticated commercial arrangement among the parties and sophisticated metering and software to support the transaction system (see ‘What to do with the electricity you generate?’ above). Often it will require interface and negotiation with EA (the regulator) and commercial negotiations among the parties.

It is tempting to think that your case is different and everyone in your community gets along great. But whenever money is involved and the project is going to operate for decades, simply relying on good relationships is tenuous – having clear expectations and legal agreements in place is important.

Integrated or microgrid

It is important to only call your project a microgrid if it meets the definition, most importantly it would need to be able to disconnect from the grid, run in island-mode and then reconnect.

The word microgrid is often used to just describe a collection of loads and generation connected, but it actually has a specific definition. The US Department of Energy (DOE) Microgrid Exchange Group defines a microgrid as *“a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected and island-mode.”*

A microgrid can completely disconnect from the grid and run independently, but can also automatically reconnect to the main grid when required. This may seem simple, but a sophisticated control system is required to ensure that a controlled reconnection occurs such that the voltage, frequency and phase all connect seamlessly.

This is very useful to ensure supply resilience because if the main grid goes down, the microgrid can continue to operate. In cases where there is insufficient power on the grid, this feature of microgrids can even help the main grid recover. It can also serve people who have lost power by providing an oasis with electricity to charge their phones, cook a meal or take a hot shower.

Microgrids typically require someone who understands them well to provide ongoing operation and maintenance support, even if from a remote location.

On the other hand, an integrated system is always connected to the main grid. If the grid goes down the system typically must shut off too or it will feed power into the main grid and create a risk that there will be live wires that repair workers thought were dead. If an integrated system does disconnect, it cannot reconnect automatically. Thus, it is not as versatile as a microgrid.

Private Networks

A private network (sometimes called secondary networks) can be a very effective way to capture the full value of your energy project particularly if it combines generation, storage, controllable load, and efficiency. There are two primary types of private network:

- An embedded network: In which the CEP effectively becomes the local lines operator.
- A customer network: In which the CEP also becomes the local retailer.

In both cases there are three key values:

- Arbitrage between bulk buy and then on-selling of distribution services or electricity.
- The ability to minimise, or smooth, the export of electricity so as to reduce the size of the interconnect, the interconnect fees or demand charges and the amount of electricity imported.
- The ability to optimise across other utilities such as hot water storage and cold water pumping.

In both network configurations, the CEP would have to take on additional responsibilities and have compliance obligations that it could either self-manage or hire others to manage. Compliance includes paying the EA levies, the metering management costs, the retailing and the network charges.

Ideal situations for private networks are new builds on a single property with a single interconnection point to the distribution grid, but they can be implemented on existing infrastructure including on infrastructure formerly owned by the EDB.

More information may be found on this in the 2015 “Secondary Network Review” performed by the Electricity Authority available on ea.govt.nz.

Embedded Network

An embedded network is a sub-network that is owned by a private organisation or by the community in the case of a CEP. It is connected to the larger network owned by the EDB. There is a defined boundary at the network supply point (a network ICP) between the embedded network and the EDB’s network. The embedded network owner (ENO) acts as a mini EDB or lines company. The ENO owns the lines, maintains the lines, and charges the end customers a separate lines charge. They negotiate with the EDB to reduce the EDB’s lines charge. This can be significant. Although the rate may be charged differently (kVA versus kWh), the equivalent cost of the EDB’s lines charges might drop from 8 cents to 4 cents per kWh, leaving the ENO with a savings that can either be passed on to the community or used to pay down the project cost. If a third party is used to manage the billing and compliance this would eat into the savings, but at sufficient scale, say 50 houses or more, there would be enough savings to make this economic.

This works best for a new development because the network assets can be owned by the community. If there is already existing lines company (EDB) infrastructure, the network can be acquired by the CEP (sometimes at the depreciated value) and the CEP would become the embedded network owner (ENO). EDBs are generally reluctant to sell assets as this decreases their regulated asset base (RAB) which in part determines what they can recover through lines charges.

A typical use case would be where there are several homes, buildings, businesses, or electrical loads on one large property such as an apartment complex in an urban environment, a papakainga or a rural lot with multiple dwellings. Other examples are a retirement village, shopping mall or port that has clear boundaries to the rest of the grid. It is best if the entire network is on a single private property as managing maintenance on council property is costly from a compliance perspective.

From a retail electricity trading perspective, under the Code, an embedded network is still considered “on market”. The individual ICPs for each building can still be served by any retailer and have their own unique rate plan. Each individual house and building ICP remains in place giving each customer the possibility of choosing their retailer. However, they can only buy and sell electricity to one another if they are with the same retailer. The CEP can negotiate for reduced network charges.

Some retailers do not want to have the additional friction of having to include the lines company and the body corporate in the billing. They consider the “cost to serve” too high. But most retailers are willing to participate. It is worth figuring out how to make this as easy as possible for retailers to use in order to increase competition and reduce the retail rate.

An embedded network shifts the responsibility for maintaining the network and an obligation to supply people in need from the EDB to the CEP. Compliance is higher for embedded networks as you need to do the market reconciliation as a distributor and need to comply with all the regulatory maintenance needs. The CEP can outsource the maintenance and management to a private company. The embedded network could be operated by the EDB on behalf of the CEP, however, this eats into the savings or benefits.

Customer Network

In contrast to an embedded network, a customer network solution requires that there is a single ICP (gate ICP) at the boundary between the customer network and EDB network such that all the electricity in and out is accounted for at that ICP. There are no other ICPs beyond the gate so the interaction with the retailer is only at that single gate ICP. Behind the gate ICP, the community would manage billing among customers using check meters and effectively act as the retailer.

From a retail electricity trading perspective, under the Code, a customer network is considered “off market”. That is, the retailing of electricity for each load or building can only be served by the community entity and they deal with one retailer for all the consumers on the customer network.

As the network owner, the CEP would have to cover the maintenance responsibilities and costs as well as the administrative ones. There are commercially available billing platforms that enable this. They read the meter, calculated the amount owed and automatically generate an invoice into popular accounting software. This could also be done manually by reading the meters and entering the data into a spreadsheet. An asset management function is likely to be required to take care of the network in the long term, however this could be subcontracted to a local maintenance partner.

Customer networks are particularly beneficial for multi-unit residential properties. This presents the opportunity to get bulk buy discounts online for charges and energy and enables one person to negotiate for all. This suits many people who are looking for low cost, reliable electricity but don’t want to deal with the details. One of the reasons that retailers would be willing to provide a lower bulk rate is that multiple units provide diversification to smooth the load. In a 20-unit network, 3 occupants may be retired and stay at home, 4 may do office work from home, 2 may work night shift all of which smooths the load enabling the retailer to purchase electricity for a lower average rate and pass the savings on.

One challenge that has emerged since 2021 is that the price of electricity has gone up substantially and so a customer network might find that their new power contracts are 10 cents higher (double) the previous price. They don’t want to have to pass on the bad news and cost to their residents. However, if they have self-generation and controllable loads, this higher price could be used to motivate additional behaviour change or investment.

Management of both embedded networks and customer networks requires a degree of expertise, and there is some risk to owning the network. In some instances, the EDB or a private company may manage the private network on the owner’s behalf which may eat into the savings.

Embedded Networks and Customer Networks are not mutually exclusive, as a Customer Network can exist on top of an Embedded Network. A Customer Network has fewer compliance requirements and could deliver more savings but it is more effort to manage. It does need to be registered and the CEP organisation will need to become a retailer (but not a market participant because it is “off market”.)

One interesting consideration is that some community owned EDBs pay out an annual dividend to customers on a per ICP basis. If you only have a single gate ICP, versus 20 individual ICPs, your collective dividend will be 1/20th of what it otherwise could have been. The Cohaus and 26 Aroha case studies are examples of a customer owned network.

Virtual Power Plant (VPP)

A virtual power plant (VPP) sounds very clever and powerful. It can be, but it can also be hype.

A useful definition comes from next-kraftwerke.com *“A Virtual Power Plant (VPP) is a network of decentralized, medium-scale power generating units such as wind farms, solar parks, and combined Heat and Power (CHP) units, as well as flexible power consumers and storage systems.”*

Initially, a VPP was intended to at least add up to the equivalent of a utility scale generation system (say 200 MW) but now it can be as small as 20 kW. Sometimes marketers label an aggregation of the loads of a few households as a VPP. The idea still holds, the aggregation of generation and loads such that they are controlled together so that they act as a single unit which can deliver the same services as a power plant. We can argue about scale but for it to qualify as a VPP there must be a way for the grid to experience it as a single entity and for it to be able to provide similar services to that of a power plant – not just electricity. The level of sophistication depends on the underlying DER assets and capability of the control system.

A VPP is not a product you buy off the shelf, it is a system that you build. The virtual element is typically that you don’t own the line infrastructure but just control the loads and generation. Whether you label it a VPP or not is mostly up to you.

Connecting to the grid

Once you have decided that you want to be, or remain, connected to the grid you will need to prepare for a discussion with your local EDB. More about this in the appendix "Guide to harmonious grid connection."

What it means to become part of the network

At a minimum, the grid serves as a giant battery absorbing power when it is generated and returning it when it is needed. Without the grid, the community project either needs to provide its own storage (expensive) or only use power when it is generated (inconvenient.) In addition, the responsibility for "keeping the lights on" in your community becomes the responsibility of the project alone.

If you decide to be part of the grid, and most projects do, then you become a member of a much larger community of generators. Being part of this community comes with social and commercial obligations because you will then be partly responsible for keeping the grid running. The people who rely on the grid for stable, low-cost power are now relying on you. This is a vital concept to consider. It is not just about what you can get from the grid, but what you can offer in return. To misquote John F. Kennedy "Ask not what the grid can do for you, ask what you can do for the grid!" Further, this is important because community energy projects will only be allowed to thrive if they can operate in harmony with the rest of the grid. All generators, all users, and all storers of electricity on the grid are part of a big community. Community energy is not about isolation, it is about interdependency, it is about community!

Whether your project is grid-connected or not, it is important to realize that you are taking on the responsibility of providing one of modern life's necessities, and, for at least the next 25 years people will rely on you delivering that service.

Getting to know your local grid

The comforting thing about the electric grid, lines and substations is that you can often find them on maps and then drive out and see them in the physical world. Typically, an EDB will publish the general location of their grid and substation in their Asset Management Plans which are pubished on their websites under Regulatory Disclosures. You can look up your area and then trace back which line you are on. If this information is not available, you can contact your EDB and ask for it. Typically, you would ask for the distribution engineering group or the GIS (mapping) group or person. Usually, the substation is enclosed in high fencing with lots of danger signs posted. There will also be power lines running to the substation. Inside the fenced-off area you will see large pieces of equipment usually dark green or grey in colour. Knowing a bit about your local substation will help shift the interconnection discussion with your lines company from theoretical to practical.

The other piece of network equipment to find is the distribution transformer. In an urban area this may be on the roadside in a cabinet and serve 25 to 50 houses. In rural areas the distribution transformer might serve a single property and be smaller and attached to the power pole.

Getting to know your local EDB

Of all the participants in the electricity sector, EDBs are likely to be the most impacted by community energy projects and are a key determinant of the success of the project. It is worth engaging with them early and seeking to understand any challenges that your CEP might create, or solve, for them and then working through the issues early to avoid expensive surprises.

If you can position your project as being compatible with your EDB and enable them to learn and test out their systems for managing DERs more generally, it may be easier to gain acceptance.

Most EDBs are endeavouring to be more customer friendly and responsive to customer needs. The challenge is to provide a tailored experience to all customers, particularly those below 1 MW or 250 kW (depending on the EDB). This may result in a mixed experience from DER owners and CEPs and a process of co-learning.

Escalation

In resolving an issue, the Electricity Authority (EA) has a directive to serve the long-term benefit of the consumer. The mechanism by which the EA would hear or adjudicate issues that might arise between the industry player (EDB or retailer) and the CEP is less clear. While your specific issue might not be resolved, it is worth letting the EA know as it may help those who follow – eventually the Code might be changed.

Another option to try is the Utility Disputes Commission udl.co.nz. You typically would have had to try resolve the issue directly for more than 20 days for this to be an option. While more focused on classic utility disputes such as unfair billing practices or customer service, they strive to be free, fair and independent. If enough similar issues get sent their way, they may find a way to resolve them.

The connection or interconnection process

The connection process may be different for each EDB but there will be similarities since all EDBs are bound to follow the requirements in the Code. As such, there are some things they can't change about the process. This would include the types of forms you would need to fill out, the inspections that need to happen, the permits that need to be obtained.

The most relevant part of the EA Code for CEP is called the Electricity Industry Participation Code 2010 Section 6. This may seem intimidating to read, but it provides some useful information such as:

- What EDB's are required to provide in terms on information,
- The fees they may charge,
- That the EDB needs to respond with a decision within 30 days of receipt of a connection request,
- That the EDB must approve the connection application if it meets a defined set of criteria,
- Which inverters are approved for use with DERs.

On the other hand, there are parts of the connection process that are designed by the EDB and are specific to that EDB. Having someone on your team who understands the process and understands where exceptions can be made will facilitate the discussion.

The key to a good experience is high quality information exchange in both directions. EDBs often get incomplete information or information that changes which may lead to delays and unanticipated costs.

Recently the number of DER connection requests has increased. As much as they would like to, EDBs don't have a great deal of time to spend on any one application. Providing all the information required as accurately as possible at the outset of the connection process, and understanding what is involved, will help to ensure it runs smoothly. Best to be well prepared and educated from the start.

The standard process

The standard process typically is an arm's length engagement and has been created to manage standard connections at scale. It is managed by a customer support or new connections team who endeavor to run every new request through a standard process. They may differentiate among small connections (say less than 5 properties or ICPs), medium size customers and key accounts or large customers.

The process typically starts with filling out a form on the EDB's website. The complexity of the form depends on the size of the project (over or under 10kW).

Once the form is submitted, the new connections team would make an assessment as to whether or not an upgrade to the grid infrastructure was needed. If it is a new connection then certainly a line would need to be run to a new pillar at the boundary. If it is an existing connection, the meter may need to be changed through your retailer, and, the EDB may require upgrades to the line from the property to the distribution transformer, the distribution transformer or even further up the network.

Initially the EDB would provide an early indicative cost. This is not a quote or even an estimate. It is just to allow the customer to decide if they wanted to proceed in round numbers such as $20,000, $50,000 a $100,000 and so on.

One key element of the cost is the location of the connection to the property. If multiple locations are possible, it would be worth providing a few alternative locations. This could be based on consenting requirements, terrain and the grid topology or constraints. Information regarding the grid topology and constraints may need to come from the EDB, but it is worth exploring how changing the location of the connection could change the cost of the connection.

Once the optimal location has been determined, and if the customer decides that they still want to proceed, then the EDB would send out one of their designers. The designer would visit the site, take some photos and measurements and then run the parameters through an estimation model to generate a formal quote. The quote would be valid for a specific period like 90 days. This quote is just the network side, that is up to the boundary of the customer property. There is also the customer side of the upgrade such as installing a new or additional conductor on the property. There may still be opportunity for negotiation on the formal quote particularly in terms of actions the CEP could take to minimize the overall cost of the upgrade (EDB network side and customer side.) This may result in further studies or re-running the calculations for the upgrade based on new information.

In most instances, if the upgrade is clearly attributable to the customer, then the EDB would expect that the upgrade cost would be 100% paid by the customer. The EDB would later ask if the customer wants to own and maintain the asset or if the customer would prefer that the EDB does this. In most cases even though the customer has paid for it, the EDB ends up owning and maintaining everything on the network side.

If you agree with the quote, the EDB will then do the upgrade work (either directly or through a contractor). They will bring the power down the pole and preferably take it underground to a pillar on your property boundary at the location of your choice. If undergrounding is not feasible, they may run an overhead conductor.

The EDB issues the ICP number if needed. Sometimes the EDB installs the new meter in which case you will need to tell them which retailer you will be using and if you will be exporting electricity. In other cases, the EDBs will coordinate with the retailer and get the meter installed by a contractor. In other cases, meter installation is done by a third party, and this would require the CEP to contact the retailer and coordinate the issuance of the ICP number by the EDB with the installation of the meter by the contractor.

The work will need a Certificate of Compliance (CoC), Electrical Safety Certificate (ESC), Record of Inspection (RoI).

The EDB has a great deal of influence over the connection upgrade and cost:

- The EDB typically determines what type of upgrade is needed
- The EDB determines what the upgrade will cost
- The EDB determines how the cost will be allocated
- The EDB does the work
- The EDB determines the schedule and priority. While the quote has a time limit, the work might get delayed without penalty. Recently supply of cables has been cited as an issue.
- The EDB gets paid for the upgrade by the customer and often ends up owning the asset.

There are several important steps to take to ensure that the process runs as smoothly as possible:

- Call your EDB, give them your address, your ICP number and, if possible, the number of your distribution transformer. This number should be written on the pole or on the distribution transformer in clear view. Ask them for the number of phases and the kVA or amps. Then ask them what the distribution transformer rating is. Is your capacity limited by the transformer or by a fuse for your share of the transformer? This at least tells you what is in place at present.
- Typically, the forms may not have sections for the full story. Some forms will ask for the rated power and the export limit. Best to figure out a way to attach a document that clearly explains your project and the options:
  - Provide a comprehensive package including variations that might be possible in terms of capacity and location of the ICP. You would want to include the capacity required and the calculations showing possible mitigations.
  - You could have a 20kW inverter, but it could limit the export to 5kW.
  - You could have loads, storage and generation that on their own might require a 100kVA connection but could collectively be managed to never exceed 50kVA.
  - You may have several options on location for the connection which may allow them to serve your load in different ways.
  - Your plans for expansion – will you be adding more EVs or batteries?
  - Your buildings might be really energy efficient, or you might be looking retrofit to energy efficient buildings.
- Most forms are looking for absolute numbers but if you give an absolute without explaining what the options are, then you may have locked in a position.
- By double checking the size of the connection you require may enable you to reduce, or avoid, the upgrade cost and you could save on ongoing lines charges, particularly if you are charged monthly by kVA capacity versus per kWh.
- When the EDB gets back to you with the estimate and cost allocation, try to understand why and where cost savings might be:
  - What makes up the cost? What is the break down in equipment and labour?

– What is the capacity that could be allocated to you without an upgrade? Is there an operating envelope that, if you stayed within it, you could avoid the upgrade?
– Is the capacity limited by the physical device or a fuse that allocates capacity?
– Is there a different distribution transformer nearby that has capacity but just needs a connection feeder? (Note: connection feeders are not cheap – a rule of thumb in an urban area is $1,000 per meter.)
– How much of the existing distribution transformer is already allocated? (Most urban distribution transformers are 300kVA and may have 25 to 50 houses allocated to them which translates to about 6kVA to 12 kVA even though each house can use up to 15 kVA.)
– What method did they use to assess the constraint? Can you or your independent engineer review the calculations or methodology?
– Did they account for the fact that you are limiting export and prepared to sign up to a demand or capacity cap?
– Why is 100% of the cost allocated to you? Does the upgrade not benefit others or would it have been needed anyway?
– Will the EDB own the equipment and, if so, how will it be accounted for?
– Would the EDB be willing to pay for a portion of the upgrade perhaps as part of a test or community enablement program?
– Are there parts of the work that could be done by others at lower cost?
– Can you get an estimate from a second supplier?
– How long will the work take and what is your recourse if it takes too long?

The EDB will assess the impact that the project will have on their grid at the connection point in a variety of ways depending on the size, complexity and what information and tools they have:

1 Using a set of guidelines or rules like "no more than 5kW of solar can be added per ICP."
2 Using the ICP data such as energy, voltage and current to determine the impedance and therefor the anticipated voltage impact and thermal impact on the grid. (Note: only a few EDBs can do this as many don't have sufficient data from ICPs)
3 In rare cases, performing a grid impact assessment. This can only be done by the EDB and is done on their timetable and often at a cost to the DER owner.

Sometimes EDBs will do their own assessment of your capacity requirements based on the number of homes or energy assets that you will have behind the meter.

Given the number of requests that the EDB needs to process, and that most of them are standard, there is typically limited possibility to talk to a person in advance and thus limited opportunity for the CEP to discuss alternatives or approaches that the CEP could take to reduce the upgrade or cost. If the new connections group could not solve the issue, then they would escalate it to the network planning department. In many EDBs.

Innovating in partnership with the EDB

Within each EDB there are several functions empathetic to DERs or community energy.

There is usually someone in charge of network transformation or grid modernization. They would be very interested in working with a new and innovative DER or CEP project if it could help inform how management of DERs may work in the future. Often with creative thinking, there are ways to enable the interconnection with limited upgrade cost, particularly as it is early days for DERs in Aotearoa New Zealand.

Sometimes the network planning department can come up with a more harmonious solution. The person in charge of innovation or grid modernization can help broker this discussion. Therefore, it is important to find this person early and build a relationship, gain their trust and position your CEP as a good partner and example.

It is vital that you can describe your project in the context of the EDB's network and convey that you are willing to work with them. Then it is important to listen carefully to their challenges and work through the issues one-by-one. From there it is a matter of working through the details in a collaborative way.

The other function that might be empathetic would be the community outreach group. In some circumstances, they can help the CEP negotiate a cost reduction in the connection cost or enable access to technical and commercial expertise within the EDB that would otherwise not be available.

More about this in the appendix "Guide to harmonious grid connection."

Specific components of the connection process

The two principal questions with integrating a DER that is smaller than 1 MW are: Will the ICP need to be upgraded or changed and will the distribution transformer need to be upgraded?

For DERs smaller than 1 MW, it is seldom the case that a feeder or a network transformer will need to be upgraded. The responsibility for paying the feeder and network transformer upgrade differs for each EDB and situation. With no bright-line ruling, it depends how the EDB interprets its responsibility for providing grid services and how those costs are covered. If there is plenty of "headroom" on a line or network transformer because of a recent upgrade there may be no charge. If a new DER just happened to be the one that tips the line or network transformer into a thermal or voltage limit then an upgrade may be required. This is an important consideration when figuring out the location and early economic assessment of a project.

The basic connection

If all the physical infrastructure is in place and the capacity requirement is the same, then connecting to the grid can be a simple administrative task.

A distribution transformer upgrade

The distribution transformer is the transformer that drops the voltage from the medium voltage (11 kV) distribution grid to the low voltage used in homes 240 V (single phase or 3-phase) and businesses 400 V (3-phase). It is sometimes on the property and sometimes off the property mounted on a pole or on the ground. It can be dedicated (only for that property) or shared (used for more than one property). It can be owned by the lines company (EDB) or it can be owned by the property owner.

This is typically the biggest opportunity for limiting interconnection cost. If the CEP can demonstrate to the EDB that they will require the same capacity as is already allocated to the property, then the upgrade can be avoided. This requires well documented calculations and understanding of the CEP and control system to explain how it will always be able to stay within the capacity limit. If you are unable to come to agreement, then it is worth finding a way to escalate within the EDB to someone in the network planning group, network futures group or innovation group. This may require patience and persistence but if your calculations are correct, you may find a constructive resolution.

Upgrade work is typically subcontracted out to a third party either associated with a lines company or completely independent. Usually, the local EDB would manage all of this on behalf of the CEP and bill the CEP while managing the contractor.

Upgrading or installing a new ICP (Installation Control Point)

An import-export meter will be required if you are installing generation for the first time as the meter needs to be able to account for energy flowing in both directions. You might also need to upgrade your meter if you are looking to do advanced billing. Certainly, if the property is switching from several meters to a single gate ICP, a new meter would be required. If you are going to work to reduce your capacity and demand charge, then you will need to have a smart meter that can read at least at 30-minute intervals. In the future this is likely to shift to 5-minute intervals.

For residential systems, smart meters cost about $200 to have installed. For commercial systems meters can be quite a lot more expensive – they are sometimes called "revenue-grade" meters.

This process requires collaboration between the EDB, the retailer and a metering company. The EDB allocates and assigns ICPs. The retailer or the EDB organizes for the ICP to be installed. The metering company or the EDB installs the new ICP and manages the data collection and storage. The retailer has access to the data and may sell the data to the EDB to enable better grid operations.

Note: Many in the industry would argue that regulations governing the management and use of ICP data in New Zealand are in need of reform. EDBs clearly need this data to manage the low voltage network, yet retailers own the data and prefer not to share it with EDB or will sell it to them at a steep price. This introduces cost, inefficiencies and keeps the EDB blind to their own grid, all of which is ultimately a disservice and expense to the end consumer. There is awareness of this at all levels and has been a known problem for at least a decade.

You can access information about your ICP here: **ea.govt.nz/consumers/your-power-data-in-your-hands/my-meter** It tells you your ICP number, how you are connected and what rate plan you are on. If you do not have an ICP and you need to get connected, the process would be:

- You would contact your local EDB either directly or through an application page on their website.
- After you have filled in your details and submitted the application, it may take 30 days or more to process. That is just to hear back on a decision.
- Your electrical contractor would need to take the power supply up to the EDB's pillar but only EDB approved contractors may access the pillar or pole and make the connection.
- A certificate of compliance is needed before the connection can be made.

The requirements and complexity of the process increase as the power rating of the connection increases. The requirements regarding connecting Distributed Generation (DG) to the grid can be found in section 6 of the Electricity Industry Participation Code 2010.

Upgrade for the line from the distribution transformer to the ICP

The line from the distribution transformer to the ICP can be divided into two sections. (1) The section from the distribution transformer to the pillar at the property boundary is owned and maintained by the EDB. (2) The section from the property boundary to the ICP is typically owned by the property owner and is their responsibility to maintain and upgrade. If the distribution transformer is on the property boundary, then the entire line is owned by the property owner.

If the distribution transformer is upgraded, it is quite likely that the line will also need to be upgraded since it would be carrying more current or have a second line installed. The work within the property is typically managed by the CEP and is subcontracted out to a company that is certified to deal with high-capacity lines. Often the same company that upgrades the transformer can upgrade the line.

Sometimes, the distribution transformer is large enough but, the line from the distribution transformer needs to be upgraded. Particularly in urban areas, this line may be outside the property boundary. In an urban setting this might end up costing $1,000 per meter for an underground line.

Lines charges

Understanding what you are charged for and why, can help you can minimize the charges. This can have a significant effect on the economics of your CEP.

The EDB and Transpower have a challenge. They have to maintain the network and grid infrastructure and need to charge customers in a way that covers the fixed cost and the variable cost of providing the service. It has to be consistent for all customers. If they simply charged a flat rate per connection, then single people with low electricity usage (e.g., a retired widower) would be subsidizing large households. If they just charged based on electricity used, then permanent residents of a beach town would be subsidizing bach owners who only used electricity for a short period of the year.

At present there are several EDBs who offer "time of use" pricing for the network and grid. An EDB may for example charge 6 cents off peak and 16 cents on peak. Couple that with a three-cent differential on electricity price from some retailers, this gives a 13 cent differential between on and off peak rates. Another EDB may charge zero per kWh for grid usage at night, so the full amount of the grid charge is saved.

It is contemplated that by mid-2023, EDBs will be able to charge a flat monthly rate. For those EDB's that switch to this method they will be less exposed to revenue loss from widespread adoption of self-generation DERs. If this is the case, then there will be no difference between on and off-peak lines charges leaving the arbitrage to be based on energy alone.

For most residential properties, there is a fixed monthly fee and a variable rate. Other than picking a rate plan that works best for your circumstances, and then minimizing electricity use, there is little you can do about the charges.

For a commercial property, farm or community on a large site, the rate structure may be more complex. This provides more scope for reducing your bill. There are three primary charges:

- Capacity Charge (also called Network Charge)
- Demand Charge (also called Congestion Charge)
- Energy Charge

Capacity Charge (also called Network Charge)

Capacity is the ability of the network to deliver electricity to your property and to all the properties on your line. Think of this as the thickness of the wires. Since the EDB does not want to overspend, they assess the maximum electricity demand forecasted for that part of the network and assess how thick the wires need to be based on that demand. Then they allocate a certain amount of capacity to each property and charge you for your portion of the capacity (the capacity charge).

The capacity charge is typically a daily plus a per kVA charge. The amount of the kVA charge depends on the estimating method used by the EDB.

Note this is not how much power you use, it is how much power you could use.

Demand Charge (also called Congestion Charge)

Demand is the amount of load you put on the network or how much power you draw from the network. The demand of the entire line must be lower than the capacity of the entire line because you simply cannot shove more electricity down the wires than the capacity for which they were designed. However, at a given moment, if your neighbours are not using all their capacity, you could "borrow" some capacity and in that moment your demand would be higher than your allocated capacity.

The demand charge is based on the amount of electricity you use at times when the rest of the network is reaching its capacity. Formulas vary but one popular formula is to calculate the average of the top six two-hour periods in a month to estimate your "peak" hourly demand. Using the average reduces the risk that a one-off spike in usage will drastically impact your demand charge. The per kWhr demand charge is multiplied by your peak hourly demand. Therefore, finding ways to reduce the peaks can result in large savings.

A demand charge makes a lot of sense because it incentivizes customers to behave in a way that reduces the peak demand and therefore keeps the cost of an upgrade down while keeping the reliability high. Demand charges penalize those who use large amounts of electricity sporadically or during periods when the network is heavily loaded.

Fortunately, a combination of generation and storage, which are often part of a CEP, is ideally suited to managing how much load you demand from the network thereby lowering your demand charges. This adjustment is made annually and there is a delay due to the calculation period so you might find that even though you have reduced your demand, you are stuck on the old (higher) rate. With some effort, you might be able convince the EDB to get you onto the lower rate earlier.

By finding ways to reduce your capacity allocation and anticipated demand, you can reduce your electricity bill substantially. You also need to be sure not to exceed your demand allowance. This may influence your design decisions such as whether to use battery storage and allow it to be managed to support the grid when needed.

The Energy Charge

This is based on number of kWhs used as measured by your meter. In some countries this would be the net of the inflow and outflow but in Aotearoa New Zealand you get charged for all the electricity that comes from the grid to your property regardless of how much you produce. What you send back is measured separately.

Other Fees

Control Fee:

Some EDB's have historically charged a fee (usually less the $2 per month) for ripple control of hot water. Ripple control has a benefit to EDBs, Transpower and the cost of generation because it can be used to lower peak demand. EDBs will assert that these savings are passed on to the consumer. For example, if your all-in rate for "anytime" electricity is 31 cents / kWh your rate for "controlled" electricity might be 25 cents per kWh. Using these figures, the first 33 kWhrs in savings would be used to cover the $2 fee but after that the consumer would see net savings.

Meter Fee:

This fee is for the meter that the retailer uses to bill you. This is usually less than $10 per month for a single house but more for a multi-unit dwelling.

Operational interconnection risks

Just because you have been allowed to connect, does not mean that your connection experience will be without risk. There are instances where a solar system has been connected to the grid and is at first able to export its full rated electricity of for example, 5kW. But later as congestion increases or other changes are made to the grid, the voltage may increase at that ICP and this may cause the inverter to automatically reduce the electricity export.

A Quick Technical side note: The high grid voltage would first cause the inverter to consume VARS (Reactive power) to increase the current and thereby reduce the line voltage. Reactive power is not real power, so the real output is effectively reduced. If the voltage goes higher the next step would be reduce the power and may curtail as much as 80% of the output. The result would be that you would be supplying a lot less power than projected and that will be reflected in your project economics.

Creating a budget and financial model

The budget describes in detail what the project will cost to build and commission and where the money for that process will come from. The financial model describes how much money the project will generate once operational, what it will cost to maintain and operate and how much money will be excess to those costs to reduce the project debt owed to financiers and investors, or alternatively, to go towards community benefit.

Budget

One of the first questions people ask is how much will it cost? It is a very important question. There are a lot of variables so it can be difficult to answer. The reasons projects go over budget include:

- Not all the costs were included because they were not known, weren't considered or were purposely left out.
- A new unforeseen cost arose during construction.
- Delays increase cost and there is additional rent, interest, and price increases during construction, between the time of the estimate and procurement.
- Stuff happens.

It is tempting to just consider the big-ticket items and then assume the rest can be covered by a contingency.

Take an example of an imaginary project of 100 kW of solar and 60 kWh of batteries. *Note: The cost figures below are rough guidelines and should not be used as indicators of the final cost.* You estimate the cost at $180,000 for the solar and $80,000 for the batteries and then add a 15% contingency for a total of $300,000 for the project. But you also need to factor in:

- Feasibility study $20,000 to $40,000 *(could be double this)*
- Final design $50,000 *(could be double or triple for a large or complex project)*
- Interconnection upgrade $0 or $20,000 to $50,000 *(could be much higher)*
- Upgrading the metering system $0 to $10,000
- Cables to connect to the distribution network $20,000
- Control technology for the loads and generation and storage $10,000
- Monitoring systems $5,000
- Balance of plant (all the other stuff that adds up) $10,000
- Project management $20,000
- Civil or building works related to wiring or upgrades $5,000 to $25,000
- Equipment hire such as elevated work platforms or security fencing $1,000 to $5,000
- Communications, fundraising, and administrative costs of $4,000 to $10,000.

Then add contingency of 10% and you can easily find your $300,000 project is a $500,000 project.

This does not even include any of the costs you might have for energy efficiency or updating the loads to be controllable. It also does not include communication technology, application fees, cost of financing, legal advice, storytelling, or celebrations.

It is important to determine the true cost sooner rather than later and be very diligent in writing down all the costs. That way you can trim them down if you come up with creative solutions like engaging a graduate student at a local university to do the energy balance or finding a way to bring down the interconnection cost by working with the EDB.

If you have done everything you can to find creative ways to reduce the budget and it still costs too much, then you may need to reconsider ambitions and preferences or scale down the project. This is one reason solar, and batteries are so useful in a project because you can reduce the size and cost incrementally.

Once the budget is set, the game is to try to beat the budget wherever you can.

Indicative cost for solar projects

As a guide to pricing below is a graph from My Solar Quotes showing the price for residential solar. In general, the larger the scale, the lower the price per Watt. For example, in 2022 the $/w price drops from $2.80 for 3kW to $2.40 for 5kW to $2.20 for 10kW. At 20kW it gets to 2 $/w and at 100kW it gets down to around 1.8 $/W. These are for straightforward installs and are just a guide. More info is at Prices For Solar Power Systems In New Zealand | Pricing Guide **(mysolarquotes.co.nz).**

These prices may still be relevant, but it is always good to check. As you can see in the graph below, pricing changes, usually it goes down, but things like supply chain issues can cause them to rise. The most current data is the most reliable.

At the largest scale (100MW) the installed cost can be as low as $1.20/W – This is a rule of thumb rather than a substantiated number.

See table and graph below used with permission from My Solar Quotes

Rough Pricing for Commercial Sized Solar Power Systems

Solar Power System Size	Number Of Solar Panels	Cost
10 kW	Twenty-eight	***$22,000** incl. GST, fully installed.
20 kW	Forty-five	***$40,000** incl. GST, fully installed.
30 kW	Sixty-eight	***$58,000** incl. GST, fully installed.
100 kW	Two hundred & twenty-eight 440W panels	***$180,000** incl. GST, fully installed.

Off grid systems typically include batteries and generally end up costing a little over twice the price of grid tied system. See more on sizes and prices here. Off-Grid System Sizes - The Range Available In NZ & The Price **(mysolarquotes.co.nz)**

Financial model

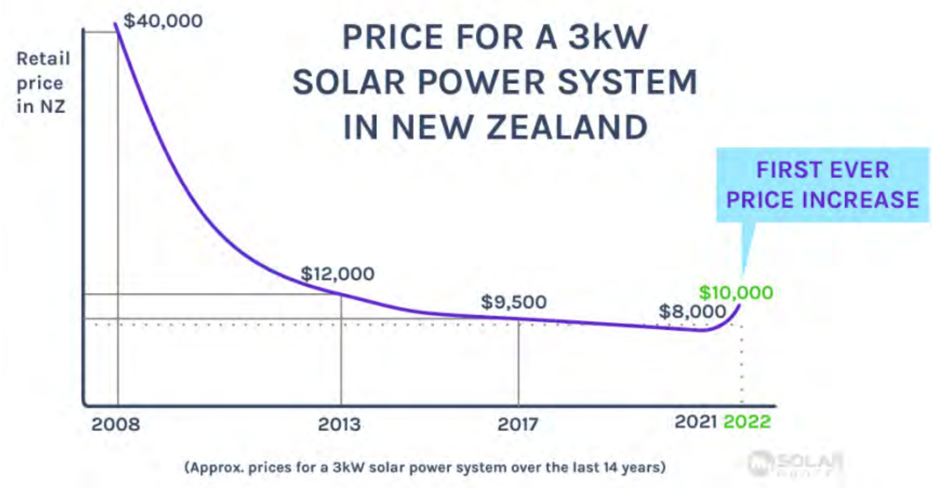
The financial model starts with the budget as an input number spread out over the period that it will be spent. It then shows the funds coming in for the project. The amounts and timing should match.

It shows the expected revenues over the next 20 years along with the estimated costs of operations, upgrades, maintenance, and potential unexpected contingencies. Out of this flows the net profit for each year, the taxes and finally the free cash flow. This free cash flow will either be used to pay back the funds, or if the funds were donated, the free cash flow would go to the community initiatives for which it was intended.

Your financial model will have a list of assumptions for each number, and as you work through the project you will refine the number and the assumptions. When you seek to access financing, you need to be sure that you can answer why you think each number is accurate or how you will manage the risk to make it accurate.

To assess the revenue, you could ask your contractor what they think the production will be and then multiply that by the anticipated price per unit. (See the contractor section.)

It is always best to check yourself. A company called Helioscope helioscope.com will enable you to do an array layout with production estimates but you will need to



The price increases in 2022 were driven by supply chain constraints and subsequent inflationary pressures.

have the solar irradiation data and other details. There are several other companies with good models. They charge a fee for use and require some effort to learn to use effectively. You would typically get about 1,300 kWhr per kW peak (3.5 equivalent full sun hours per day). Anything above 1,600 kWhr per kW peak would be overly generous for a static (non-tracking) solar array.

You also need to account for the direct operating costs:

- insurance (can be a bigger than expected)
- maintenance - cleaning, mowing, (could be by contractors or volunteers)
- administration - billing and maintenance management
- data management (small scale and may not be necessary)
- land lease.

There might also be indirect operating costs such as compliance or administration fees. It is also worth accounting for volunteer time because you never know when a volunteer might quit.

Finally, you need to assess whether the free cash flow will be sufficient to pay back the funds within a reasonable time frame. This would be determined to a large extent by the type of financing and the return expectations of the funder.

The goal with financing is to match the surety and size of the net cash flow with the surety and size of the financing payments so that you (and the financier) could be sure that you would be able to service the financing costs and reduce the amount financed. That is why lenders and financiers prefer to have a long-term power purchase agreement (PPA) rather than rely on a merchant arrangement where the price you get paid for electricity fluctuates with the market. It is also why equity investors want you to have a fixed interest rate for the life of the loan so that the cost of servicing the loan does not suddenly escalate.

If you have received grant funding to partially fund the project, the financial model can be used to assess how to cover the costs above the grant funding amount. However, it is very important to note that the grant funding needs to deliver community benefit, not increase the financial returns to investors.

This will provide a very good view of whether your project will succeed. Equally, it allows you to have a constructive conversation with counter parties assuring them that the project can be built and operated for the long term. It also allows you to make the trade-offs while understanding the financial impact. Now you are ready to engage with counter parties and partners.

Engaging with counterparties and partners

Mindset

As you develop the CEP you will encounter people who say “yes” who inspire you to keep at it. You will also encounter people who say “no”. The trick is to understand why they are saying “no” and to mitigate their concerns. Work towards understanding the conditions under which they could support (or at least accept) the project. The best way to get support for a project is to include people in designing something that is appropriate for the local context, and which delivers value for local people.

Preparation

There is a saying that “Success is when preparation meets opportunity.” You may not meet opportunity at first, but you still need to be prepared. There are four key elements to preparation.

1 Walk in their shoes

Whether you are talking to a person at an EDB, a financial institution or a contractor, they all have a job that they are paid to do. They report to someone, they don’t want to get in trouble or fired or passed over for promotion. You need to understand how you can help them. If what you are asking for requires them to do something which may be risky or unusual, you need to assess how to mitigate or reduce the risk or potential cost for them.

In many cases you will be interacting with people who are more experienced and knowledgeable in the topic than you are. Typically, if they are good, then they will be busy and will only allocate limited time. It is important that you show that their time will be well spent with you.

Ask yourself “What is in it for them?” and then ask them and think of a way to meet their need.

2 Know what you want and need

Being able to use the correct words, technical terms, and industry jargon, and, clearly articulating what you want is vital to establishing creditability, ensuring you end up with what you need. It is also worth knowing in advance what you want (best case) and what you need (the bare minimum) to get resolution quickly.

3 Know your rights

As pleasant as the counter party may be, it is not their job to look out for your rights or interests. There may be obligations on counter parties that even they might not even be aware of. It is worth understanding your rights and their obligations so that you can, at opportune times, gently point them out. Regarding EDBs, sources for finding out your rights include the Electricity Industry Participation Code 2010 (section 6), the EDBs own websites and policies, the EA and other CEPs. This also helps navigate resolution or escalation if you get turned down.

4 Be open to expertise

After all the preparation and assessment of what you want, it is sometimes hard to remember to relax and be open to the idea that the person you are meeting with may have solutions that are better for all. Be open to others wanting to help you and if you have done the above steps right, they will see it in their interests to find a solution that is mutually beneficial.

Talking to your lines company, distributor, EDB

Lines companies (EDBs) have a difficult job in that no one thinks about them when everything is going well, but when the power goes out, everyone thinks about them, and not in particularly charitable ways.

More about this in the appendix “Guide to harmonious grid connection.”

Become a vital partner for the EDB

Since your CEP project can provide all kinds of benefits to your EDB, it is possible you could become a vital partner to them. Keep this possibility open during your discussion with them.

Talking to funders, financiers, and community investors

Many of the same guidelines of mind set, preparation and being open to others’ ideas apply when meeting with financiers.

The fundamentals of funding

Every commercial funder has the same two concerns:

- Will they get their investment back? - Risk
- What return will the earn on the investment? – Payback/Value

Grant makers and philanthropists may not be interested in the getting their money back, but they do want to know that the project has a good chance of success (risk) and to see the funds well spent and to see a return – even if it is non-monetary (payback/value).

Every funding conversation has the same basic elements.

1 How much are you asking for?

2 How long will it take for the funder to get a return (get the money or other benefits back)?

3 How can they be sure that what you say about (1) and (2) is accurate and will become true?

Fundamentally, it is about building a relationship of trust between the funder and the borrower and confidence in the project and the team developing it. Trust helps to secure funding but also allows for the relationship to weather the inevitable variances as the project is developed and operated.

Transparency is also important when talking to funders and goes hand in hand with trust. You will need to share commercially confidential information with funders in order to get them to trust you and to make their own assessment of the risk vs value for themselves. Transparency however doesn't mean an open book. Share what you need with funders to collaborate, build trust and negotiate. However, remember preparation elements 2 & 3: know what you want and know your rights, you don't want to seem frivolous, and you want to be confident that funders will follow through on their promises.

There are three distinct phases of a project that need financing:

1 The development phase (from the inception to the start of construction)

2 The construction phase (from the day you break ground to the first flow of electrons)

3 The operating phase (from the first flow of electrons to the last flow of electrons)

Each phase has different risks, time horizons and capital needs.

The development phase is the least certain. Decisions on technology, budget, location, consenting, etc., are all still in flux. Typically, this phase is self-funded by the community or a benevolent sponsor. Private and government grants can also be a good way to fund different parts of the development, for example, grants might be available to do feasibility studies, develop models or undertake geotechnical studies. Though the capital requirements are usually lower than the other two phases, commercial funding for this phase is rare.

This is also the phase when you will be engaging your community and having lots of discussions about what you want to achieve and how. The resources you will need to do this should also be considered, along with how you will respond to criticisms or backlash.

Development approval and capital raising. Once you have all the plans and consents required, you can seek investors in the project to fund the capital works, etc.

The construction phase is typically well bounded by a budget and timeline. The risk lies in whether it can be built on time and on budget. The biggest risk is usually what lies underground, when installing foundations or laying cabling. Once above ground, if the technology is well established and the contractor is experienced, the build is likely to go as planned. Construction phase financing might be the specialty of a specific funder. It typically is seen as riskier than the operating phase and therefore usually has a higher interest rate with the more conservative funders being less likely to want to fund this part.

Once the plant is operational, delivering electrons and a revenue stream then more funding at lower rates would be attracted to the project. The proven revenue stream provides surety of payment, and the completed plant may serve as collateral or at least assurance that there is an asset that can be sold.

Regardless of whether someone is being asked to fund one phase, or all the phases, the challenge is that the project is yet to be built. So how do you know what the costs and net cash flows will be? The most effective way to answer these questions is to build a financial model in the form of a spreadsheet. Typically the most effective way to communicate is with graphs and diagrams derived from the spreadsheet. You could try to do it all on the "back of an envelope" but you may quickly lose track of the details and these details will likely cost the project a lot of time and money.

Once your spreadsheet is built, then you need to go through each line and plan how you will make each of those lines become true. For example, if your spreadsheet says that you will sell your power to the local council's pumping station at 11 cents per kWh escalating at 2% per annum, then you need to plan how you will negotiate that into a signed contract to provide reassurance that it will become true. Similarly, if you think it will cost $435,546 to build the project then you would want to have estimates or quotes that show that. The more binding the estimates are, the more believable they are and the stronger your case with the financier.

Most serious financiers will want to perform due diligence, which simply means understanding each possible risk and how it will be mitigated or covered. This keeps everyone disciplined. However, this takes considerable time and effort from both you and the funder.

This is one reason why larger projects are often easier to finance the smaller ones. The amount of due diligence is about the same regardless of size therefore financing ten different 100kW projects is more expensive in terms of administration and due diligence than financing one 1 MW project.

As part of the due diligence the funder will want to review the following elements of the project and make sure everything lines up and is accurately reflected in the financial model.

The revenue from the sale of electricity: For funders, the more certain the revenue is, the better. A Power Purchase Agreement (PPA) is a contractual agreement between energy buyers and sellers. They agree to buy and sell an amount of energy which will be generated by a renewable asset. PPAs are usually signed for a long-term period between 10-20 years. A fixed price 20-year contract is more valuable than an arrangement to sell on the spot market even if the market price is expected to be higher, this is because of the certainty a PPA brings.

The Power Purchase Agreement (PPA):

- The PPA should be legally binding and tightly drafted so that there is no risk of non-payment.
- The off-taker (the buyer) should have solid credit and be a predictable user of electricity with the ability to pay for the duration of the PPA – often 20 years.
- It helps if the off taker has a track record of using PPAs to procure electricity.

An example would be to have a PPA with a data centre owned by a large tech company.

The Construction contract:

- This should be legally binding and well drafted, fixed price with penalties for delays. It should be clear how costs will be managed and how completion will be guaranteed.
- The contractor should have a solid credit rating and have sufficient financial stability to get the project built and through the period of the guarantee.
- They should be experienced in electricity and in the specific technology that you are using.
- Typically, this means that financiers want to see large companies with strong and established brands building the projects.
- Sometimes they will want a third-party engineer to review the design or to monitor the construction.

The O&M Operations and Maintenance contract:

- This is like the construction contract but would be for a longer term and focus on how well the maintenance will be performed within budget.

Technology and supply chain

- Financiers do not want to take compounding risk. Therefore, with all the other risks they want reduce or eliminate technology risk. They do this by requiring the technologies used are well tested. Not just that you are using solar panels, but that the solar panels are from a trusted brand.

- Because electricity financing is new in Aotearoa New Zealand, funders will often consider any electricity financing to be new technology. Even though in international markets solar, wind and hydro are all established as low-risk technology.
- As described in the supply chain section, financiers may also insist on proof of ethical sourcing.

The financing contracts:

- These documents need to be clear and fair without hidden fees or interest rates that are subject to change, particularly if there is more than one funding entity,
- It should be clear which financing facility is senior to the others in terms of getting paid, step-in rights (ability to take over the project) and rights to collateral.
- All the financing documents should be coordinated so that the funds get committed in the right sequence, often simultaneously.

The track record and experience of the developer:

- Financiers are wary of getting involved in the first project that a community or individual has done because it is believed that first time developers are more likely to make errors than more experienced developers. Those errors could lead to a reduction in revenue, delays, cost overruns or other circumstances that reduce the ability of the project to repay the financing.
- One way to address this concern is to build a relationship and trust with the financier well in advance of needing their funds so that they can see progress and believe in you and the project.
- A first-time developer can reduce the perceived risk by including more experienced developers as advisors, showing definitive progress against milestones and being diligent through having design, drafting, and consulting work done by well-established firms. This adds legitimacy to claims of serviceability and reliability.

Banks (Lenders)

We start with banks, not because they are necessarily the most likely sources of capital for a CEP, but because they set the standard for everyone else in terms of thinking about funding for projects.

The banking business model

On the surface a bank's business model is simple. They take in money from depositors and lend it to others. Some of their revenue comes from fees for services to depositors but most of their revenue comes from lending money to people, to buy big things like houses or cars, and to companies to buy inventory, build facilities or build energy projects. Banks will say that they are in the business of lending. Their business model is to put money to work, they just don't want to lose it.

They are not allowed to lend out all their depositors' money. Some money must be held in reserve if depositors want it returned or if a loan is not repaid. The smaller the reserve requirement, the better for the bank as it means they can lend more.

There are three factors that drive the size of the reserve that they are required to hold. It is important to understand these because they impact your ability to borrow for your project.

1. **The probability of a default.** The higher the probability the more reserve they need to hold. Things that affect this probability scoring negatively would be technology risk (new technology), unproven contractor, uncertain revenue stream or poor operating cost control.
2. **The loss given a default.** The more they stand to lose, the greater the reserves. This can be bolstered by having security over the asset, land or something they can sell to recoup their principal.
3. **The term of the loan.** The longer the loan is available for, the riskier it is since the more likely it is that the borrower's situation will change. Banks like loans that are amortized over a long period but that get reset periodically and rolled over. This allows them to have the option to get paid back early and increase the interest rate if needed.

This explains, in part, why banks are risk averse and need to do extensive due diligence. Banks can get surety of payment from secure revenue streams, the collateral of the asset or related assets, the creditworthiness of the company or a backstop or guarantee from a third party. In all their normal business lines like mortgages and business loans they have tried and tested models for how much money is needed, how it will be paid back and the surety that it will be paid back. They also have trusted advisors who understand the asset they are financing such as buildings and can oversee the construction so they can be confident their money will be returned.

Since electricity, DERs and CEPs are new to many banks, they don't yet have a standard approach to finance energy projects cost effectively. For some banks just the idea of solar will sound technologically risky. It matters little that solar cells were invented in 1883 or that solar panels have been in commercially available for 50 years or that billions of dollars of solar have been financed in the last decade overseas. If it is new to the bank, it's considered risky.

Deal size and complexity

In general, the larger the deal size, the more commercially sophisticated the deal can be because the bank's team has more time and resources to dedicate to each deal. They can invest the time to determine new categories like energy projects and get them through the bank's approval process. Since community projects would typically fall into the smallest size category of $1m to several $100,000 dollars they would ordinarily be reviewed by the team with the least amount of time to dedicate to each deal and possibly the least experience in electricity.

To keep things as simple, consider three groups in a bank that might work in the electricity sector:

1 Project finance (or infrastructure finance, specialty finance, structured finance)

2 Commercial banking

3 Retail banking

Project finance or any of the other related terms typically deal with large projects where they can invest at least $10m. In international markets they normally won't look at a deal under $100m. Project finance is often non-recourse which means that the only security they have is the revenues from the project. Unlike financing a house, which the bank can possess and resell, a power plant that doesn't deliver the promised revenue may not be resold for enough to cover their loss. Project finance transactions are very rigorous and might cost a million dollars in lawyer and bank fees to structure. Therefore, the deals need to be large.

While most community projects would not need $100m or even $10m in financing, there are many lessons that can be taken from project finance and applied to smaller projects such as:

- Ensuring that the off-taker has good credit and the contract requires them to pay.
- Ensuring that the contractor is credit worthy and can build the project on time and budget.
- Ensuring that the technology is well established, or if new, that the risks can be managed.
- Ensuring that the financial model accurately reflects the costs of construction and operation.
- Providing clear visibility of the risks and how they will be managed.

At the other end of the spectrum is retail or consumer banking. This is all about volume and standardization. If they are financing houses based on the buyer's income, they want the house to be as standard as possible and the income to be as stable as possible. They want all the mortgages to look as similar as possible from a financial risk perspective. This helps keep the cost of each transaction low and enables more volume. It also helps when mortgages are packaged up together into a "security" which then can be sold to a syndicate of other banks. This frees up the first bank's capital to enable them to lend more money and repeat the process.

The part of the bank that serves the commercial sector might be the most aligned with community energy projects (CEP) in terms of complexity. The commercial sector is used to looking at a business' cash flow and balance sheet to assess the risk of lending to them for growth projects such as opening a new store or manufacturing line. In the case of a CEP, they would need to assess the potential revenue stream against the cost and risk of construction and operation. The first hurdle is that they prefer transactions where the loan amount is at least one million dollars (perhaps they could do $500K in special circumstances.) The other challenge is that DERs and CEPs are new to most commercial lenders. It would take them a lot of time to understand the project and they would need to get over the hurdle of understanding that the technologies are proven and the surety of the revenue stream or which invertors or panels are reliable. Not only that, but they would need to convince their manager, who would need to convince their manager and ultimately a credit committee. Each layer would be increasingly fiscally conservative and have less time to understand the specific deal. Volume of projects is important so that it becomes worth the banks while to invest the time and effort.

To summarise

The people in the project finance group, who might understand the CEP conceptually, prefer to work on big deals and with parties that they consider financially sophisticated.

Those in the commercial and retail groups may be less well equipped to understand the project at least in terms of time they can allocate.

The CEP manager's job is to show the bank that the amount being asked for will be paid back and that the entity that holds the project can provide surety of payment.

It is important to remember that banks don't just "have money". Banks are stewards of their customers' and shareholders' money, and they need to be very careful how they lend it. The market reality is that each deal needs to make commercial sense to the bank and the loan will be priced to achieve a reasonable rate of return.

Whoever you are working with in a bank or any financial institution, there will always be someone that they report to that they need to convince – your job is to make your counterpart's job easier.

Finance the phases of the project separately

One approach to financing a project would be to split the financing into two phases. The construction phase and the operation phase. As described above in the general section on financing, banks are more likely to be willing to finance the project once it is operating. This is sometimes called "take out" financing. For example, the project could be constructed with community funds and then, once operating, a loan could be arranged to free up (reliquefy) some of the community funds for the next project. Just like with a mortgage, you might need to leave some community funds in the deal. What percentage would depend on the size and surety of cash flows.

For a well-structured, low risk deal on an operating project, banks like to see a coverage ratio of at least 1.2. That means if the cash flow is assured to be $120 dollars per month, then the bank will be prepared to believe that you can reliably pay $100 per month in principal and interest. The size of the loan would then

be calculated based on the $100 per month, the interest rate, and the term. The rest would need to be from the original funding source. This could be from a community fund, a grant, private equity, or a philanthropist.

The term (length) of the loan depends in part on how long the project is expected to operate for. Wind or solar projects that are expected to last 20 or 25 years, might attract loans that would be amortized over 10 or 15 years or possibly longer. Often these are mini-perm loans which means that the first sub term of the loan is say 5 years after which the credit and interest rate are reassessed. It is in the banks interest to roll the loan over to the next 5 years because they already understand the deal and have put in the work to set up the loan, so most of the time these loans run to maturity by rolling over multiple times.

This does introduce some risk to the project because generally your revenue is fixed or escalating gradually and if the interest rate rises, the cost of servicing the debt will increase possibly impacting the coverage ratio and the amount you can borrow. At a minimum it would reduce the amount of free cash flow left over for the community.

The other way to split the funding into two phases is for the same bank to fund the construction phase and then roll over the loan to the commercial operation phase. This is useful to the bank because the construction loan can be for a shorter term (say a year) and have a risk premium on the interest or collateral, while the loan for the operation phase can be longer term, a lower interest rate and lower collateral requirements.

Include first loss capital

Most energy projects using proven technology are likely to deliver their expected revenue or close to it. Note: while “proven technology” can be difficult to define it is generally up to the lender to decide. If they do miss their revenue target it is often by a few percentage points rather than complete non-performance. In addition, there may be high years and low years as the resource such as wind, solar or hydro fluctuates. To ensure that they can ride through these variances, banks like to see first loss capital in the deal. The bank gets paid first, the first loss capital (which might be 20% of the deal) gets paid last. And if the project needs to be sold to recover the banks remaining capital the bank gets paid from the proceeds first and then the first loss capital gets the remainder.

First loss capital can come from any non-bank entity such as a community fund, a grant, private equity, or a philanthropist.

Provide a backstop

A bank may ask for someone to backstop the financial obligations of the CEP. This could be a role for a sophisticated philanthropist or government agency. They may not have to put any cash in up front, but if the project fails to repay the bank, then they are on the hook to cover the remainder. This is useful because the backstop entity does not actually have to put any money into the deal. The just need to have the wherewithal to cover the losses.

Create a loan guarantee

Some markets have a loan guarantee program. It is like a backstop and can be a very effective use of government funds. It needs to be well structured so that all parties take due care to manage the risk rather than just letting it fall on the guarantor. Tesla used a US loan guarantee program when it needed cash in 2009 and that seems to have worked out reasonably well for everyone.

A dedicated loan facility

Sometimes a bank will put together a dedicated loan facility aimed at financing a specific type of asset or project. A bank might make a deal with a specific solar provider to finance any solar project that meets a pre-agreed standard set of criteria. The solar provider can then offer that product combined with financing to its customers and generate a larger volume of standardized sales. The loans to these standard projects can then be packaged and sold down to other banks. Typically, the loans are secured by the creditworthiness of the off taker, that is, the entity that is getting the solar installed and then paying a fixed fee for the electricity to pay back the loan via the solar company to the lender. The lender will likely set the credit criteria for the customers that the solar provider would need to use as a guardrail.

Some banks create a dedicated pool to serve a greater social purpose such as preventing people from having to fall victim to pay-day lending and the high interest rates these lenders charge.

This is interesting for CEPs and DERs in general, is that if there were enough CEPs that were similar from a financial point of view, then they could be financed efficiently with a dedicated loan facility. It is likely that several of the approaches described above would need to be combined to get the project financed.

Other returns

Banks are considered a key part of the Aotearoa New Zealand's solution to GHG emissions. They are eager to show how they are doing their part. If your project would make for a good marketing story for the bank, they might be willing to spend a lot more time and effort to make the deal work. The deal would still need to make financial sense. The bank would still want a return and their money back, but they might be willing to involve senior people who would otherwise not work on such a small deal.

The other form of return is to enable the bank to learn so that they can then create a more efficient process. If you can show that you are the first of 100 similar deals, then they are more likely to be interested than if you are a one off. As above, your specific deal will still need to make commercial sense.

Learning from others

In more mature and sophisticated markets, banks are happy to finance DERs if the financial model makes sense and there are contracts in place to ensure that the financial model will hold true. At present, getting bank financing may be a long and patient conversation with banks and others to bring together a financing package that works for all. It would be worth having someone on your team who has some familiarity with project finance or finance in general.

Government Agencies

Sometimes, as has been the case with MBIE and the grants for Māori CEPs, government agencies will provide grant money to support part, or all, of the costs of a project. This is very rare. It is in many ways the opposite of a bank because they are not looking for any financial return. They just want to be able to see the community benefit and test out some ideas.

The government's business model is also simple. They collect taxes from as many people as they can and bring in revenue through state ownership in enterprises like Transpower and gentailers and then try to use the money for public good. A fair portion of the money is spent on administration. So, if you get a dollar from MBIE for your project, you and other members of the public may have collectively paid more than a dollar to the government in taxes and electricity charges to get that dollar.

As described in the banking section above, one way that government agencies can use their funds effectively is a loan guarantee program. Say that MBIE had a budget of $10m for an energy support program. They could give $10m in grants or they could guarantee $100m in loans and set aside that $10m to cover bad debts. They would need to determine what percentage they might need to cover but energy projects usually deliver some revenue and out of a portfolio of 100 projects only a few might miss their targets.

Another efficient use of government agency funds would be to provide supplemental funding as a grant to serve as first loss capital. If the project cost $500,000, $300,000 might be borrowed, $100,000 might come from the community and the last $100,000 might be a grant that is in a first loss position.

Governments like to show that they are helping the people they serve in the way that people appreciate. Providing positive stories of how energy grants have impacted communities helps advocates for this type of funding get more funding. It is in the grant recipient's best interest to use the funds effectively and show metrics of how the funds benefited the community. The person in the agency who is championing the grants needs to convince a lot of other people that this is the highest and best use of funding. Through taxes, the funds for the grant came from people in other communities just like yours so it is incumbent to spend their money wisely.

Not-for-profits

Not-for-profit, or community or charitable organisations are sometimes set up to help a specific sector of society. The funds can come from individuals, governments, corporations, or some combination. The not-for-profits are professionally managed and are charged with finding ways to put the money to good use for the benefit of the sector of society that they are intended to serve. If you can find a way to position your CEP such that it genuinely meets the criteria of the non-profit, then you could get some or all of your funding from this source. When approaching not-for-profits, you still want to have a credible financial model and have contracts to show that you will be able to build the project for the amount that you say and that the project will generate revenue, and other benefits for the community.

Creating an ongoing revenue stream for the community to fund other community projects is like economic payback, but, because the revenue stream is used for other community projects, it may be able to tap into a unique set of funding sources that share the same community objectives.

Not-for-profits can work in collaboration with financially motivated lenders in the same way as government agencies in terms of providing loan guarantees or first loss funding.

Private equity investors

Private equity investors could be a single person, a group of people or an institution. If you are fortunate enough to find private equity investors that are interested in helping you to build your CEP, then you will need to be very disciplined in terms of how you present the project economics. You may be able to raise funds from the community of your project.

Private equity could provide funding at any stage from funding development all the way through to take out funding once the project has been in operation for several years.

They will want to understand the return, the risks and how you plan to mitigate those risks. For private investors, it is often their direct personal wealth that you will be using to build the project. So they care very much about making sure that they will at least get their money back, and, most likely that they get a return on the money. In this way they are much like banks.

Because they are willing to take on higher risk, private equity investors will usually be looking for higher returns than banks. For a CEP, it is important to find a private investor who is not just looking to make a profit, but also looking to help promote the project or the community. If this is the case, they may require a lower return, and that may enable the project to be financially viable.

One of the greatest benefits of private equity investors is that they are among the most savvy and creative funders. They may bring together a creative coalition of the willing to fund a project. They may turn you down politely after the initial meeting but then reconnect if they find a complementary partner – perhaps they found a buyer for the power who they see has a stronger credit base. They also have a lot of market knowledge of recent deals so interacting with them can sharpen your pitch. If they cannot do the deal, they may know others who can, or they may do your next deal. They may also find creative ways to construct a portfolio of projects that includes yours to enable financing at scale. A good private equity financier is always trying to learn new ways to put money to work to earn a good risk adjusted return and they generally have far more flexibility than banks.

Crowdfunding or Crowdsourcing

A tried and tested model internationally, crowdsourcing funds is similar to private equity, but the amounts each individual put in are much smaller, some contributions as low as $50 or $100. The other big difference is that the people contributing funds won't be as experienced investors as private equity investors with large sums of money, they will often be more passionate about the project and getting a return is a more secondary consideration.

A return is expected however, and the risks and benefits must be clearly explained in plain language. There is often regulation in place to protect people investing through crowdsourcing campaigns, so it is important to do research or seek a professional platform to run the campaign. The main disadvantage is that you won't have just a few funders to deal with, there will be hundreds, potentially thousands of people who need to be updated on progress and, once the project is operational, paid a return. The administrative burden of crowdsourced funds is one of the highest on this list.

The big advantage of this model however is that it allows the community to become directly engaged with the project, own and potentially make ongoing decisions about it's operation. Having low barriers of entry mean that households don't need a spare $10k to become investors and can contribute what they can comfortably risk. Community benefit is then not only in the supply of cheaper and cleaner power, but also some inclusivity and financial benefits as well.

Philanthropists

Philanthropists are often misunderstood as rich people who merely want to give away money. In fact, they are still looking for a return on their investment … it is just not all about money. The key to philanthropists is understanding what they want to be known for, or what return or benefit they want to see that is not monetary.

Philanthropists are often driven by causes. Part of that drive is to bring their knowledge and skills that they used to make the money, to the area they're trying to support. Often modern day philanthropists will want to see that a financial return is generated on the money. Even if the money doesn't go back to them, they want to make sure that money is being generated and delivered to the community. This means that philanthropists often bring the same level of discipline and experience to a project as private investors. As with the other forms of financing, you would need a robust financial model along with clear contracts that shows the assumptions in the financial model will be made true.

With any grant funding, whether from government, philanthropists, or non-profits, it is vital to find out what information they need from you and provide it to them so that they can continue to get more funding. Invariably, the person that you are dealing with must convince someone else up the chain and finally and investment committee and sometimes the public. Showing the value that the grant brought and appreciation for the people who did the work to get the grant can be as important as doing the work to get the grant in the first place.

Tiered financing

By now it should be clear that no matter who you talk to about financing your CEP, you will benefit from having a robust financial model and supporting documentation. Also, different types of financiers will be willing to take different levels of return for different levels of risk. This means that a project can be financed from multiple sources and that the sources of funding can be stacked or tiered by their risk and return profile.

The most conservative funder, for example a bank, would get their money back first. Then the private investor who is willing to take on more risk for higher returns and then finally at the top of the pyramid, there might be grant money or philanthropical funding which requires no return and is therefore the last to get "paid."

This is a bit like buying a house where a mortgage must be paid on time every month, but you also borrow money from your wealthy uncle that does not have to be repaid right away, and you also get some free money from your parents, and then you put in some savings. You must make sure that everyone gets paid back.

Grant funding is much more valuable than just free money. It can act as the surety that all the other funding can get paid. If you have a $100,000 grant, you could just build a $100,000 project. Or you could use that $100,000 as surety to raise or borrow a second $100,000 and build a $200,000 project.

Selecting a contractor

The contractor's dilemma

Selecting a contractor is an important part of creating a project that is high quality and cost effectively built. Most people would like to think that they've selected a contractor that they can trust.

The dilemma with contractors is that they typically have the most knowledge about how to build the project while being incentivised to charge as much as possible for the project. This means that to select a contractor and get the best mix of quality and price, you typically want to go out for competitive (contestable) bids.

However, you need the knowledge that a contractor has to create the competitive bid package and then you need to understand the responses and verify if the responses have merit.

One way out of this dilemma is to find someone in the community, or who you can hire, who has close to the same level of knowledge as a contractor so that they can assemble and manage a bid package and process for you.

Many contractors will just want to give you a set price without describing the breakdown of the components of the price. Contractors who do not want to provide a breakdown may not be revealing that they are using lower quality components or plan to take short cuts. This is your first indication that they should not be selected.

Asking for a breakdown of labour rates, number of hours and costs of individual components will help make trade-offs in terms of the size, scope and materials used. It will also help you understand what is involved. If one quote shows the labour hours for installing the solar panels to be half that of everyone else, it is worth asking why. In some cases, it is possible to get a fully open book at cost plus margin quote which allows you to accurately judge if the quote is fair.

The contractor should also be able to give you:

- Peak Power
- Annual electricity and electricity production profile
- All the details that you will need to fill out the interconnection application.
- A breakdown of labour and parts
- Ideas of where money can be saved
- Ideas of how community members or others could contribute.

Specifics about electricity generation contractors

Since CEPs and DERs are relatively new in Aotearoa New Zealand, it is unsurprising that many of the contractors may not have sufficient knowledge to accurately estimate the cost of a more complex project upfront.

Certainly, there are many installers of residential solar panels. But if your project is more complex or if it is a larger project, then the number of qualified contractors drops off rapidly. For example, if you were building a microgrid that included battery storage, solar, controllable load and sophisticated controls, there may be only one or two companies in the Aotearoa New Zealand who could deliver this project on time and budget.

However, some contractors may bid on projects outside their current competency. Perhaps so that they can learn or because they might think it more lucrative. It is important to understand what projects the company has done before, not just in terms of volume, but also in terms of complexity. Ask how the projects they have done in the past would relate to yours and check up with references to ensure that the contractor delivered a satisfactory project.

Two organisations in Aotearoa New Zealand work to create a list of reputable installers seanz.org.nz and mysolarquotes.co.nz Both are a good place to start. However, just because a company is not on their lists does not mean they are not right for you but knowing that they have been vetted should give some additional reassurance and possibly recourse if they do not live up to their promises. SEANZ will also investigate complaints against contractors on their list.

Aligning incentives

Another way to assure that you get good quality at a fair price is to align the contractors' incentives with your needs. For example, if this CEP is one of the first projects of a kind for that contractor, you could offer to be a reference customer for them. This may mean that they pay extra attention and care to delivering your project so that you will provide a good reference.

Another way to align incentives would be to see whether you could have people from the community work on the project to reduce cost, while ensuring that the work was being done as planned. You might also structure some sort of bonus if the project comes in under budget.

Making sure that your system is the right size

It is very common for contractors to specify a larger electricity generation system than is needed. There are several good reasons for this. Sometimes it is just as economic to build a large system as it is to build a slightly smaller one. Or it might be that, in the future, a larger system would be needed.

It is important that the community decide how large the CEP should be by following the steps described in the guide. If the contractor suggests that a larger or smaller project be built, this can certainly be taken into consideration, but this decision should be made in the context of the analysis that you did yourself so that the project is the right size for the needs of the community.

Understanding inclusions and exclusions

In any construction contract there will be exclusions that are either not covered in the cost or are payable by the contractee if they arise. An example would be a contractor putting in a garden path would quote for labour and materials, but if they find a water pipe, that will need to be moved at extra cost. Inclusions are also important because these are the things the contractor is guaranteeing a price for. This may be a fixed cost for solar panels that if they have problems getting, the extra cost is borne by the contractor. For this reason, contractors often over quote for inclusions to supplement the risk of potential cost rises.

Both are important when assessing a quote or contract. Exclusions that are very likely may mean that your budget needs extra contingency, likewise, inclusions that are very unlikely might mean the quote is higher than it needs to be. Also, different contractors have different inclusions and exclusions which makes comparing apples with apples difficult. Often contractors on large projects will be willing to negotiate on inclusions and exclusions, but you need a lot of experience to be able to assess what is good for the project and negotiate on what needs to be changed. This goes back the earlier point of finding or hiring someone with expertise in the area who can guide the community through this process.

Sourcing

One of the biggest cost drivers of any project is the cost of the equipment. Equipment for CEPs can vary dramatically in cost and quality. In Aotearoa New Zealand, the cost of equipment for DERs is much higher compared other countries. In many cases this is simply structural in that the importer has secured the exclusive rights so is able to charge a premium.

There are also many manufacturers outside of Aotearoa New Zealand whose equipment is not yet used here allowing for the possibility of cost savings. Of course, there is a trade-off as this would require additional work on your part. The value of taking the direct import approach depends largely on scale. Another way to reduce the cost of equipment is to piggyback on larger projects or by bulk buying with other projects nearby. When securing low-cost equipment, you do take on additional risk which can affect the financing of the project.

In addition, you will need to make sure that the equipment meets the electrical code and will be allowed by your EDB and financier. Any equipment, regardless of brand or cost, might not be ethically sourced all the way through the supply chain.

Ethical sourcing considerations

More attention is now being paid to where equipment comes from. It is also becoming increasingly possible to track manufactured goods all the way to their source. There are three key considerations:

1. How much carbon is embedded in the product during manufacture?
2. Are the labour and sourcing practices ethical?
3. Are the components recyclable?

Each community needs to decide what is important to them with respect to cost, ethical sourcing and quality. For an indigenous (or any other) community it might be very important that they do no harm to other indigenous groups in the process of building their CEP. These considerations may also impact the financing and acceptance by the wider community.

Installation

How much can you do yourself?

There are some parts of the project that must be done by a qualified professional, particularly when it comes to connecting to mains electricity or civil works where certification is required. However, there is a lot that can be done by volunteers if they are well organised, have skills in the trade and have good instruction. Depending on your community and their appetite for physical work, this can lead to significant cost savings in the project. Finding a contractor who is willing to work with volunteers, to train people and to coach them as they learn would be important. This is particularly helpful in building community spirit. Of course, you would need to take care that everyone works in a safe and respectful manner. Compliance with the Health and Safety at Work Act is still required for volunteer workers and Percons Conducting a Business or Undertaking (PCBU's).

Upskilling for yourself and others

Since building community energy projects (CEPs) is relatively new in Aotearoa New Zealand and growing exponentially around the world, learning by building a CEP now would allow you to use these skills to help others. Whether you provide the help for compensation or pro-bono, the skills you learn are transferable to help others build their CEPs. Members of the community who already have a trade such as an electrician or digger driver could cross-train to specialize in electricity projects

Operations and maintenance (O&M)

Operations and maintenance (O&M) is often overlooked because it seems fairly simple, particularly for electricity systems that appear to be passive, such as solar photovoltaics. However, even a photovoltaic project must have maintenance performed on it from time to time. The panels need to be cleaned, the wiring needs to be checked and the system needs to be monitored to make sure that all the panels are operating as they should. If anything appears to be out of order, then a technician needs to be dispatched to adjust or replace components.

On projects that have more complicated equipment such as batteries or wind turbines, O&M is even more important. It needs to be done on a regular basis and the systems need to be monitored to see when maintenance needs to occur.

All this needs to be budgeted for and managed over the life of the project. Part of the challenge is that this phase comes after the project is built, after the excitement of developing the project and after all the pomp and ceremony.

The operational plan

An operational plan is not something that is left to the end. It will be needed to create the financial model and have constructive conversations with funders, the EDBs and contractors. Funders and EDBs will want to know that the project will be well managed over its lifetime and that there will be enough money to cover the cost of O&M and pay back the funding. Otherwise, the EDB gets stuck with dissatisfied consumers and the financier does not get their return. Because of this the operational plan can often inform the design of the system as it might need certain features to operate as intended. Having the operational plan will also help ensure that the contractor builds something that can be maintained within the budget and doesn't leave any unpleasant surprises.

General management

An operating plant comes with legal obligations and financial responsibility. Somebody must pay the bills. Somebody must make sure that the electricity is accounted for. If anything goes wrong, someone needs to be there to ensure that it gets fixed. This is the role of the General Manager (GM) – not necessarily to do the work, but to make sure that the work gets done. Much of the actual work can be outsourced such as billing, operations & maintenance, security, and electricity trading.

For a small project this may be a part time job, on the order of a day or two per month. Commonly, it is performed by someone who was involved in the project from the start and continues to champion the project. The role may be uncompensated, but sometimes the GM is given a share in the revenues, or an equity share in the project to compensate for them for their time.

Tracking the electricity production

Once the project is producing electricity, you will need to track it. Of course, there will be billing meters at the generation assets and at any of the major loads. There may also be software that accounts for when the energy is generated and when it is used. Someone will need to oversee all of this to make sure that it is still being accurately captured and managed. This too is a part time job for small projects, but it does need to be assigned to someone, whether the General Manager or someone else who has an interest in this aspect of the project. For more complicated projects such as a microgrid with multiple loads and multiple generation sources and storage, this could be part of the fulltime Operations and Maintenance role.

Managing the money

Managing the money, paying the bills and the loan payments, receiving the income, and generally making sure that all the financial obligations are met, such as paying taxes and GST can be completely outsourced. Or it could be done by someone in the community on a part time basis. This function would report into the General Manager so that there was some element of accountability.

Governance

Governance is just as important in the operating phase as it is in the construction and development phase. Whatever entity was selected and whatever governance body was created for the construction of the project, should continue in some form during the operation phase.

Having a governance board allows the GM to report to a group of people who can collectively make decisions regarding the project. This also allows for accountability to be shared among more than just a few people. It also enables transparency for the rest of the community members so they can be assured the project is being run to achieve the agreed benefits.

It may be that some of the members of the governance board change during the operation phase. You might want people who have a particular set of skills or relationships. Some of the people who financed the project, whether private investors or philanthropists, may want to be on the board to keep a close eye on the project.

Since the project will be running for 20 to 30 years, it is quite likely that many of the board members, the GM and other roles will change over the years. This is another reason why setting up a governance structure and an entity that can endure is so important rather than simply relying on the people who happened to be there at the start of the project.

Supporting the community to get the most out of the system

Having a generation or storage system that is managed by, and for, the community will be new to many community members. It is not enough to simply describe it at the commissioning day event, and then expect that community members will be able to adjust their behaviour to make best use of the energy generation system. This will be an ongoing education process with members of the community, so they understand how to use the electricity generation system most effectively for their benefit.

Some people may take to it right away and immediately see reductions in their electricity bills. Others will find difficulty in changing their behaviour to maximise the value of using the electricity generation system. Everybody should be allowed to proceed at their own pace with the educational materials and people capable of helping them being available along their journey. It is reasonable to expect that it will take at least a full year or two before people are fully comfortable with the new system and understand how best to use it. At the end of this guide there is an appendix with a few sub guides that might be helpful in this regard.

This “How to Guide” is being developed into micro-credentials to support further in-depth learning which will also be available to support workshops on community energy projects.

Celebrating milestones

Ceremonies and celebrations are an important part of any project. Celebrating and commemorating small wins along the way can keep people motivated and inspired and bring new people in.

There are several big milestones that deserve celebration.

The start of construction

The start of construction is a definitive event that can be celebrated and bring the community together. It is in part a celebration because construction can only start once much of the difficult high-risk work has been done – the money has all been raised, the contracts are all in place and the project is going ahead.

Flicking the big switch

After construction is complete the project is commissioned. This involves a final set of checks and then power can start flowing. The moment that power finally flows is another big time for celebration. At this point the project development phase is over and the new phase of operation and maintenance starts. This is also a great time to develop a plan to keep the community engaged in the energy conversation and to check if the goals that you set out to achieve have been met.

Telling the story

Storytelling has always been a powerful way to garner support for any project. Particularly with the prevalence of social media, it has become ever more important to ensure that the story of your project is heard. Not simply by the community, but also by those who might be influenced with respect to funding, enabling interconnect or enabling access to the electricity market.

It is important that you start to tell your story early and often so that you can build momentum around a consistent narrative, rather than waiting for your story to be told by others. Building the narrative early is important so that you can highlight the positive aspects of your project. This is particularly important if a dispute or issue arises further down the track.

The value of having a good storyteller as part of your project team should not be underestimated. They make sure that pictures get taken at key moments, that progress is documented and that everyone involved is kept up to date.

An integral part of the process

Storytelling should be an integral and essential part of the process so that it aligns with, and conveys, the values of the project and the community.

Impact on funding

Storytelling often has a significant impact on funding. In the funding section it was emphasized how important the hard cold numbers were, and they are, but they are only 50% of it. Story telling is the other 50% because those funders are heavily influenced by those around them. If the story is positive and inspiring, they are far more likely to spend the energy to decide how to fund the initial project and work with you to ensure that the project succeeds.

Impact on support and the community

Since CEPs generally take much longer than most people anticipate, it is easy for supporters and the community in general to begin to lose interest in the project as the reality and hard work set in. Storytelling allows the community, and the support network, to stay connected with the project, even if they aren't actively involved. At least they can read about it, watch videos, understand the progress, and travel along on the journey with the people working on the project. This becomes vital when you get to key stages and support is needed or you need support from the community either to work on the project or simply to show up and represent for the project.

Sharing your knowledge to support others

The story of your CEP will also inspire others to build their own community energy projects. Because of this they may want to reach out to you and learn from your experience: What some of the challenges were and how you overcame them. This is a very powerful way for you to help others with their CEPs.

If you would like to add your project as a case study to this guide, feel free to contact us and we can work with you to get the case study included.

If the guide helped you, how can you help others?

A living guide

It is intended that the guide be the start of a living source of information that is constantly updated as new projects are developed and come online. In the future, we would like to see an interactive website that will serve as a resource for people as they plan projects, build projects and operate projects, and then finally contribute to the site to enable other people to build CEPs.

Your experience of the guide

Please let us know what your experience was of the guide. Was it helpful? How could it be improved?

Appendix: Building community engagement and participation

What is Community?

There are many types of community, such as communities of interest (e.g. sporting, hobbies), geographic communities and cultural communities. Communities are bound together by a common situation, circumstance, or interest. For the purposes of engagement in a community energy project, the community will comprise all people living in close geographic proximity of the proposed project, as well as others who might live further afield but who have a specific interest in the project. The boundaries of this local geographic community will be site-specific.

While this boundary will vary according to context (e.g. close geographic proximity), the community is likely to include all people living within a kilometre of the project area or the transmission corridor. This is the community of people with the highest interest and highest stake in the project and so they will need to be engaged in a more intensive way than the broader local community.

The idea of a community energy project will invariably start with a single person or a small group and will need to be socialised to the immediate and broader community.

Community engagement needs to start early and be sustained over time. The intention is beyond communication, it is to create enthusiasm, a sense of group ownership and participation in decision-making.

A fundamental difference between stakeholder and community engagement is that community engagement involves group-based engagement activities and encourages group discussion and deliberation.

Local organisations and institutions also form a significant part of local communities, and it will be important to include them in engagement plans and partner with them to help understand and access different segments of the local community better.

For many in the community, they would have little experience in a community energy project and so local and long-term relationships will ensure people can be brought along the journey in a valued way where they can increase their knowledge and participation.

Building community support requires careful attention to all the contact points a project has with the community as no community is homogenous, there will always be a range of views.

A community energy project has at its heart not only a community benefit, but a community cost and investment, therefore it is important that people understand the legal, financial, and operational elements of the project. For many this will be a new area of knowledge and learning, therefore how engagement occurs And how trust is built is very important.

Authentic and preferably face-to-face engagement methods delivered on-the-ground and in community are essential strategies for project development.

Trust is a social asset developed through consistency and delivering on expectations. As such, community support needs to be earned, actively maintained, and

continually evaluated. Community support is built when people feel both the processes and outcomes of the project are understood, agreed to, and are fair.

To ensure that trust can be developed and maintained, the community needs to be brought along on the development process in an informed and valued manner. Show that outcomes are delivered on commitments (however small or large).

Genuine engagement is based on the following principles.

Authenticity

Allow opportunities for community input to influence actions and decisions relating to the project. Tailor the approach to match the local context based on local input. Over the course of a project, the community needs can change and a project that can adapt to those and deliver mutually beneficial outcomes will retain community trust.

Do this by seeking community input and feedback, listen actively, report back what has been heard, respond thoughtfully, and make clear how community feedback has influenced the project (or not) and why.

Inclusive

Reach different people with different needs within the community using a good mix of methods that are sustained over time, recognise and reach out to the many segments of a community (eg including first nations, youth). Support people to participate where required.

Mutually beneficial

Seek outcomes that benefit all parties. Remember that good practice will deliver better outcomes for communities, projects, developers, and Government

Collaborative

Seek out local organisations already doing good engagement and community development in the project area to get advice from and partner with.

Creating engagement opportunities

Some strategies for increasing the accessibility of community engagement include:

- Ask people how they would like to be engaged and communicated with.
- Offer multiple, concurrent options for participating, e.g. 1-on-1 meetings if they can't make a group session; use phone or mail if email is not an option.
- Awareness of the acoustics of public events to allow hearing-challenged people to participate.
- Offer to meet people in a place of their choosing, where they feel comfortable.
- Offer childcare services or to cover costs of childcare. Have a casual meet and greet with parents in a park after school.
- Offer translation options if required.
- Use gender neutral language.
- Engage with local social services and social advocacy organisations and get their advice.
- Allow time, be patient – don't rush things through.
- Start on time.

Different types of engagement methods include:

- 1-way engagement: communication broadcast that might be personalised (eg letters) or general (eg newsletters, media articles, websites);
- 2-way engagement: surveys, forums, workshops, stalls, drop-in information sessions that allow for dialogue via conversations and discussion.
- Online/virtual: phone calls, emails, webinars, online workshops, websites that facilitate virtual engagement.
- In-person: meetings, shop fronts, 'kitchen table' conversations, focus groups, workshops, drop-in sessions, stalls, events that facilitate face-to-face, in person engagement.
- 1-on-1 versus group-based deliberation: sometimes it is important to create space for communities to discuss ideas and issues with each other, hearing from their peers; and
- Formal and informal: allow for both, some people will feel intimidated by formal settings (eg, forum) and prefer an informal environment (eg shop front drop-in),

Community engagement means participation

Although community engagement has become a commonly used term, the ways that it is implemented vary widely and reflect varying degrees of commitment to participation in directing the processes and outcomes of a project. A useful way to understand these varied levels of participation is the International Association for Public Participation' Spectrum of Public Participation (modified in Table 2.1 below) that positions practices along a spectrum from simply informing through to empowering in the process of engagement.

Participation is an action that:

- Occurs over time, throughout the life of the project;
- Involves people in different ways, to different degrees via diverse engagement options;
- Creates opportunities for communities and stakeholders to impact the project; and
- Generates pathways for local people to be active participants.

Community Engagement plan

A Community Engagement Plan outlines the proposed approach to engagement and how these feeds into project development phases. It will outline the principles that guide the strategy and its desired outcomes, as well as the specific methods of engagement and when they will be undertaken and why. It will also outline plans for dealing with issues and complaints. Finally, it will indicate how on-going evaluation of engagement will be done.

A spectrum of approaches to community engagement (adapted from IAP2)

	Inform	Consult	Involve	Collaborate	Empower
Community engagement objective	→ Provide balanced and objective information → Assist community in understanding all aspects of the project, including possible problems/ issues	→ Obtain feedback from the community on plans, options and/ or decisions	→ Work directly with community throughout the process and all stages of the project → Ensure community concerns and aspirations are consistently understood and considered	→ Partner with community in each aspect of planning, development and decision making, including the development of alternatives and the identification of the preferred solution	→ For the community to lead the development of the renewable energy project → Placing decision-making in the hands of the community
Promise to community	→ To keep the community informed through all stages of development, including issues and delays	→ To keep the community informed → Listen and acknowledge suggestions and concerns → Provide feedback on how input influenced the decision	→ To work with community to ensure concerns and aspirations are directly reflected in the alternatives developed → Provide feedback on how input influenced the decision	→ Look to community for direct advice and innovation in formulating solutions → Incorporate advice and recommendations into the decisions to the maximum extent possible	→ To implement what the community decides

Example outline of a community engagement plan

1 Project information and stage
2 Social context
3 Engagement activities and outcomes to date
4 Community Engagement Principles
5 Community Engagement Objectives and Desired Outcomes
6 Key Stakeholders and Desired Level of Engagement (including Stakeholder Mapping)
7 Communicating: One-way Engagement Methods
    7.1 Key messages and project narrative
    7.2 Communication Methods
8 Seeking Input and Feedback: Two-way Engagement Methods
    8.1 Key times and types of decisions that will benefit from two-way engagement
    8.2 Engagement methods
    8.3 Methods of reporting back to the community
9 Implementation Plan Across Project Phases (including reporting on historical activity)
    9.1 Site selection
    9.2 Feasibility studies
    9.3 Design
    9.4 Planning and Approvals
    9.5 Financial close
    9.6 Construction
    9.7 Commissioning and Operations
    9.8 Decommissioning
10 Complaint Resolution Process
11 Evaluation Process and Timing
12 Staff and Resource Allocation

Acknowledgement:

Further information is available from the Tasmanian Government guidelines on Renewable Energy Development.

Guideline_for_Community_Engagement,_Benefit_Sharing_and_Local_Procurement.pdf (recfit.tas.gov.au)

Technical_Supplement_2_-_Plan_Community_Engagement.pdf (recfit.tas.gov.au)

Appendix: Guide to understanding energy

We have all used electricity and have an intuitive understanding of it. However, to build an energy project, support others building an energy project or just become better users of electricity, it is helpful to have a common understanding of the concepts and terms. All of the information in this section can be found in textbooks or on the web. It is compiled here to make it easier to read and reference in the context of a Community Energy Project (CEP).

What is community energy?

The idea of community energy predates the invention of electricity systems. People paddling a waka in unison is a form of community energy. Often in a village there would be a communal fire that was kept burning by the community with many people contributing wood to maintain the fuel supply. Centuries ago, in other parts of the world, there were windmills to mill grain into flour and water wheels to power sawmills. The common characteristic was that a community group banded together to create an energy device for the collective benefit of all.

One of the first projects of Thomas Edison, a renown pioneer in electricity systems was a community energy project (CEP). That was a single generator with a grid that connected to lights in a single neighbourhood. In Aotearoa, the first electric systems were CEPs, typically created by rural communities deciding to build a shared local energy system.

In the modern context, a CEP has come to mean a self-generation and/or energy storage project that is owned by, and serves, a defined community that is either separate from the grid or has a distinct interconnection point to the main grid. The generation is usually from renewable resources and there is typically a clear social or community purpose or benefit.

A useful definition comes from Dr. Anna Berka: *"Any clean energy activity that is i) managed in an open and participative way, and ii) that has positive local and collective outcomes."*

A historical example would be the Kourarau Hydro Scheme near Gladstone just north of Wellington. This was established in 1923 to power local farms. It was capable of running independently from the rest of the grid because the amount of energy coming out of the generator could be matched to the amount of energy being used by the farms at any given moment. Since it is fed by artesian springs, there is a continuous supply of water and therefore power. It still runs today as a community owned project and is now fully integrated into the main grid.

The evolution of community energy projects to the modern grid

As more community energy projects like the Kourarau Hydro Scheme came online in Aotearoa, it started to make sense to connect them together and send the electricity from where it was being generated to where it was needed most. Different sources of generation have different characteristics so having many generators on a single large network made it easier to provide consistent supply.

In theory, the greater the number and variety of generation sources, the easier it should be to create a resilient grid. To make this work harmoniously, there needed to be a way to manage access to the grid for each new generator so that it fitted with the overall mix.

Rules and regulations were created defining what generation could be added to the grid, what the process would be to interconnect, what the fees would be do that and how much each entity would be paid for the power it produced.

As the grid became more extensive with larger players and larger generators, the smaller community energy projects (CEPs), that were the foundation of the grid, became less of a consideration. The rules were increasingly tuned for larger players and larger projects. Today, community energy projects must navigate a system that is no longer ideally set up to accommodate them. There are signs that the situation is improving for CEPs and you and your CEP get to be part of that change.

Community Energy Projects finding their place in the grid again

For many decades the electric industry had convinced itself that building large centralized generation and delivering it to loads (homes, business, and industry) was the most cost effective and reliable way to provide electricity. But the cost of building big projects and transmission lines has increased while the cost of buildings small projects close to the load (including CEPs) has decreased. New technology to control and manage a very large number of small generators Distributed Energy Resources (*DERs) has also improved so that it has become less daunting to manage a more complex grid. There has been a growing realisation that DER's, if well designed, integrated, and managed could add to the resiliency and reliability of the grid, while delivering lower cost, or at least more stably priced, energy. This means that the value of CEPs to the grid is likely to improve making it easier to get CEP projects financed, built and connected to the grid.

Mindsets in the electricity industry are changing, albeit slowly. Today, CEPs are still stepping into an arena that was not designed for them, and this often means finding unique approaches to gain acceptance and access to the grid and power markets.

**DER (Distributed Energy Resource): include small scale generation (such as solar photo-voltaic systems and wind power), batteries, electric vehicles connected to smart two-way chargers, and other new smart technologies that will see our homes and business play an active role in the operation of the power system of the future. – Source: Transpower*

Creating a CEP that's right for your Community

Sometimes communities build the power system that fits their budget or fits the land or roof space. The result can be a system that is too large or too small and this can have a negative impact on the economics and the level of satisfaction. It is helpful to have researched what type and size a system you will need to fit your purpose. To do this there are some technical basics to understand. This is part of a broader category of the development process called detailed design. For the detailed design phase, it is likely that you would need professional support, however there is much that you can do yourself with a little bit of support along the way.

Power and Energy

Even experienced professionals confuse power and energy so let's start with the basics. Power is the ability to do work. Energy is the amount of work done over time.

Say you have a horse. The horse represents the ability to do work. In fact, you have exactly 1 hp (horsepower) of power. The power of a car or motorboat is measured in horsepower. This was a way to compare the power of these new machines to the power of something most people understood – a horse. A 20 hp outboard motor is as powerful as twenty horses – but easier to fit on a boat.

It is only when the horse actually does something like walking around in a circle to turn a mill wheel to grind grain that it delivers energy. The longer the horse walks, the more energy it delivers. Energy is the combination of the power and the length of time that the power is being used. So, if you run your 20 hp outboard motor at full power for 2 hours, you use twice as much energy than if you run it at full power for 1 hour. But if you run it at half power, for 2 hours then you use about the same energy as you would running it at full power for an hour. In the case of an outboard motor the energy used is reflected in the amount of petrol or diesel left in the tank.

In electricity we use the metric term for **power** which is watts or kilowatt (kW) (1,000 Watts). For comparison, one horsepower (hp) is about ¾ of a kilowatt (kW). Since the amount of electricity you use depends on how long you use each device for, we use the metric term kilowatt hours (kWh) for **energy** or electricity used. In the electricity industry, kWh are simply called "electrical units."

An efficient light bulb can be 6W and a large heat pump can be 6kW (a 1,000 times larger).

A 6kW heat pump is about 8 hp. That doesn't seem like a lot compared to a car (100 hp) or a boat (5 to 500hp). But in your house, you are using some energy all the time so it all adds up.

There are two important measures for any project:

- The Power – The maximum power you could put in or take out of the grid measured in kW.
- The Energy – Based on how much power you use for how long measured in kWh.

In the main guide we described that solar PV is the most common form of DER and, In Aotearoa, the most likely to be used in a CEP. Below we describe a bit more about solar.

A bit more about solar

In Aotearoa, the best orientation for panels is to face North at about a 30-degree angle from level ground. (If you want to maximise winter production then 50 degrees is better). Panels that face Northeast or Northwest generate about 3% less energy, if they face due west or east then 20% less and if they face south then the reduction in production is significant and it would be better to have the panels flat. You may have an orientation other than North if you want to generate more energy in the morning or evening but that is a nuance for the detailed design phase. *This information is based on empirical information gained from solar trials performed on nine Gisborne homes by Eastland Network an EDB. More information can be found in their guide Spotlight on Solar.*

For more about solar profiles see this link **mysolarquotes.co.nz/about-solar-power/residential/solar-power-self-consumption/**

There are several myths about solar in Aotearoa that need to be debunked.

1 The first myth is that Aotearoa is too far south for solar to work effectively. This is not true. Aotearoa spans approximately the same latitudes (distance from the equator) as "sunny" California where solar has proliferated. Being known as the land of the long white cloud might indicate low solar PV resource, but most locations in Aotearoa would have sufficient annual hours of sunlight for reasonable solar production since PV does not need clear skies. You can find out the solar irradiation data and solar production estimate for your address here **Solarview (niwa.co.nz)** (from NIWA Taihoro Nukurangi). There are also commercial sites such as solcast.com, solargis.com, pvcalc.org for comparison to the rest of the world.

2 The second myth is that solar equipment is too expensive because we are too far from where it is produced. Yet Aotearoa is no further from global markets than Australia. Solar equipment is expensive in Aotearoa for the same reason other things are expensive in Aotearoa – a common New Zealand business model is getting exclusive import and distribution deals with overseas suppliers and then charge end-users premium prices. This happens on many types of equipment in Aotearoa and solar is no exception. It is worth shopping around to determine a way to get quality equipment at a reasonable price. Installation is also expensive, in part because the regulations make it artificially time consuming. Often safety is used as a rationale, yet other countries appear to be able to safely install solar faster. Contractors in New Zealand are reluctant to provide price transparency in their quotes such as separating parts and labour which makes it difficult to compare. Sites like mysolarquotes help with this to some extent.

3 Another big myth is that solar is not economic without subsidies. This is also not true. The biggest determinant of the economic value of solar is how much of what you generate you can use and what price you can get for the residual energy that is exported. In Aotearoa the best price you can get from a retailer in 2022 is 12 cents per kWh. Yet the price you pay for energy as a consumer is 28 to 34 cents per kWh. Therefore, for every kWh you can use yourself rather than export you earn an extra 20 cents. For an average house that uses approximately 7,000 kWh per year this is an extra $1,400. Any load that you can shift toward to the time of day when you are generating solar energy and exporting to the grid will help improve your economics. This is called using your energy behind the meter because the meter only measures the net energy flow. It cannot calculate what you were generating and consuming behind the meter.

For more information on how to use solar see Appendix "Guide for new users of solar."

Appendix: Guide to harmonious grid connection

The key to successful and harmonious integration of a Community Energy Project (CEP), or any Distributed Energy Resources (DER), into the grid, lies in the collaboration between the Electricity Distribution Business (EDB) and the CEP. The chances of success greatly improve if both parties understand the other's situation, constraints, and point of view.

There are several structural features that are worth considering.

- The EDB and the CEP are both genuinely intending to serve their community and feel accountable to their community.
- The definition of community for the EDB might include the thousands or hundreds of thousands of people in their service territory, while the CEP's community might be fewer than fifty individuals who all know one another.
- The EDB has a legislated responsibility to operate, maintain and reinforce the grid to ensure that it serves the community reliably. The CEP organisation has a self-defined responsibility to provide electricity often along with other community services.
- The EDB's actions and business model are managed by regulations. The regulations were designed to protect consumers, but are now, in many ways, constraining or disincentivizing EDBs from acting in the best interest of DER owners.
- In general, the grid is a very cost-effective way to provide power to a large number of people but may not meet the custom energy needs of a specific community. The EDB's perspective would be that they are serving everyone as well as they can in an economically effective way given their operational constraints.
- There is no guarantee that the CEP will be able to meet the specific needs of the community any better or cheaper than the grid. Under the current cost and price structures in Aotearoa, the CEP would be doing well to get to grid price parity, although it might be able to improve its resiliency and price stability.
- The EDB sees the CEP as a potential DER asset to help manage the grid. EDBs consider DERs as potential source of "flexibility services" – the ability to increase or decrease the real and reactive power they consume or inject into the grid. The CEP sees themselves as serving their community first and the grid second. They see the grid as an entity that serves the CEP's needs. This is a fundamental difference in perspective. The CEP needs to find a balance between flexibility for the grid and serving the needs of the community.
- The CEP believes that they are reducing costs for the EDB because they are generating locally. However, the EDB has to have a clear and provable cost reduction such as an asset upgrade deferral. It needs to be able to calculate the value of this and then find a way to share this value with the CEP. Then, the EDB has to have some surety that the CEP will deliver the services as promised.
- The EDB is a vital part of the electricity ecosystem, but it is not the only part. The CEP must navigate all parts to succeed and the EDB can only help the CEP in the areas it controls.
- The value to an EDB is often lower than the CEP expects. For example, if the typical household uses 7,000 kWh and pays lines changes of 8 cents per kWh then they pay $560 per year. The value to an EDB of typical household being able to manage its capacity may be 10% of that or $56 per year. A typical homeowner might not want to bother or invest in technology unless the savings exceed $200 per year. This mismatch makes it difficult to implement cost-effective solutions on small scale generation.
- The CEP typically has less negotiating power, fewer resources and insufficient information about the grid. The EDB is not obliged to be fully transparent about the situation on the grid. It may not have the information, it may be concerned about providing it, it may not know how to use it effectively or simply may not have the resources to dedicate to communicating it. This imbalance of power and access to information can be a major barrier to harmonious integration with the grid.

The situation can be navigated by starting with the first point, that both EDB and CEP are intended to serve their communities. From there, the EDB and CEP should work to improve the experience of the other party and work through the constraints and differences.

Understanding the EDB

The EDB is responsible for maintaining and upgrading the local grid to meet new demands. They are responsible for making sure that the local grid can handle all the power that goes in and all the power the gets drawn from local grid. They have metrics called SAIDI and SAIFI for the Duration and Frequency of outages respectively. If they miss these targets or are worse than their peers, they get penalized. If the quality of the power (voltage or frequency) goes outside of defined limits, the grid can fail, the lights go out,

customers get annoyed, the EDB gets penalized and needs to spend money it didn't plan for to fix the problem.

In addition, if poorly managed or maintained, the EDB's lines and equipment can cause fire, damage to property, or injure or kill workers and members of the public.

Understandably these responsibilities cause EDBs to be risk averse, conservative, and develop bias toward structure and control. This has led to a grid management approach which has worked reasonably well in most parts of the world up until about the turn of the century.

Since many of the assets last a long time (50 years) and are expensive, EDBs need to carefully plan where they spend the money. They typically create a long term (10 year) Grid Asset Management plan every year. To do this they talk to the local council, housing developers, large industrial and commercial users about potential future developments. From this they estimate which lines and substations they should upgrade based on the additional forecasted loads and the condition and age of the existing lines and substations. This approach has worked well because growth in electricity need was reasonably predictable and generation was centralized so it could be added predictably to meet anticipated load.

After the year 2000, many new types of energy resources started getting added to the distribution grid in ways that were not predictable and not in the 10-year plan. With energy being injected at the distribution level, managing the power quality such as voltage and power factor became more difficult. There was also the risk of when lines were down they could still be powered on the consumer end. In addition, unlike central power plants which have contractual agreements for the timing, volume, and quality of electricity they produce, many of the DERs delivered energy ad hoc. This makes the local grid much more difficult to manage requiring more detailed information about the distribution grid and a more complex relationship with large numbers of prosumers.

In addition to generation DERs, many new and large loads such as electric vehicles (EVs) are being added without the EDB's knowledge. For example, a typical house is allocated 15 kW of capacity (the max it can draw from the grid). However, most houses only use a max of about 7.5kW and on average peak load for all houses on a feeder averages out to about 2.5 kW. Therefore, the grid is designed assuming that peak on a given feeder or distribution transformer will be about 3.5 kW times the number of houses on that feeder or distribution transformer. But an EV dedicated charger can draw 7.5kW which is about 50% of the total allocated capacity of the home and twice the assumed average peak load. If all the houses on one feeder or distribution transformer charged their EVs at the same time, the feeder or transformer could overload. In addition, typically adding an EV to a household increases the energy consumed by about 50%. This additional draw of energy can reduce the voltage locally.

Depending on how they are configured and managed, DERs can help, or make it harder, to manage the grid. This has thrust EDBs into a new role, requiring new technology, skills, processes and attitudes. Most EDBs are not equipped to optimise these new resources.

Even though this change has been 20 years in the making, for many EDBs it feels like it happened overnight. Partly, this is because the grid has very long-lived equipment and takes time and money to adapt, but it is also partly because EDBs are reticent to act too quickly. If EDBs adapt too slowly they are viewed as unimaginative, but if they change too quickly and misspend money on new technology, processes, or staff, they are seen as irresponsible stewards of customers' money.

To add considerable challenge, the EDB's business model was set up decades ago and it too is out of date. Since the EDB is a natural monopoly, regulators determine what EDBs are allowed to charge. Every five years the EDB files a rate plan called a DPP (Default Price-quality Plan) with the Commerce Commission that determines how much they can spend on upgrading the grid (CAPEX) and how much they can spend on running the grid including buying services (OPEX). Once they have their allowance set, it is very difficult to change. If they over-spend, they can incur a penalty of up to 25% of the overspend. If they underspend OPEX they get a reward of 25% of the savings but their budget gets cut to the new lower level in the next DPP. There result is that most New Zealand EDB's are running lean on the OPEX and yet OPEX is required to pay DERs for services, hire or train staff to make integration easier, buy meter data or manage control systems. Furthermore, the EDBs are allowed to earn a rate of return on CAPEX but not on OPEX. This does not incentivize capital efficiency or innovation. Instead, it gives them an incentive to build out more grid assets rather than contracting for services from a DER or CEP.

The EDB recovers the CAPEX and OPEX through the lines charges that everyone pays. Unfortunately, while most of their costs are fixed (per kW) they are required by regulation to charge a variable fee (per kWh) which means that they are incentivized to have customers use more energy rather than less. In the future, after 2025, they will be able to charge fixed fees which will alleviate one of the perverse incentives but still leaves the business model inappropriate for the new environment. In April 2025 most EDBs will receive their new DPP. This is their opportunity to rebalance toward having sufficient OPEX and CAPEX to better integrate and manage DERs to capture the benefits. If the EDBs get the mix right, this could mean a much smoother path for CEPs in the future. However, EDB's track record of adopting new approaches (like smart meters) has been mixed.

EDBs have a scale asymmetry problem. Many small DERs, in aggregate can disrupt grid operations. However, those same small DERs, if aggregated and controllable, could be beneficial to the grid, but the cost of managing them would exceed the value. EDBs are only equipped to manage larger DER (over 1MW or 250 kW depending on the EDB) but most of the DERs will be much smaller.

Since EDBs can only figure out how to manage large DERs (over 1 MW or 250 kW depending on the EDB) they are starting with these first. They are putting in communications standards and management systems for these larger DERs and they are attempting to implement Distributed Energy Resource Management Systems (DERMS) to manage them. The idea is that eventually this will trickle down to smaller DERs. Meanwhile small DERs are being added without these standards or controls capabilities.

A small DER or CEP owner could explain to the EDB that, even though they are not at large enough scale, they would like to set themselves up so that in the future, the EDB or aggregator could manage them along with others to be a controllable load. This would at least get the CEP set up for future integration to the grid. If the EDB doesn't set them up correctly from the start they will find in economically prohibitive later and have millions of small DERs that they cannot view, manage, or control.

This is the same challenge that showed up in Germany, then Hawaii, then California and then Australia. Each jurisdiction thought they were unique, and it would not happen to them. In Aotearoa we think we are unique, and it won't happen to us.

Allocating the cost of grid upgrades

If a new, unexpected load like a large hotel or a new commercial DER gets added to the grid, then an unforeseen upgrade to the grid infrastructure may be required. Since this is an additional cost, it must be paid by someone. Some would argue that it is the responsibility of the EBD to ensure that the network can support all new interconnections. Others would argue that for large installations like a hotel, they should have to pay for the upgrade rather than everyone on that local grid. On that basis some would say that if an upgrade is required for a CEP, then the CEP should pay. For the EDB, if they can get the CEP to pay for the upgrade then:

- They don't have to raise everyone else's rates.
- They can just put in a big piece of equipment (which they know how to do).
- Their existing business model pays them when they invest in large grid assets but does not pay them to harmoniously integrate, or reduce charges, to DERs.
- The legacy process and regulations are clearly on their side.
- They avoid having to overcome internal institutional momentum by simply applying their legacy process "equally" to all situations.
- They avoid having to change practices, adopt new technology, or hire or retrain staff, all of which introduces risk without clear direct commensurate upside.

On the other hand, a CEP could actually help the EDB to manage the grid because a CEP:

- Is providing power, not just taking it.
- Could reduce the load on the grid if managed correctly.
- Could provide VAR support and voltage regulation.
- May reduce the required upgrade or reduce the size and cost of the upgrade.
- May defer or eliminate the need for a planned upgrade.
- Could provide the EDB with optionality regarding future investment.
- Could buy the EDB time while they implement new upgrades.
- Could provide its own resiliency thereby easing redundancy requirements.
- Could provide community resilience if the main grid went down.

There is a growing awareness within EDBs, or at least with select individuals at EDBs, that DERs can be of benefit to the grid, and they would be well served to figure out a way to integrate DERs more cost effectively for themselves and the DER provider.

Often, individuals within EDBs want to be supportive of DERs or CEPs but they are constrained by regulation in what they can do, are allowed to do, or can afford to do.

The EDB's dilemma

In an effort to decarbonise the economy, Aotearoa is following as similar pattern to the rest of the world: Convert operations, vehicles and devices that run on carbon-based fuels to electricity and then add more renewable generation to the grid. This exacerbates the challenge for the EDBs in three ways:

1 New loads are being added to the grid in increasing size and volume over much shorter time scales such that EDBs cannot build out the grid fast enough.

2 Since customers are switching from other fuels, they are far more reliant on the grid so the grid must have greater resiliency even as it is being overloaded.

3 The cost of local renewable generation and storage being added to the grid is trending down, while the cost of managing DERs and grid upgrades is increasing. At some point, in the not-too-distant future, self-generated and stored power may well be lower cost than grid power leading to people leave (defect from) the grid.

While EDBs don't want to charge customers more, particularly those that are community owned, they must continue to maintain a reliable grid for all. Enlightened EDBs acknowledge that they can't just keep increasing rates. Additionally, regulatory change is slow and the new business model for EDBs is not obvious.

This is motivating EDBs to be more engaging with DERs and CEPs because:

- EDBs want to get ahead of the coming wave of DERs knowing if they don't, they will be stuck with an expensive bill to upgrade the grid.
- Customer trends – Prosumers seek to use DERs to improve reliability and resiliency and EDBs wish to be responsive to customers.
- Government investment focus on GHG reduction – DERs can reduce GHG emissions but a high level of DER penetration is required to have a meaningful impact.
- The forecast uptake of EVs for the next 10 to 20 years is very high and DERs can be a way to mitigate the impact of EVs.

This presents an opportunity for CEPs to partner with EDB while still being aware that even well intentioned EDBs have hurdles to overcome including:

- Since many EDB's are small relative to international EDBs, they may be understaffed.
- This may be the first DER of this configuration encountered by the network engineer.
- The network engineer at the EDB may not have time to understand the project.
- Attitudes towards DERs are still in the process of changing toward acceptance.
- The EDB may not be able to determine if an upgrade is needed.
- The EDB may not have the data, software or expertise to assess the grid impact.
- The EDB may have just completed an upgrade or had one cancelled in that area.
- They might not have the spare OPEX to procure the CEPs energy services.
- There might be a crisis on the go.

The perfect DER project from an EDBs perspective

It is helpful to consider what the EDB would see as the ideal DER project or CEP as this could facilitate negotiation or at least promote understanding:

- The EDB would want to have clear visibility of the energy flows in and out, along with characteristics of the energy, such as voltage, power factor, frequency etc.,
- They would like a CEP to be fully controllable by the EDB (or a third party) in terms of amount and direction of real and reactive power. This would allow them to use the CEP to balance out the other loads and generation on their grid.
- Ideally, this control would be automated with a single reliable interface.

- They would want the entire project to act as a single entity (like a Virtual Power Plant VPP) – not have multiple loads, generators and meters to manage.
- They would want a single point of contact to call if issues arose.
- They would want penalties for non-performance on the part of the CEP.
- They would want financially surety that the penalties would be paid.
- They would need to have a clear business case based on a calculable value such as an upgrade deferment.
- They want the commercial agreement to be simple, fit their existing rate plans and be managed automatically.
- They may want to be able to call on the CEP to disconnect from the grid if the grid went down or support the grid if the grid needed power.
- They would want all of this without the responsibility of fixing the system if it breaks or interfacing with too many people.

Understanding the CEP or DER owner

Typically, a community energy project is initiated to serve some ideal or to address an unmet need. As the project progresses the realities of cost and capacity to address that need start to come into play. Often, there is an assumption that the CEP will be providing value to the grid and therefore the interconnection cost should be low to zero. But even if the CEP is adding value to the entire grid system, it could be injecting issues at the local point of interconnection. The CEP has no visibility of the grid or grid requirements. They often are not able to talk to their EDB and when they do, it is seldom with someone who has the authority and technical and commercial understanding to create a harmonious solution. On top of this, CEPs run on tight budgets and delays or additional costs can mean a reduction in the size of the project or cause the project to fail. Often the CEP is only one of several services that is being provided to the community so the impact of increased cost may extend beyond energy to health and wellbeing. They may only have one DER project whereas that same project may be one of one hundred for the EDB. The stakes per project feel much higher for the CEP.

The CEPs dilemma

Since a CEP is typically a one-off for any community, this is their first time and possibly only time building an energy project. They seldom have the full suite of expertise within their organisation and if they hire a consultant, it is typically costing them a big slice of their budget before they break ground. They may be attempting to reduce energy hardship in their community so seeing costs mounting for upgrades or consultants is unsettling. They need a time- and cost-efficient process that delivers a cost-effective solution. The managers of the CEP are also working with a community that may not have the time or interest to understand the issues and may not be willing to share information or surrender control of assets to an aggregator, retailer or EDB. Their view could be that the EDB exists to serve its customers and they are customer so the EDB should serve them in the way that meets their needs. At a minimum they expect cooperation and transparency.

The perfect DER project from a Community's perspective

The CEP is first and foremost intended to serve its direct community and only seeks to serve the EDB or greater grid if there is clear benefit. Some of the features include:

- Most communities don't want to have to think about their energy, they just want low cost, reliable energy.
- They may seek energy sovereignty or independence.
- They may not want to provide data on usage to the EDB for privacy or trust reasons.
- They typically want the energy to be clean but can't afford unwarranted expenses.
- They may expect the EDB to be flexible serving each community as it desires.
- They don't want to have to be responsible for the grid and may expect someone else to be able to manage all the independent ICPs on their project.
- They may seek a reduction in their lines charges.
- They may want the EDB to still be responsible for their lines or embedded network.
- They don't want to be on the hook for penalties and they don't want someone else turning their power up or down from a remote control room.
- They want the interconnection process to be simple and they do not want to pay for interconnection or upgrades to the grid.
- They want to be able to use the grid when they need it but not be paying for services that they don't use.
- They do not want to learn to be a distribution engineer just to get one project connected and they don't want to have to spend money unnecessarily on consultants to help them.
- They want to maximise the value of the CEP through value stacking which implies full control of when and how they use their energy.

Meeting in the middle

There may seem like many points of difference but there is a great deal of middle ground. For example:

- There are multiple ways for the EDB to get flexibility from the CEP without direct control. They could send a price signal or Demand Response (DR) signal. They could work through an aggregator.
- The CEP might (through special dispensation) be able to participate in a demand reduction program that is usually reserved for operations 10 or 100 times their size.
- The EDB may only need load reductions, energy production or VAR support for a few hours a year. The rest of the year the CEP would have full control.
- The CEP may be willing to trade off energy sovereignty (owning and controlling all the assets) for energy resilience (ensuring they have reliable power.)
- The CEP might be able to include more controllable loads like an electric shuttle bus or might be able to add more controls capability to their system.
- Both parties might be able to use the project as a training sandbox or showcase for similar future projects.
- The CEP may be able to mitigate the impact of other adjacent DERs (current or planned) in the same area.
- The EDB might be willing to provide a contract for demand reduction that includes a front-loaded capacity payment for the first few years along with an ongoing response payment in future years, thereby providing both certainty and upside.
- The EDB might be able to allocate some of its community outreach funds to support the upgrades for the CEP.

Meeting in the middle requires a conversation with preparation and expertise on both sides. It requires patience, finesse, and a belief that a solution can be found.

If a harmonious mutually beneficial relationship can be created it will not only help with getting the project financed and delivered on the front end, but it will help with management on an ongoing basis.

How EDBs can contribute to a successful outcome:

- Recognise the inevitability that DERs are going to proliferate in the next decade in Aotearao as they have in other parts of the world.
- Hire and train front-line staff (customer care, new connection team and grid planners) to be able to hold the harmonious integration conversation with a sophisticated DER owner. To do this the staff will need to:
  - understand the value of each type of DER and combinations of DER
  - understand the needs of their grid at the specific interconnect point
  - be willing and able to iterate enough times to find an legant, harmonious and cost-effective solution
  - be willing to listen to and learn from their customers
- Upgrade grid visibility so that the characteristics of the low voltage network are sufficiently well known to enable DERs to be connected and managed for maximum value to both parties. Grid visibility varies widely across EDBs in Aotearoa, and most are behind their international counterparts, yet most seem to assert publicly that their level of visibility and control is about right. With so much variance between EDBs, how can they all be at the right level?
  - Ideally an EDB should be able to read voltage, current, power factor and infer impedance at every ICP and then compare this to aggregated data at each sub-station or transformer. Without this visibility, how can EDBs assess need and value at each ICP or control the power quality locally?

- Provide sufficient visibility of the grid situation to the DER owner applying for interconnect so that they can offer possible strategies to solve for grid issues.
- Treat the DER owner or CEP as partner in solving a common set of challenges.
- Account for a proliferation of DERs in future DPP filings so that the OPEX and CAPEX is available to integrate DERs. This may mean reducing CAPEX to increase OPEX to pay for flexibility services and incentivize DERs to act in harmony with the grid.
- Manage the grid sufficiently well such that voltage spikes and transients don't trip off or curtail DERs.
- Consider innovations like managing export rather than simply limiting invertor size.
- Judge DER projects and CEPs on their merits to the grid rather than scale, relationships or cultural affinity with the DER owner.

- Consider that an EDB's view of customer centric, may not accord with the customer's view of being customer centric. As far as customer relationships might have progressed, they still have room for improvement.
  - Being customer centric is not something an EDB can self-declare, it is a title awarded to them by their customers.
- Recognise that until these capabilities above are in place, the experience for the DER owner may not be satisfactory to the DER owner. This may necessitate a temporary channel for communication with DER owners that might be non-scalable.

How CEPs can contribute to a successful outcome:

- Adopt the position that your CEP can be beneficial to the grid and understand what trade-offs you are willing to make and what reasonable compensation you expect.
- Be prepared to accurately describe and characterize the project in a way that the EDB can understand. Is it a microgrid, a VPP, a controllable load?
- Explain the benefits of the project, how it will interact with the grid over the long term and how it will be managed and maintained in harmony with the grid. Such as:
  - the commercial and governance structure of the CEP
  - how intra-community participant accounting will work
  - how local/private networks will be supported
  - What the post construction plan is with respect to O&M, commercial management, interface with EDB
  - how the project will remain viable over the asset life
- Know what information you need about the grid to configure your project to work optimally with the grid.
- Be clear on the request to the EDB in terms of technical and commercial support.
- Seek to understand the EDB's process and requirements.
- Be willing to iterate on the project in terms of scale, mix of generation, storage and load, flexibility, and control to enable harmonious integration with the grid.
- Budget adequately for the cost of upgrade and the cost of expertise required.
- View the EDB as a partner in delivering energy services to your community.
- Consider putting in systems that will be beneficial to grid harmony in the future even if the EDB is not yet ready to take advantage of these capabilities.

Enlightened Solutions

Some EDBs are realizing that being flexible could help them manage the grid. One example is the rule on household invertors. To manage voltage and thermal constraints on the local grid, folklore suggests that a household solar invertor should not be more than 5kW. This is an Australian guideline that most New Zealand EDBs have adopted. But it is "management by blunt instrument" since it doesn't account for other assets efficiently.

A more enlightened approach is to say that you can have any size invertor you like so long as you limit the export to a maximum of 5 kW. This is useful because houses are typically allocated a capacity of 15 kW. If a house has three dedicated chargers each at 7.5 kW (total of 22.5 kW) and solar array with a 20kW invertor, all three cars could be charged at the same time without drawing much from the grid or two cars could be charged and 5kW could be exported. It doesn't matter what goes on behind the meter, it matters what happens at the meter.

One reason this type of approach is not widely adopted is that many EDBs cannot accurately monitor export and so it's easier to simply set the invertor size at 5kW. This misses a huge opportunity and creates a constraint, all because EDB don't have the visibility and control they need in their grid.

This approach could be applied to larger systems also. This is done by providing the EDB with an analysis of all the anticipated loads and generation, showing which ones are controllable and how they will be managed to be within capacity brackets that result in zero or lower cost upgrades.

For larger CEP projects (100kW to 1MW) another option would be clear pricing signals through tariffs or incentives to set up projects in particularly vulnerable locations.

- Tariffs set to reward generation at times when the grid (at the substation level) has high levels of demand. This would be extra to other pricing signals such as energy market pricing.
- Reductions on connection application fees
- Cost sharing on connection works and grid upgrades

The Opportunity

Aotearoa can avoid the errors of other jurisdictions by learning from them. Implementing the solutions needs to start right away and at speed.

The fastest way to build a bridge is to start from both ends and meet in the middle.

Appendix: Energy balance and energy inventory

An Energy Balance

An energy balance means comparing the energy you use to the energy that you generate. This process is similar whether it is being done for a large community centre or a small apartment. So, an extra benefit of doing this as a community as part of a CEP is that the members of the community will better be able to do their own balancing at home. For this reason, it is better to include as many people as possible in the process as part of an educational program to help improve community benefit.

Practical approaches to an energy balance

You will need to know two key things:

- The maximum power you could possibly need at a single moment in time.
- The amount of energy you use or will use in a 24-hour period and over a year. (Later, it will be good to understand your 5 minute and 30-minute usage.)

To calculate the amount of energy that you use over a year look at your bills for 12 months. Depending on your retailer, you should be able to ask them to send you a spreadsheet of your energy use for each 30-minute increment for a certain time period such as a month or even the whole year. This data is useful so that you can start to see how adding various DERs might reduce your bill. If most of your power is used at night, solar by itself will not help much. When calculating your energy use, be sure to keep an eye out for opportunities to reduce energy usage through energy efficiency or to determine which loads are, or could be, controllable. If you display your energy usage visually over time in a load profile, it is easier for members of the community to relate their activities to the usage at different times of the day and year.

This approach does not tell you how much energy you will use in the future. To estimate future use you need to consider what new appliances or loads you plan to add and when you will use them and for how long. If this all sounds too daunting, remember that even this first step, understanding how and when you use energy, will be helpful in controlling costs, even if you never build a CEP. For you, winning might be just getting a handle on your energy use.

Example: If you were going to add a television to the community centre, you would look at the power rating of the TV in watts and then estimate when and how long it would be used every day. For example from 6pm to 9pm. Then you would multiply the watts times the hours and divide by 1,000 to get kWh.

To calculate the max power, you need to add up the power rating of all the devices that could be connected and running at the same time. Typically, the power rating is on a small metal plate (called a name plate), usually inconveniently located and difficult to read. Sometimes you have to look in a manual or look it up on the web. Just to make it more difficult, sometimes rather than showing the power rating in Watts the device shows the current that it would draw measured in Amps. To get to watts you need to multiply the amps by the voltage (in Aotearoa this is typically 240 volts, but large pumps might be higher voltage so best to check the name plate.) To get from watts to kW divide by 1,000.

This may seem complicated or tedious but it is important to understand your current and projected power and energy usage so that you can select the correct type and size generation.

The three most valuable parts of the energy project are:

1. Determining ways to save energy
2. Determining ways to shift energy use to a different time
3. Determining the most economically viable amount of energy to produce and store.

All of this can be done by an enthusiastic person with a spreadsheet. Once you have done your energy balance, you should have a long list of opportunities for energy efficiency and controllable load.

Energy inventory of your current system

Often there are energy assets in your community or in adjacent communities that are underutilized and can be integrated into a CEP project. This may be roof space at a local school, heating for the community pool or back up generation for a clinic or hospital. These are all resources that should be taken into account when planning a CEP. An inventory of your current system can be as simple as starting with a blank sheet of paper and a pencil, or printing a map and building a spreadsheet. Then try to answer the following set of questions:

- What energy assets do you have today (generators, solar, storage)?

- What space and buildings do you have (both for load and roof or ground-space)? For ground mounted solar you can typically fit about 600kW per hectare on a flat, even site.
- What resources do you have (sunshine, river, elevated land, geothermal, wind)?
- How to decide what to include? (Start as broadly as is realistic and then trim the list down.)
- How many phases do you have and why does it matter? When power was first brought to your property, they either brought single phase or 3-phase. Most houses are single phase, while most commercial or industrial sites are 3-phase. Farms and rural properties could be either. The positive of single phase is that all your loads and all your generation (solar) and storage will be on one phase so they are easier to balance. 3-phases allows you to have higher capacity but if your solar is on one phase and loads on the other, it requires more skill to set up your solar to serve your load.
- Where do you interconnect to the distribution grid? Follow the power cable with your eye from your house to the power pole. If there is a metal box about the size of a medium sized microwave oven then you are connected to the grid by your own distribution transformer. If not, then you are sharing a transformer. Next you can ask your lines company for a network map that includes your property or look it up in their Distribution Asset Management Plan. This will show you how you are connected to the grid and what other properties you might be able to partner with who are on the same line.
- What other energy assets are on your line? If there are a group of properties on the same line that all want to do CEPs then your combined influence on the grid would be accounted for at the substation to which you all connect. Collaborating with neighbors could help in your negotiation with the lines company.
- What is the capacity of the distribution transformer, feeder and network transformer (substation) relative to load? The biggest concern for the lines company is that new sources of energy or load will overload their substations. By talking to the lines company or reading their asset management plan, you can find out how much spare capacity they have on the distribution transformer and at the substation. This allows you to plan how you can be most compatible with the grid and thereby argue for the lowest cost to connect or even gain revenue by providing flexibility or ancillary services.

Appendix: How to access the spot market

It is important to understand what the spot market is and how it works. The colloquial description below is intended to provide an introductory understanding and therefore may lack precision in its use of terms.

The primary role of the wholesale spot market to ensure that the capacity of generation matches the consumer demand for electricity. The New Zealand wholesale spot market is a Security Constrained Economic Despatch (SCED) model. This means that generators that are despatched (allowed to generate and supply power to the grid) in any given period are those with the lowest priced offered that can be despatched without breaching any security constraints that exist on the grid. For each period any generator can bid in an offer price. The bids are accepted in order of lowest first and bids continue to get accepted until there is sufficient capacity to meet demand for that period. The wholesale market spot price is set by the highest priced generator that is despatched in each price period. It is called the reference price. Every generator that bid in for a given period gets paid that highest (reference) price regardless of what they bid in.

For example, 5 generators of equal size producing 10,000 kWh for a given period each bid in the market each at the following prices #1 @ 1c/kWh I #2 @ 2c/kWh I #3 @ 3c/kWh I #4 @ 4c/kWh I #5 @ 5c/kWh. The market operator determines that it only need the generation of 35,000 kWh. So, starting from lowest bid the market buys energy from #1, #2 & #3 at full capacity (10,000 kWh), #4 at half capacity (5,000 kWh) and none from #5. The price all the generators are paid is 4c/kWh regardless of their bid because that was the highest bid that put in energy. If the grid only needed 18,000 kWh the price would be 2 c/kwh or if the grid needed 41,000 kWh the price would be 5 c/kWh.

If you were to purchase energy in the spot market you would have to pay that reference price, even though many of the generators can supply at much lower prices.

To avoid paying these high prices, large industrial customers have long-term contracts for supply at fixed prices. The prices are often below the average market price.

Gentailers that own both generation and a retailer have a natural hedge based on the same principal. For example their average cost of generation is 8 cents from their generation portfolio and they have contracts to sell energy to a set of consumers at 12 cents a kWh through their retail arm. This locks in a profit of 4 cents for every kWh they sell regardless of the reference price. If the reference price is 17 cents, they make a 5 cent loss in the retail business and a 5 cent gain in the generation business per kWh. If the reference price is 10 cents they make a 2 cent gain in the retail business and a 2 cent loss in the generation business. No matter what the reference price, they are always making a net 4 cents for each kWh.

Retailers that don't have generation are not so lucky. If they agree to sell energy at 12 cents per kWh to consumers, they need a contract to purchase at for example, 11 cents per kWh from somewhere. Typically, they need to purchase the energy from the gentailers who are their competitors. This makes it tough to be an independent retailer. It also limits their growth because much of the energy is already pre-allocated in contracts to large industrials or the retail arms of the gentailers. Further, since the low-cost energy is likely contracted first, independent retailers are contracting based on the higher priced generation.

Small consumers who wish to purchase energy are in the least advantageous position of all. They are not large enough for gentailers to spend time negotiating a long-term contract with and they have to purchase their energy through a retailer. The retailer is either part of a gentailer or they are a retailer who must buy from a gentailer. Either way the small consumer is subject to pricing from a gentailer. Since energy delivered by the lowest cost generators would be the first to be contracted in bilateral agreements, the energy that consumers have access to typically comes from the higher cost generators.

If the small consumer were to gain access to the spot market price through a retailer, they would always be paying the reference price i.e. the highest price bid for a particular period. This can make sense if the consumer has generation, controllable load, storage, trading capability and the long-term enthusiasm to manage this. But if the consumer is simply buying energy for its own use, paying the reference price is generally a losing proposition.

In New Zealand the wholesale market has two reference nodes and 249 grid connection point nodes. The wholesale spot price between these nodes is variable and can be quite different. These differences are caused when constraints on the network that require more expensive generation to be despatched. Transmission system losses also contribute to the nodal price differences.

The spot market participants are generally limited to large grid connected generators, retailers and large businesses. Small generators or consumers usually access the spot market through a limited number of retailers who provide access to the market for a fee (typically 10%). The retailer does not set the price, the market sets the price by matching real-time supply and demand. The prices are published by the Pricing Manager as required in the Code administered by the Electricity Authority (EA).

Historically, consumers who have been exposed to spot market prices have eventually been caught in price spikes and have experienced uncomfortably high bills. To mitigate this there are five key ingredients:

1 The ability to shift, curtail or limit your load
2 Energy storage buy low (including self gen) and sell high
3 A control system that can read market signals and optimise
4 The ability to negotiate a long-term hedge contract.
5 The long-term enthusiasm and interest to manage it all.

Without these mitigations, there is a real possibility that even if your solar energy were free, you might end up with a higher energy bill than paying fixed price from a retailer.

The spot price varies in three ways:

- Location on the grid. There are two reference nodes (one in the South and one in the North Island) and 248 nodes on the New Zealand grid and each node has its own price. There are two types of node:
  - Grid Injection Points (GIP) – where large generation connects to the grid. There are 52 Injection Points. It would be unlikely that a CEP would connect to a GIP, but one of these GIPs may be the closest point to determine your price.
  - Grid Exit Points (GXP) – where the grid connects to the local network and where retailers and major industrials buy their power. It is possible that the electricity injected into the grid by a CEP would be occur at a GXP. There are 196 GXP's (9 of which are major GXP's)
- The time period. The price is updated for each 30-minute interval of the day. These 30-minute intervals are called trading periods. The factors that go into the price include how much electricity is being drawn from the grid, how much is being generated and injected into the grid, the forecast for each and bids from generators.
- The price category. There are five categories of price schedules:
  - Forecast – looks up to 36 hours ahead and is updated every two hours for the trading period.
  - Real time prices – are calculated at the end of each five-minute period for every node using data from the beginning of that five-minute period. These are still a forecast because only the full 30-minute trading period counts. So, the five-minute price only tells one sixth of story.
  - Provisional – the prices calculated after the electricity has been consumed often on limited data.
  - Interim – the price calculated 24 hours after the period will full data but still subject to dispute.
  - Final – these are the prices used to calculate the settlement invoices.

If your CEP consists only of generation then there is not much trading to be done – you might as well sell what you have when you have it. However, if your CEP includes generation, controllable load and storage then it is worth considering your trading strategy. If you wanted to keep things simple, you would just trade on the 5-minute real time price, manage your generation, load and storage accordingly and let the market sort everything else out. You could set a simple trigger to sell energy if the price went above for example, 20 cents and buy if it went below for example, 10 cents for any five-minute period. The final price that you would get would be based on the 30-minute average. You would only find out the final figure a few days later and this would only be reconciled on your monthly bill. You could adjust your trading strategy over time. Suffice to say that even "keeping it simple", starts to get complicated.

The next level of sophistication would be to look at the forecast 36 hours ahead so that you could consider ways to prepare for price swings. The forecast prices allow generators and loads to adjust the quantities that they offer into the market in each time period. If a CEP can control the amount of electricity it generates or consumes, it could manage its offers to maximise the value it obtains from the sales/purchases of electricity. For example, should you top up your batteries in advance of an anticipated price spike? Should you plan to pump water or to run other loads during forecast low price periods? You would likely still trade on the 5 minute "real time" information but be better prepared based on the 36-hour forecast.

This clearly requires a degree of automation with software, including software that can learn from the past patterns to improve the trading strategy. At that point you would likely be looking to purchase software or create it yourself if your community had those skills. The data is available through the EA API (Electricity Authority's Application Programming Interface.)

As your trading approach becomes more sophisticated you might monitor the provisional and interim prices to ensure that you were being compensated correctly. More information on how to gain access to pricing information can be found on the EA website **Pricing manager — Electricity Authority** **(ea.govt.nz)**. All of this assumes that you can gain access to the wholesale market, and that depends on your retailer.

Some people also look at lake levels to understand how hydro might be priced in the future and consider larger weather affects like el nino or el nina to forecast the potential for dry year scarcity.

Sources for good information are energynews.co.nz **Energy News | New Zealand Energy Sector** which requires a subscription and energylink.co.nz **Energy Link – Plan and Execute your Energy Strategy with Confidence**. Both will give you access to data but you (or someone on your team) will need to know where to find the data and how to do the analysis.

For a list of data that you can request from your retailer or other parties see this link on the EAs website. **ea.govt.nz/operations/consumer-services/provide-a-service-with-electricity-data/**

Appendix: Peer-to-peer electricity trading and multiple trading relationships (MTR)

Peer-to-Peer trading is the practice of an individual with excess energy selling or donating it to a separate individual who needs energy. The seller might have excess energy generated from their solar system or stored in a battery.

Effectively, the buyer and seller establish a bilateral agreement for energy sale and purchase that is outside of the wholesale market. Big industrial companies do this with gentailers. The Tiwai aluminium smelter is a well-known industrial example.

It would be worth reading Appendix "How to Access Spot Market Prices" for background before reading further. The colloquial descriptions in this appendix are intended to provide an introductory understanding and therefore may lack precision in the use of terms.

Under the Code, peer-to-peer at the consumer level is only supported in Aotearoa when enabled by a registered retailer. The registered retailer ensures that the billing is accurate, that the transaction complies with regulations and that energy can be supplied to both parties when the generation is not available. Both buyer and seller must be with the same retailer and each can only have one retailer for all their energy needs.

It could be called peer-via-retailer-to-peer trading, but we will stick with peer-to-peer.

If you were on different retailers, you could not have a bilateral agreement and the energy trade would be settled in the market. One of the market challenges with peer-to-peer is that if peer-to-peer became a significant portion of the market with a large volume of energy transacted through bilateral contracts outside the market, the wholesale market liquidity might be reduced, and this may mean higher prices in aggregate for everyone else. But we are a long way off from this.

In theory you could do a peer-to-peer transaction with someone on the opposite end of the country but the more closely the peer-to-peer the transaction maps to the physical grid, the more potential value there is to the electricity system as a whole and the more likely some of that value can be captured by the peer-to-peer scheme.

To illustrate we start with a simple example: You and grandmother live on the same property behind the same ICP but in separate houses. Further, you have solar and grandmother has an EV with a fast charger. You are out during the day and she charges the EV during the day. If, according to a check meter on each device, the EV is charging at 5kW at the same time that you are producing solar at 5kW and there is no net energy coming in from the grid, then you could legitimately say that you are providing energy from solar to the EV charger and you can calculate the number of kWhrs. Your ICP meter will not read the energy from the solar or to the EV as it will be netted out behind the meter. Therefore, no-one but the two of you would have a record. You could then have an agreement with her that she pays you 14 cents per kWh. You would get more than the 9 cents your retailer might pay for solar and she would pay less than the 34 cents she would have paid the retailer. From a grid perspective, this is a behind the meter peer-to-peer transaction because you are not using any of the grid infrastructure or metering services for these kWhrs.

At the other end of the spectrum if you lived in Kaitaia and your grandmother lived in Kaikōura it would be difficult to claim that your solar power was going to her EV charger. You are not even on the same island let alone the same distribution grid. The physical reality in this case is more analogous to the grid being a big lake and you are pouring apple juice in one end and she is drinking through a straw on the other side of the lake. She won't taste apple juice. Rather she will taste a mix of everything that went into the lake. There is no way to track the apple juice, but the lake level stays the same. In this case peer-to-peer is the accounting mechanism that records how much energy went in and how much energy came out but it does not track where the electrons went.

Your kWhrs would be injected into the grid up north and used somewhere on the grid. Your grandmother would draw power down south from somewhere on the grid. That transaction would rely on every part of the grid. The EDBs would be different and would be connected by the Transpower transmission network. The electricity would be balanced by all the generators on the grid including fossil fuels. She receives whatever the mix of generation is on the grid at the time she purchases energy.

If you were both with the same retailer you could still effectively have a bilateral agreement for the energy at a mutually agreed price. However, whichever retailer is enabling this transaction would still need to make money so they would charge a monthly fee or commission, and, since you are using infrastructure and services of others to enable the transaction, your grandmother would have to pay all of the lines, levies, metering and other charges. Her total bill would include all the usual costs. The only difference would be that the energy charge would not be set by the retailer or the market but by you. To make it worth her while, the price would need to be below whatever her alternative flat rate of energy would be.

If your grandmother didn't pay for that infrastructure and those services, everyone else, including those who can least afford it, would have to pay more.

Going back to first example and extending it, if you have a single ICP for a single property and network that you own and you have several houses, loads and generators all with check meters behind it, then you can justifiably account for the energy flows behind the ICP. This is called a customer owned network (see the section called "Private Networks"). In this case you can get savings from bulk buying the lines services. You can also bulk buy the retail energy you need for use outside of the solar generation periods. Your metering fees and other fees are also lower per household because they are spread over a larger group. All of these savings can be allocated among the participants however you see fit.

Alternately, all participants could be on the same embedded network but with separate ICPs and the same retailer. This would allow for the retailer to trade energy amongst the participants while still allowing for bulk purchase savings in lines charges. However, the retailer still has to cover the cost of reading the meters, managing the billing and purchasing supplemental energy from the market. Since the retailer is a wholesale market participant and they are using the grid infrastructure on which the market relies, they are considered "on market" for the supplemental energy.

Although there may be some savings in energy cost for the participants, the retailer, to retain profitability, would need to add a margin on the supplemental energy, charge a transaction fee or charge a monthly subscription fee.

In situations where the ICP's in your scheme are on the EDB's network, the value of local generation is more difficult to track. If all the generators and load-only users are behind the same distribution transformer (might serve 20 to 50 houses) and you can demonstrate that no net energy is flowing from the low voltage side to the medium voltage side then you could argue that the generation is being used locally. The same is true if you are on the same 11kV feeder or behind the network transformer. As the definition of "local" becomes a larger geographic area or portion of the distribution grid, the energy flows get more difficult to track.

The grid is hierarchical in that at each successively large transformer serves as an aggregation point for all the power flows further out in the network. If you could measure the real time energy flows at all transformers then you could track which ones had power flows upstream and which had power flows downstream. For a given transformer if the net power flow was toward the edge of the grid for a given trading period then you could argue the all of the energy from DER's behind that transformer must have been used up behind the transformer during that period. And therefore, from an energy perspective, that power was not using any of the grid upstream of that transformer including the transmission system.

The benefits from transmission are much broader than the transmission of energy, they include access to reserves, security of supply, frequency stabilisation. Nonetheless for energy that is clearly consumed locally, there is certainly an argument to be made that for the energy you generate and use behind these grid points in the EDBs infrastructure you should not be assessed the full transmission charge since you are not using the transmission network for energy transfer. Transpower might argue that you are still using certain services like frequency keeping. Your argument is greatly strengthened if your energy production is reducing a known transmission constraint.

Similarly, since you are only using a portion of the EDB's grid you could argue that you are reducing their cost to serve in terms of maintenance and future upgrades. This argument is greatly strengthened if there is a known constraint at the distribution or network transformer that you were helping to manage. However, the EDB would need to be able to measure this, calculate the value of easing the constraint and be willing share the savings with you through a price break on lines charges or procure flexibility services from your scheme. Unfortunately, visibility in the low voltage network is seldom at the level it needs to be to enable this and EDBs don't have a regulatory incentive to do this. Further, they cannot bias favourably toward one customer.

If the ICPs are on different network transformers, even if still on the same EDB network (you are in Kaitaia and your grandmother is in Kerikeri) then value to the EDB is lower and it is even more difficult to account for the energy flows. Finally, we would get back to the case where you and grandmother are in completely different EDB territories and you are fully using the national grid infrastructure. In both these cases it is more difficult to justify that the other market participants should surrender some of their revenue. At this point it reverts to a bilateral contract for energy with the buyer paying all the usual non-energy charges.

Peer-to-peer trading when combined with other cost savings, like a fixed rate contract, can deliver value to both parties. However, when peer-to-peer is paired with access to the spot market for the supplemental energy, an energy consumer can be exposed to price spikes particularly in the early morning and evening peaks when they would not have solar. Historically these spikes in spot market prices have led to instances of very high bills. To mitigate this there are four key ingredients:

1 The ability to shift, curtail or limit your load
2 Energy storage to enable you to buy low (including self gen) and sell high
3 A control system that could read market signals and optimise the trades
4 The long-term enthusiasm and interest to manage it all.

Without these mitigations, there is a real possibility that even if your solar energy were free, you might end up with a higher energy bill than paying fixed price from a retailer.

If you are selling your power to someone else, typically the best you can do is get the same price that they are currently paying or less – otherwise why would they switch? By being knowledgeable about rates and knowing how you can maximise the value of your energy assets, you can typically reduce the cost of energy to the load you are serving and reap greater rewards. For example, if the load you are serving is on a flat rate and they don't manage their energy well, then you could move them on a different retail rate, manage their energy better, provide your energy and pocket some of the savings.

If you are going to argue for a reduction in transmission or distribution charges there are five considerations.

1 To what extent can you guarantee that you would always manage your energy production so that it had a positive impact on the grid. What would occur if you failed to meet that obligation? If more generation was added by your community or others, then there might be a risk of too much power or erratic drops and spikes in demand. This raises the question of who would manage all of this and who will be willing to take the on the risk and penalties?
2 There would need to be a way to accurately meter, on a fairly granular basis, what was being generated and what was being consumed. Currently, most metering is on 30-minute intervals and a lot can happen in 30 minutes. Supply and demand could be balanced for the first 5 minutes, then generation could drop out for 10 minutes, then the load could drop to zero of the next 10 minutes just as the generation came back on line and then they could be nicely balanced for the last 5 minutes. In aggregate it could be that you generated as much energy as you used over the 30-minute period. However, in reality the transformer could have been experiencing the movement of power back and forth.
3 There would need to be an accounting mechanism for all the electricity flows so that money could be correctly assigned, and it would need to be legal for these transactions to occur.
4 The lines company may need to construct and manage a special rate structure. This would be difficult to manage and their current systems are not set up to have a range of bespoke rate structures to suit each customer and they have regulatory options to not bias favorably toward a particular consumer or type of consumer.
5 All of the parties, Transpower, the EDB's and Retailers may need to give up some portion of their revenue. Unsurprisingly, they are reluctant to do so and are well practiced at finding reasons (some based on fact) why they should not have to give up revenue.

Since the regulatory structure is not yet in place for the commercial structure to fully match what is technically possible, and what is technically possible is not always implemented, the commercial arrangements currently have a degree of fuzziness to them that needs to be agreed by all parties.

Ara Ake is currently coordinating the Multiple Trading Relationships (MTR) pilot that is testing the benefits to consumers in being able to contract with multiple providers of electricity services, at the same ICP, at the same time. By enabling MTR, consumers will be able to access peer-to-peer services as an additional service to that of the rest of their consumption service. Currently if a consumer would like to access a peer-to-peer service from you when you have surplus solar generation, both you and the other person would have to switch all electricity consumption to the same retailer that can enable this service[1]. In the Code the ability to contract with multiple services is not allowed and therefore is a regulatory barrier to enabling a greater uptake in peer-to-peer trading.

Additionally, the MTR pilot is investigating if there are any concerns around the reconciliation of network and metering charges if there are multiple service providers at an ICP. If a retailer is providing a peer-to-peer service and this service is being provided at a time when there is minimal grid congestion (distribution and/or transmission), should the recipient of this service pay a lines charge reflective of this?

MTR would allow communities to be able to better value their EV, solar PV and battery investments by being able to access multiple services at the same time. Due to the community centricity of the MTR pilot this guide will be updated as further information becomes available.

1 Two retailers (one providing peer-to-peer and another general consumption) can have a bilateral agreement at an ICP under existing regulations, but this still does not allow a community to be able to use a peer-to-peer service to share solar locally, as this would require many bilateral contracts between retailers which is inefficient.

Appendix: Maximising the utility of EVs

Electric Vehicles (EVs) can be important to the economic viability of a Community Energy Project (CEP). If your community offers services such as meal deliveries or transportation for wellness or education, choosing to have the vehicle be electric can make a difference in the economics of the whole project. A shared EV can also make sense for a more urban community energy project in co-housing where the vehicle is used in conjunction with public transportation and walking or biking. Use of the EV can be billed separately based on usage.

Most people don't want to have to think about when, or how fast they charge their EV, but paying attention to this can be valuable as it is often the biggest load in a home and can make up a third of the electricity used.

At first, EVs were compared to petrol engine vehicles. There were concerns about how far the EV could travel on a charge and where to recharge (range anxiety), how long batteries would last (number of charges before degradation) and the cost to buy and run an EV.

Today, some EVs can do over 500km on a single charge. It is conceivable that in the next decade EV batteries will have long lives and can be charged and discharged as many times as you like without much deterioration. Finally, people are realizing that EVs cost very little to maintain since there are fewer moving parts and electrical equipment lasts a long time.

All of this makes an EV a very good complement to solar or other intermittent generation resources. Here are some way EVs can be used effectively.

- If you are delivering meals, the EV might be used more in the evenings and be charging for a good portion of the day. Similarly, if the transport is for wellness or education, the vehicle will not be in use all the time and can recharge a little bit during down times and on weekends.
- If your commute to work is less than 40km each way then you could charge the car on the weekend during the day and be able to use it the entire week.
- If your commute is over 40km you could still do most of your charging on the weekend and top up during the week from the main grid. If you are on time-of-use rates, you can top up during the night when the rates are low.
- If you are living in geographically dense housing such as in an urban environment, the EV can be shared and used by all residents when they can't use alternatives such as public transportation or biking. Most cars spend 99% of the time parked and unused.
- It might also be possible to provide services to the grid such as charging the car when the EDB needs the voltage on the local line to be decreased or there is too much solar generation at a particular transformer. See more about this in the section below "Managing EV charging to manage the grid."

If you have significant solar generation or low off-peak energy rates, then it is worth investing an extra $2,000 to $4,000 in a dedicated charger rather than a regular wall plug. This allows you to rapidly charge the EV from the solar during the day. If you just charge from a conventional power outlet you can charge at 8 amps. With a fast charger you can charge at 32 amps or 4 times the rate. This allows you to deliver over 7 kWhrs to the car per hour. You can get faster chargers than this, but 7-11kWh is the limit most EVs have on charging currently.

Charging example: a Tesla 3 gets about 6 km/kWh so if you drive 450km then you would need 75kWhrs of charge. A 10kW solar installation would deliver about 40kWhrs per day. Therefore, you could fully recharge the car over 2 days on the weekend. But you would need a dedicated charger to be able to fully utilize your solar production.

Cost saving example: An energy efficient petrol car gets 15km per litre so that is about 15 cents per km. A Tesla 3 gets about 6 km/kWh so that would cost 5 cents per km (30/6) if you just charge from the grid, 3 cents per km (20/6) if you charge off the grid but sell that same kWh back when the sun is shining and zero cents per km if you charge off solar.

Let's assume that your commute is 60km a day 5 days per week: A petrol car would cost you $45 per week in fuel. An EV would cost you $15 if you charged from the grid with no solar, $9 if you charged off the grid but sold the same amount of energy back to the grid and $0 if you charged off solar. Over a year that could save you over $2,000 in not buying petrol.

Dedicated chargers can also be made smart. Almost any clever way you can think of to charge your car, a good smart charger can do. It can respond to a price signal, it can wait until the house batteries are full, it can charge based on a specific time, or at a specific rate.

If your CEP also has a stationary battery pack, then you could charge the car from the batteries – assuming this still leaves enough for other uses.

As you use the EVs and the generation system, you will find new ways to optimise the use and savings from the EV. As EV battery technology progresses it will be

possible to use the car as a stationary battery. This will increase the value of the EV from a resiliency and price arbitrage perspective.

Managing EV charging to manage the grid

At the time of writing, EVs were top of mind for EDBs and gentailers, mostly because they fear that EVs will become, in aggregate, a large and unmanaged load on the grid. This presents a future opportunity for CEPs. The EDBs concerns are expressed as follows:

Most consumer connections are Low Voltage (LV) 240V, 63Amp single phase (15kW). Typically, an EDB will plan that even during peak load events, while a single all-electric residence might peak at 7kW (half the capacity allowance) households on a given feeder on average will be using a maximum of between 2.5 to 3.5 kW (North Island) and about 4 kW on the South Island. This metric is called the After Diversity Maximum Demand (ADMD). The additional 7kW of EV charging load could push that single residence right to the edge of its capacity allocation. But the greater concern is that if a feeder has a large proportion of fast EV chargers all charging at the same time, then the average at peak (ADMD) will no longer be 3 kW to 4 kW but closer to 10 kW and most feeders and network transformers were not designed with this much load. An electrician or EV charging company may recommend that EV charging be done outside of peak usage hours. However, if everyone follows the same advice and is charging "off peak", this could create a non-diversified artificial peak on the LV network. If there was communication among the smart chargers or to an aggregator, then smart charging can be staggered to flatten the peak.

Note that a possible response is for EDBs to raise their ADMD. This would require more network infrastructure to be built thus raising the EDB's RAB (Regulated Asset Base) which would allow them to charge higher lines fees. A more asset efficient alternative would be to manage the peak.

At present, chargers can be added to the LV network without informing the EDB. If a large number of EV fast chargers are added to the distribution company's LV network (something that they have very poor visibility and controllability over), and the EV charging loading is not visible and controllable, the distribution companies will use blunt instruments to provide supply (i.e. expensive capital upgrades - bigger distribution transformer, larger cable, phase balancing). EDBs are looking at energy orchestration platforms and engaging with customers directly to manage their EV charging load to avoid expensive grid upgrades.

It is critical that these EV chargers be connected to the internet to be able to extract value from smart charging functionalities. Dumb chargers (i.e. extension wires with in-built RCBOs) can be unsafe with extension leads lying about and no dedicated circuit or protection equipment for the EV Charger.

The most accepted and used smart charging communications protocol is OCPP. It is critical that the EV charger that is installed is at the minimum compliant with OCPP1.6J

However, none of this is mandated, incentivized or very well explained. It is indeed strange that households must register the smallest solar installation and are typically limited to 5 kW of energy export but can add 7kW of load without notice. This puts New Zealand on track to repeat same errors made in other geographies in solar and EVs.

For CEPs that would like to be prepared for a future where EVs are managed sensibly on the grid, there several steps that can be taken during installation:

- Follow WorkSafe guidelines and use approved and electrically safety tested equipment when installing smart EV chargers.
- Check with the local distribution company (EDB) to see if they would at some point like access to the EV charging demand to manage it on their network.
- Understand your loading profile by requesting HHR smart meter data so that you know your normal usage peaks.
- Accommodating V2G/V2H technologies to serve as a back-up or feed into the grid during peak times for financial reward from energy retailer or network company (in the future.)

Appendix: Guide for new users of solar

This guide will help you make best use of solar no matter if you own it or buy it. Solar may be installed on your own house, it might be installed on a marae or community building feeding power to your home, or it might be on your apartment building and you are one of many users. Regardless, the ways to use solar most effectively are the same. If you don't want to think about it at all, solar will happily generate energy for many years with only an annual washing of the panels with fresh water. No need to read any more of this guide.

If you would like to derive maximum value from solar, it is pretty simple. Use energy when the sun is shining and minimize energy use when the sun is not shining.

That's pretty much all you need to know. No need to read any more of this guide.

The reason to read this guide is that there is a very wide range of value that different households derive from solar. Some can get their total energy bill to be close to zero while others hardly save enough for it to be worthwhile. If you would like to dramatically cut your power bill, then it is worth reading the rest of this guide.

Because solar is something you pay for, have installed, and then (hopefully) have to do very little aside from some occasional washing and maintenance, the time to get solar right is at the design stage. This means you need to anticipate as much as possible about your future energy needs and decide what you want to do most. There will likely be trade-offs between some of the features of solar in this guide.

For a great explanation of how solar works, check out the video on Mysolarquotes mysolarquotes.co.nz/about-solar-power/residential/how-grid-connect-solar-power-systems-work/

Key attributes of solar

Resiliency

Most stand-alone solar installations cannot run when the grid is down so they have limited value for

resiliency (to still have power when the grid goes down). This is because:

- Safety – Companies that manage the grid cannot risk having uncontrolled power being fed from the customer side into a downed power line as this may cause injury to workers or the public. Therefore, in the event of an outage, solar systems shut down automatically.
- Energy balance – It is possible to have more complex control systems to disconnect from the grid and run in island mode, but then you need to balance the solar production and energy use in your home which is difficult and costly. If you turned on the stove you would need more energy and when you turned it off you would need less. This requires sophisticated controls and storage. There are new invertors that claim to be able to provide this automated control, but prior to 2022 they were not available in Aotearoa.
- Storage – solar panels cannot store energy – you would need batteries and a control system to store the energy and use it to supply your house in isolation from the grid when the grid is down.

Saving money on your energy bill

To maximise the economic benefit of solar you need to be aware of five factors:

- Solar generates the most energy when the sun is shining brightest (in the middle of a clear sunny day) – More in summer and less in winter, less in the morning and evening or when it is cloudy and zero when it is dark.
- You want to use as much of the solar energy that you generate as possible and export as little as possible. In Aotearoa, the price that consumers pay for electricity is high compared to other similar countries (28 to 34 cents per unit) while the price that consumers get paid for the solar electricity they generate is low (8 to 12 cents per unit.) The difference in value between self-consumption and export is about 20 cents. Most people can self-consume about 50% of the solar electricity they produce and end up exporting the rest back to the grid. Each unit or kWh of usage that you can shift to when solar is generating will save you about 20 cents.
- Some loads like EV charging can be 1,000 times bigger than other loads like a light bulb. Knowing your biggest, most moveable loads is crucial to improving the economics with the least inconvenience.
- Generally shifting consumption is more cost effective than shifting generation. You could shift when you generate solar by arranging the panels so that they follow the sun, but this gets complicated. The other primary way to shift solar is to use batteries to store the energy when produced and use it later. In general, because of the upfront cost, using batteries just to save money does not make economic sense. It can make sense if you are a trading energy in the spot market or needing the batteries for resiliency anyway.
- If you can't shift your demand to when the panels are most effective, you can orientate your panels in a fixed position to when you use the most power. If you aren't home during the day and use most of your power when you come home in the afternoon, you can orientate your panels north-west to take advantage of more afternoon sun. Over all your panels will produce less, but they will be producing more during times when you can self-consume, which MAY result in more savings
- Another system design option is to correctly oversize your solar array, so you make the most of your inverter. Inverters are usually the most expensive part of a solar system after labour costs. So adding a few extra panels will make very little difference to the overall price. Oversizing is when your panels have more rated capacity than the inverter they are connected to. You may have a 6.5kW array, but only a 5kW inverter. You do this because even though the array is rated at 6.5kW it will usually be putting out a lot less than this due to the sun not being at the optimal angle or there being cloud cover. In fact, a solar array may only be putting out its max rating for an hour on a clear summer day, the rest of the time it will be less. Having an oversized system means you will be producing closer the rated capacity of your inverter.
- Selecting the best rate plan. Aside from the basic electricity pricing plan, there are two options: (1) Time of use rates and (2) Spot market rates. Both can enable greater savings but also carry the risk that you will need to buy electricity at high rates during peak times:
  - Time of use rates in New Zealand typically charge more during peak times roughly 7am to 10 am and 5pm to 9pm and much less at off peak times such as 10am to 5pm and during the night 10pm to 7am. The game is to not be buying power during peak times, either by using energy when solar is producing, or late at night from 10pm to 7am when the price is low.[2] Some lines companies also charge zero grid charges between 10pm and 7am further improving the savings. This is an example

2 Note that is it likely that some lines companies will change their pricing structure in future years so that rather than charge the lines fee as a variable 8 to 10 cents per kWh, they will charge a fix monthly fee. This would likely reduce the savings from solar since the monthly fee will need to be paid regardless of how much electricity is consumed.

of pricing from Powershop powershop.co.nz/help/get-shifty/what-are-my-peak-and-off-peak-times/

- Spot market rates enable you to sell the energy you produce to the wholesale market. You can do this through certain retailers who will trade your energy on the spot market on your behalf. The catch is that you also have to buy your power from the spot market. This can deliver much more income but requires more effort to set up and carries some risk. If there is a price spike at 6pm when you are cooking dinner and you don't have solar because the sun is low, you could end up with an expensive dinner because of the price you pay for that 30-minute peak.

Together, this means that you can get the most value from solar if you are able to use all your electricity during the middle of sunny days and none during the peak times. Of course, for most of us, this would be impractical. We use the lights at night and if we are at work during the day, we use most of our energy in the morning and evening. In addition, some appliances and devices use relatively little energy so it may not be worth the effort.

However, everyone's circumstance is different. A nurse who works nights and commutes 30 km each way in an EV would be an excellent user of solar as the car could be set up to charge between the peak solar generation times of 10am to 4pm. Someone who works from a home office could cook their main meal during the day and preheat their home for the evening to minimize the use of energy during the evening.

In addition, there are many things that could be automated so that we would not need to even be aware that they were optimising for solar. For example, an electric hot water cylinder could be controlled with a timer so that it only heated water between 10am and 4pm when solar was generating and secondarily between 10pm and 5am when energy was cheaper or local lines company was not applying grid charges. Note: a special timer is needed for the hot water cylinder to manage the temperature correctly.

It is also possible to turn on too many appliances or large loads such as charging cars and air conditioning during solar production hours and consume more energy than you are producing so you may need to stagger when you use big loads to optimise the use of solar. Over time, and with the right monitoring equipment, you will be able to find the right balance.

Shifting the biggest and most flexible energy users

Below are some of the biggest loads and how they can be shifted to either when solar is producing or when the cost of grid power is lowest. The average house in Aotearoa (without an EV) uses about 7,000 kWh per year so that is $2,100 per year that is up for grabs. With an EV, total household energy usage can exceed 10,000 kWh. To make best use of solar it is often worth some incremental investment in load management technology.

Electric Vehicles (EVs)

While the cost per km of running an EV is lower than the cost of running a petrol car, charging an EV uses a lot of electricity compared to your house. An EV fast charger uses about 7.3kW per hour whereas the average use of the rest of the house is at about 2 or 3kW per hour. Therefore, if all you do is make sure that your EV is being charged off solar, it's a big win.

For example: A good petrol car gets 15km per litre so that is about 15 cents per km. A Tesla 3 gets about 6 km/kWh so that is 5 cents per km (30/6) if you just charge from the grid, 3 cents per km (20/6) if you charge off the grid but sell that same kWh back when the sun is shining, and zero cents per km if you charge off solar. Let's say that your commute is 30km each way 5 days per week.

A petrol car would cost you $45 per week in fuel. An EV would cost you $15 if you charged from the grid with no solar, $9 if you charged off the grid but sold the same amount of energy back to the grid and $0 if you charged off solar. Over a year that is saving you $2,250 in not buying petrol.

Space heating (15% to 30%)

Heating the home in winter is typically the biggest user of electricity (about 30% of electricity use). Typically, electrical options are space heaters or a heat pump. A heat pump is about three times more efficient. Most small space heaters are rated at 1.8kW to 2kW. Typically to stay comfortable in winter you might have 1 running for 6 hours of the day and 2 or 3 running in the evening so that is potentially 2kW for 6 hours, and, 6kW for 3 hours at night or $9 for the whole day. A heat pump would cost you about $3 per day for the same heat. Over 120 cold nights a year that is about $1,100 for space heaters and $350 for a heat pump. With solar, any heating you do during the day is free. Depending on how well insulated your home is, you could preheat your home when the sun is shining and possibly save a third of your nighttime use which would work out to be about $600 if you had space heaters.

Hot water cylinder (15% to 30%)

Hot water is typically the next biggest user of energy in the house at about 15% of the total home consumption. A standard hot water cylinder is about 3 kW and a hot water heat pump is about 0.5 kW. This illustrates the value of energy efficient appliances. The hot water heat pump is about six times more efficient than a standard hot water cylinder. If you are changing hot water cylinders and choose to get a hot water heat pump, then be sure to get one that is set up for solar. Hot water cylinders do not run all the time (perhaps about 3 hours at the rated capacity). They create hot water which is stored in an insulated tank. Therefore, you can shift when hot water is created.

To make sure the temperature in your hot water cylinder cycles up to 60 degrees Celsius at least once per day to curtail bacteria growth, it is important to use a timer specifically designed for hot water cylinders or a solar divertor. (A solar divertor, automatically diverts energy to certain appliances when solar energy is being produced.) Setting your hot water cylinder to run between 10am and 4pm when solar is generating and secondarily between 10pm and 5am when energy is cheaper (if you are on time of use rates) and /or local lines company was not applying grid charges, could reduce your cost from about $900 to $300 over the course of a year.

To optimise this further, if you or your family members are at home during the day or work flexible hours then using hot water during the day would be beneficial. People at home could shower closer to midday so the cold water coming into the hot water cylinder can be heated with solar electricity. On weekends schedules are more flexible.

Any device that uses hot water could be timed to run so that they are using hot water when the sun is shining. This includes dishwashers (even though they have their own separate heating element), clothes washing machines and if you happen to have one – a spa pool.

Each of these actions might save just one or two dollars but if they become habits for the whole family it quicky starts adding up to an additional pizza night or other alternative uses of money saved.

Air conditioning or cooling (10%)

Air conditioning is used much more in other countries so in Aotearoa the proportion of household use would likely be lower than 10%. However, with so many heat pumps being installed in recent years there will be a lot more people using them for cooling. The great thing about cooling is that it typically coincides with sunny days. One way to make even better use of solar is to pre-cool the house in the mid-afternoon to maximise the use of solar. This can be automated if you are away during the day.

Refrigeration (5% to 15%)

Fridges and freezers use a fair amount of electricity at about 5% to 15% of the total home consumption. You can mitigate this by not having a fridge in the garage or a spare freezer that you don't really need. Probably best not to put the fridge on a timer due to managing frozen goods and food spoilage. The main determinant of how much energy the fridge users is how long the door is open for. People who decide what they need and then open the door to get it, use a lot less energy than "open door deciders". Preparing your main meal for lunch will help as this is when the fridge and freezer are used most. Restocking or cleaning the fridge during solar hours will also help.

Moderate energy users

Other moderate sized energy users are:

- TV's use about 3% of the electricity in some households, but best to not be watching TV during the day anyway.
- Pool pumps – while we are on the topic of luxury items like pools, if you have a sauna, spa pool, etc., these big users of energy should be run or pre-heated during the day.

Everything else uses 1% to 5% or less

- Clothes dryers – use about 1% to 3% but are occasional and can be timed to run during the day
- Clothes washing machines and dishwashers – use about ½ % due to hot water and the motors. These can be put on timers or run during solar hours by habit.
- Jug or electric kettles and microwaves are quite large instantaneous power users at about 2kW but they are used for very short periods of the day. It is not worth waiting until 10am for your first cup of tea or coffee.
- Electric hobs and ovens – use about 1.5% to 5%. You could consider cooking your main meal in the middle of the day – this also helps with hot water for washing up and refrigerator use.
- Charging large battery operated tools – Brush cutters, mowers, saws, etc,

Small energy users

Some devices use surprisingly little energy and are not worth the cost or inconvenience of trying to shift to daylight hours. It is, however, worth turning them off when not in use. There are many appliances that use power even when just in standby mode.

- Charging a computer 60W or 0.06kW
- Charging a cell phone 6 W or 0.006kW about the same as a light bulb

- Lights – if energy efficient 8W
- Lights – if not energy efficient then 60W – these bulbs should be changed
- Fans without heating elements 60W. You could run your air-conditioner or heat pump in cooling mode until about 4pm using solar and then switch to fans to circulate the cool air in the evenings at peak time.

With modern appliances that have programable timers, much of this can be automated. It really depends on how much you want to balance reducing your electricity bill and living carefree. Part of the benefit of the behaviour change will be that you are using energy more deliberately and become more conscious of leaving the TV and heaters on and opening the fridge door. Any energy you don't use is energy you don't have to pay for or generate. For some folks this is too much work and inconvenience. For others, they love the challenge of seeing how small they can make their power bill.

More advanced considerations

The guidelines above are generalized for all of Aotearoa and all days of the year.

But there are differences between winter and summer. In summer, your biggest load might be cooling which is happily coincident with when the sun is shining. In addition, the sun is up for much longer and so you produce more solar and over a longer period of the day. In winter your biggest load is heating and mostly in the evening and early morning. Not only do solar panels not produce when you need the heat most, they also produce less during winter, and you are using more hot water.

It also depends on where you live in Aotearoa. If you live in Kaitaia, the temperatures are more moderate so less energy is needed. If you live in Queenstown, the temperatures are more extreme but the skies are quite clear with good solar production, while over in Wanaka winter often brings a layer of fog. Dunedin is more overcast, but the temperatures are moderated by the ocean.

Moreover, for solar panels that are optimally positioned (North facing at a 45 degree angle) solar production ramps up slowly in the morning, peaks for a few hours during midday and then ramps down in the evening. The more they are West facing the later the peak and the more they are East facing the earlier the peak. In addition, clouds can create production drops and if tall trees or buildings are close by, their shadows should be monitored at different times of the day and year to see how they might move across the roof and affect panels. Some shading is tolerable if taken into account.

On average solar production equates to the equivalent of about 4 hours of full rated power per day over the year. However, if you are drawing big loads like charging cars or heating or air conditioning, it is possible that you would be drawing power from the grid even during the middle of the day. So, you may need to stagger when you use big loads so that you can optimise the use of solar.

More about solar profiles at **mysolarquotes.co.nz/about-solar-power/residential/solar-power-self-consumption/**

Solar panel production drops by about 20% when they are dirty. So, while you might be able to get away with washing them once a year, more frequent washing with a hose and soft cloth, particularly after a pollen or dust event, will keep energy production up.

Your solar system should show you how much you are producing, and this will allow you to match usage to the amount generated. Your meter should show you how much you are importing or exporting. If you know how much each appliance uses, you can decide which ones to run at a given time. Over time, and with practice, you will be able to shift more of your energy use to match your generation.

Applying the lessons of solar to other technologies

The basic ideas behind using energy when it is produced would apply to other types of technologies also including wind, geothermal or small hydro. Since wind is less predictable it may be more difficult to automate, but it could be a great match for electric heating on a cold and windy night.

Adding batteries to the mix means that you can shift when energy is delivered. Batteries offer limited storage so you might be better off getting the solar basics and habits in place first, before adding batteries so that you can estimate how much battery power you need to deal with the times that solar is not generating. Batteries are super helpful for short duration flickers in production such as on intermittently cloudy days as they can smooth the solar production and thus the amount of energy delivered to loads. If you buy and sell on the spot market, batteries can also protect you from having to purchase power during a price spike.

The principals remain the same – matching energy usage to when the lowest cost energy is available.

Humans have been matching their energy usage to the sun and seasons for thousands of years. With time and practice you would be able to adjust your use of energy to the solar production ramping up toward midday, using less when there are clouds and ramping down toward the end of the day.

Case Study: 26 Aroha Sandringham

A customer owned network with solar hot water and solar PV

26 Aroha started with a vision: Create hubs of people that can live in a sustainable, affordable and friendly way with minimal impact on the planet and be positive to the neighbourhood.

Founders Jules and Blair MacKinnon achieved this with a 13-unit apartment building in Sandringham, a suburb close to the Auckland CBD. The building, which has received a Homestar rating of 10, features a thermally optimised building envelope, solar PV, central solar hot water and a shared EV on a customer owned network along with a worm farm for composting, a community garden and water saving systems. They use about half the water and half the electricity as the average Auckland household while generating only half the waste.

One of the intentions is to provide people who are renting with similar quality of features as owners. They do this with a suite of amenities from roof top BBQ, kitchenette and laundry and a rentable guest room.

Governance

Jules and Blair own the building through a trust. They manage the building operations and all the utilities (energy, water and waste.) This governance structure has enabled effective decision making and savings allocation during the construction and operations phase. It has enabled them to take advantage of scale on systems such as PV and solar hot water and contract relationships with utility companies. Savings are returned to residents through lower utility bills and, in the case of waste management, a slush fund for general use. They hold regular huis with the residents to solicit input and there is an online chat group.

People and skills

Jules' mother had built up a rental business over decades. When the business passed to Jules, this property was developed under an existing business framework along with Jules' experience as a health care professional and family history of property management. 26 Aroha hired architects, builders and consultants such as Revolve Energy for the energy systems design and enablement.

Project steps

Land acquisition:

The land was already part of the property portfolio so it was a matter of disassembling and upcycling the 1920's bungalow materials into a 13-unit complex managing to meet their 90% recycling target for the old house.

The design:

The design was intended to offer long-term, quality rentals in a sustainable, low-carbon building. Parking was reduced to the absolute minimum of two rentable spaces and the one shared EV. The rentable carparks were prioritised for young families. Communal living is optional with the design allowing for shared space and private living.

Sound financial decision making

As this building is a livelihood for Jules and Blair, they had to make sure that the capital expenditures made commercial sense over the long term. The savings had to be realized and shared by both the residents and the owners. One example is the hot water system.

The central hot water system gets about 70% of its heat from a 30 m^2 roof mounted solar hot water heater which cost about $80,000. This additional capital cost will be paid back over time in reduced energy use. The supplemental 30% of heating is from an electrical heater element powered by grid or solar electricity depending on the time of day.

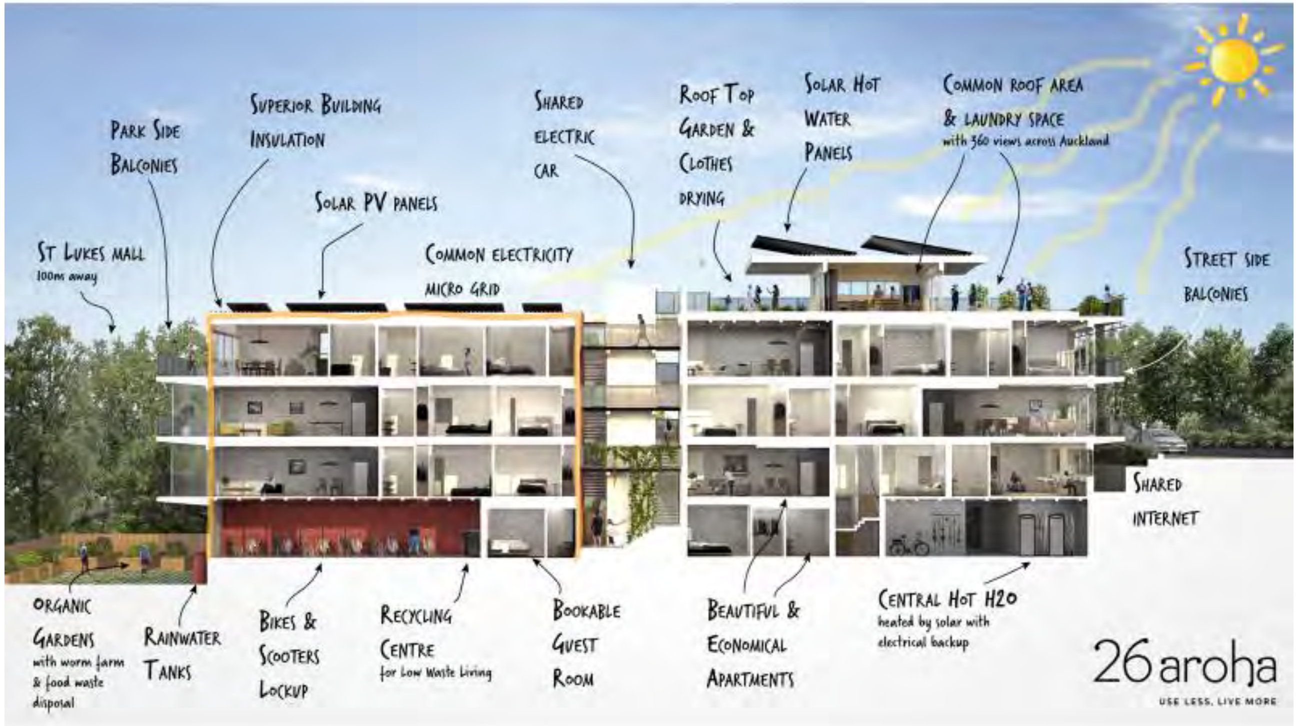
The central hot water system freed up space in each apartment that allowed for additional storage room amounting to a collective savings of about $65,000 in alternate use floor space. While the $65K is not a direct one-for-one offset against the $80K, it certainly shifts the balance clearly in the direction of central solar hot water.

The energy system

Consumer owned network

26 Aroha operates a consumer owned electricity network with a single grid connection to supply electricity to the 13 units and to all shared loads such as laundry, communal lighting, hot water and EV charging. Cold water is similarly distributed to apartments from a single Watercare connection. Hot water is completely internal to the site with a central on-site hot water plant delivering hot water via a circulating ring main.

The property has a single gate meter at the grid interconnection point. This means that Vector, the local lines company, only has one connection and one customer, and, Ecotricity, the energy retailer, only



A pictorial representation of 26 Aroha and its features

has one customer, rather than 13. This gives 26 Aroha buying power to get a cost-effective energy rate of about 12 cents per kWh fixed for 3 years and a lines charge of just over 5 cents per kWh.

Within the property there are check meters for each unit and for most of the key loads such as the central hot water system and the shared EV charger. This enables 26 Aroha to monitor and allocate the cost of services to each unit.

Internal billing is managed by the owners using a software billing system designed by Revolve Energy for customer owned networks. The owners also manage the relationship with the retailer Ecotricity. This enables the residents to enjoy the benefits of low cost and self-generated energy without having to spend time managing it.

Having a single gate meter and operating a consumer owned network enables 26 Aroha to take full advantage of their on-site generation and controllable and flexible loads to generate savings without compromising comfort and convenience.

Photovoltaics

The 10kWp (peak) roof mounted PV system feeds the customer network and therefore all loads on the property. Given that 75% of the solar is used on site, the payback on the $40,000 investment should be faster than a single home PV system which often can only consume 50% on site. Energy consumed on site offsets against a flat rate energy tariff of 12 cents whereas they would get about 9 cents for exported energy. However, they still need to pay about 5 cents per kWh consumed in lines charges. While both the lines charge and the energy tariff are significantly lower than they would be for an individual house, there is a net benefit of ~8 cents for every kWh (12+5-9 =8) that they can consume directly from solar versus exporting and buying back later.

In the future there might be ways to further optimize the use of the PV to be used on site. The owners did not want to compromise the lifestyle of the residents by actively managing the EV charging times.

Central solar hot water

The central hot water system is set to maximise the use of the 30m² solar heater using timers. A hot water system has to reach 60 degrees at least once per day to eliminate bacteria. This 60-degree peak is set to occur each day at 4pm which gives the solar heater as much time as possible to get the hot water up to temperature so as to minimize the supplemental heating needed. This also means that the water is hot for the residents evening activities. The temperature is then held at 55 degrees throughout the night until 9am, after which it is allowed to fall waiting for the solar heater to kick in and return the temperature back up toward the 4pm peak. This may be optimized further over time as usage patterns and solar PV self-consumption is optimized.

Space heating

Since the units are very well insulated, the space heating requirements are relatively modest and could be served by small 1.5kW to 2kW space heaters in each apartment. Some residents hardly ever use the space heater.

EV chargers

The shared electric vehicle is charged with a smart fast charger. At present there is no active management of this load or attempt to have charging occur during solar generation. Since the EV is a Nissan Leaf with a range of 150km, it is not worth the risk that residents might experience the inconvenience of a half-charged car.

There is likely a way to optimize all of this with a booking system integrated to the charger that can be set up in the future.

Allocating costs fairly

The data acquisition, metering & billing solution ensures that the operational costs and future upgrade/replacement costs of the system are recovered fairly from the residents.

Interactions with the lines company

Since the property was shifting from a single 1920's bungalow to a 13-unit building it was likely that a larger power supply would be needed. E-cubed, a services engineering company, developed an estimate of the capacity that would be needed and provided it to Vector, the local lines company. Vector concluded that the best way to supply the estimated power would be by connecting the property to a different distribution transformer 100 meters away. This did not require an upgrade to the transformer but did require a new conductor be laid at a cost of $100,000 to the project.

In retrospect, there might have been an opportunity for 26 Aroha to consider other mitigation strategies that might have reduced this cost but it could equally turn out that this was the most cost-effective solution. It also provides some degree of future proofing if more loads such as additional EVs or air conditioning is added.

Interactions with the retailer

Ecotricity provides energy to the property at a flat rate of 12 cents per kWh locked for a three-year period. Lines charges are separate and a pass through. This, in combination with solar, makes the middle of sunny days the best time to use electricity and hot water.

Special thanks

Thanks to Jules and Blair MacKinnon for being willing to share their journey and for their time in discussing the project. Thanks to Shay Brazier of Revolve Energy for making the introduction and taking the time to describe the project and review the case study.

References

nzgbc.org.nz/Story?Action=View&Story_id=750

stuff.co.nz/life-style/homed/sustainable-living/128267487/carless-apartment-tenants-in-auckland-saving-1854-a-year

homemagazine.nz/aroha-apartments-sandringham/

Case Study: Cohaus in Grey Lynn

A consumer owned network supporting a community housing project

Cohaus is an integrated housing project created, designed and financed by the people who call it home. The project incorporates five key elements of community, housing, transportation, water and energy. Cohaus started with a clear intention and a set of requirements to provide reasonably affordable, high-quality housing for 10 to 20 families within easy biking and public transportation distance from the Auckland CBD, and, to be ecologically minded within commercially sensible constraints.

The incorporation of these five elements enabled capital savings in one area be used to invest in long term savings in other areas so that, as a whole, the project was cost effective for residents of the community.

Governance

The governance structure enabled effective decision making, collective consultation and individual ownership. Each of the families who would become owners set up a trust with shares in a development company that was managed by two directors, each of whom were community members and future residents. Once the project was constructed, the trusts converted to unit title with a body corporate and the development company would be dissolved. This allowed people the flexibility to participate from the start all the way through to being occupants or to swap out during the process. Ultimately most of the families that started became owner occupants and residents.

People and skills

The project started from a series of meetings of the founding families. The two directors of the development company, one of whom is the architect, had the power to make decisions quicky. Cohaus would hire consultants for specialized areas such as Revolve Energy for the energy systems design and enablement.

Project steps

Land acquisition:

First, they set about finding and purchasing a suitable site, which turned out to be in the suburb of Grey Lynn close to the CBD, bike friendly and well served by public transportation. The site had a single building which was no longer to be used for its intended purpose, making the property prime for redevelopment into co-housing.

The design:

The design was intended to maximize community green space and shelter it from wind and street noise with the buildings. The buildings would anchor the perimeter. Car parking was minimized to maximize green space.

The buildings were designed for living functionality rather than features that would might look good on a brochure but have minimal practical value. Where possible, amenities were shared. Reducing complexity reduced the capital cost.

Photo by Adam Luxton

Sound financial decision making

Features and technologies that enhanced sustainable living needed to stack up economically. Financial models were used to evaluate options and make trade-offs.

One clear example was the decision to go with a central heat-pump hot water system. Heat pump hot water systems are higher capital cost but, being three times more energy efficient, deliver a much higher net present value. One central hot water system is more cost efficient to purchase, install and maintain than 20 smaller hot water cylinders. In combination, this decision had a payback of three years which is very quick given the life of the project. In addition, eliminating the hot water cylinder from each unit, freed up space equivalent to a large closet per unit.

Since the solar PV system was of clear economic benefit but had a longer payback, it was financed separately with a loan from one of the families. This removed the capital cost burden from the project and the loan could be serviced from savings realized on energy over time. Once the loan is repaid, this additional fee can be put toward other uses or removed from the monthly bill for each unit.

Six shared vehicles offer a number of economic benefits. They reduce the amount of parking needed allowing for more green space and a shared garden or extra units. There are the savings from shared cost of maintenance, WOF, insurance and other fixed operational costs and well as the upfront capital cost. Currently two of the shared vehicles are EVs and four are hybrids with the goal to go to all EVs in order to maximize the use of day time solar production and sustainability.

The energy system

Consumer owned network

Cohaus operates a consumer owned electricity network with a single grid connection to supply electricity to the 20 units and all shared loads such as laundry, communal lighting, hot water and EV charging. Cold water is similarly distributed to apartments from a single Watercare connection. Hot water is completely internal to the site with a central on-site hot water plant delivering hot water via a ring main.

The property has a single gate meter at the grid interconnection point. This means that Vector, the local lines company, only has one connection and one customer, and, Ecotricity, the energy retailer, only has one customer, rather than 20. This gives Cohaus buying power to get a cost-effective energy rate and allowed them to reduce the collective interconnection capital cost and operating cost.

Within the property there are check meters for each unit and for most of the key loads such as the central hot water system and the EV chargers which enables Cohaus to monitor and allocate the cost of services to each unit.

Internal billing is managed using a software billing system designed by Revolve Energy for consumer owned networks. One of the residents manages the internal billing and the relationship with the retailer Ecotricity including analysis for future energy strategies. Their renumeration for this part time work is modest compared to the energy savings. The rest of the residents enjoy the benefits of low cost and self-generated energy without having to spend time managing it.

Energy control system

Having a single gate meter and operating a consumer owned network enables Cohaus to take full advantage of their on-site generation and controllable and flexible loads to generate savings without compromising comfort and convenience.

The control system manages the demand so that the limits set by the lines company are not breached and the demand charges are kept to a minimum. In the event that the property is nearing peak demand, there are three controllable loads that can be turned off or delayed; EV chargers, hot water heater and the outlets on a dedicated circuit for each unit's space heaters. The residents are aware that these services are subject to curtailment and understand the economic benefits. The control system also seeks to utilize as much of the solar energy generated on site by heating the hot water and charging the EVs during the day.

Load control operates to reduce operational cost by maximising the use of onsite generation. If Cohaus moves to time-of-use rates in the future, load control can be used to take advantage of lower (off-peak) tariffs.

Demand control has allowed the site to reduce the grid connection capacity allocation by 30%, down from 250 A to 180 A. This eliminated the need to upgrade the distribution transformer which saved at least $40,000. In addition, since the lines charge is proportional to the capacity (Amps) allocated the 70 Amp reduction (250-180) saves about $750 per annum in lines charges.

Photovoltaics

The 40kWp (peak) roof mounted system feeds the consumer network and therefore all loads on the property. In New Zealand, the cost of a kWh of energy from the grid is significantly higher than the price paid to the owner for a kWh of solar exported to the grid. The value of solar energy is maximized by the control system to ensure that, to the extent possible, the energy generated is used on site particularly by controllable loads such as the hot water heater and EV chargers.


Photo by Adam Luxton

Central hot water

The central heat pump hot water heating system cost about $100,000 which was about $50,000 more than having conventional individual hot water heaters. However, the additional capital cost of the heat pump system will be paid back through energy savings in less than 3 years ($15,000 of operational savings per year, increasing over time). In addition, over 20m^2 of floor area was saved in the apartments by avoiding the installation of individual hot water cylinders, with a built floor space value of $100,000. Thus, the payback was instant from a space savings perspective and delivers an additional $15,000 of operational savings per year, increasing over time. The hot water heating set point can be increased when there is excess on-site solar electricity available.

Space heating

Since the units are well insulated, the space heating requirements are relatively modest. Therefore, it was decided to use a dedicated, controllable circuit for the outlets (plugs) for the space heaters, but leave the decision on size and number of space heaters up to the owners. In a peak capacity event, the space heater circuit can be curtailed if needed.

EV chargers

The shared electric vehicles are charged with smart fast chargers that integrate into the demand control system. This allows EV charging to be reduced or curtailed during times of peak demand and for charging costs to be reduced by maximising charging at times of excess PV generation and in the future low electricity pricing.

Allocating costs fairly

The data acquisition, metering & billing solution ensures that the operational and capital costs of the system are recovered fairly from the residents. The system:

1 Records and stores the metered electricity, hot water and cold water use of each apartment.

2 Allocates the costs of the shared vehicles by distance travelled.

3 Optimizes energy cost by storing and managing tariffs for the service centrally, including time of use tariffs for any service.

4 Allows onsite solar PV generation to be determined on a half hourly basis and billed to each unit at a separate rate to grid electricity to incentivise residents to change their usage patterns.

5 Automatically generates monthly invoices for the services which are pushed into Xero to be managed and communicated.

To start, billing has been kept simple. Over time, as residents become more comfortable, and ways to save or shift energy use become evident, the billing system might become more intricate to create incentives for residents.

Monitoring and visualisation

The same data that has been captured for billing, plus data from additional check meters which measure central loads (e.g. heat pumps, PV & EVs) can be visualised centrally. A fully customisable dashboard allows the managers of the site to keep track of consumption, and generation of electricity, heat and cold water.

A simplified dashboard will be shared with residents to allow them to understand the best time to use electricity & hot water.

The system also tracks costs and savings in real time to allow live reporting of cost and carbon savings

Interactions with contractors

Supported by Revolve Energy, Cohaus, put together a clear set of system specifications that could be bid out in an RFP (request for proposal) process that enabled direct comparison of offers from contractors. This ensured that best quality, price and service level was achieved for each system. Revolve Energy continues to act in an advisory capacity to Cohaus.

Interactions with the lines company

Lines companies are transitioning in their attitude toward innovation in the distribution grid and this was reflected in the Cohaus experience. In general, the lines company will supply whatever capacity is needed. Vector was prepared to supply the 250 A (three phase) suggested by the electrical building services engineer. However, Vector was initially not prepared to tell Cohaus what capacity threshold was available to the site without the need for a distribution transformer upgrade. This information was vital to the economic decision to invest in a load control system to reduce the capacity needed or to simple go with a higher capacity connection. This required navigating to someone at Vector who was prepared to provide the information. Once it was established that the threshold to avoid a transform upgrade was 180 A (three phase), the decision was made to go with load control and save the cost of the transformer upgrade of at least $40,000.

However, even the 180A capacity allocation is higher than needed and Cohaus will seek to demonstrate this with data over time and seek further reductions in lines charges. The peak load to date has been 85A (one half of the capacity allocated.)

Further, while Cohaus has achieved internal cost savings, they have not been able to engage with Vector to provide ancillary or flexibility services such as load shedding, load shifting, voltage support or reactive power support. Perhaps these opportunities will arise in the future as Vector seeks to procure these services and puts in place the grid management technology to be able to provide a demand signal and API feed of current tariffs.

There is also a future opportunity to be able to operate in island mode in the event of a grid outage but this would require batteries to be installed to balance the generation and load.

Interactions with the retailer

Ecotricity is considered to be an innovative retailer supportive of community initiatives for self-generation and load management even though it means they sell less electricity. They provided two options for energy. One based on time-of-use and the other a flat rate. Because of the volume purchase, both were considerably lower than they would have been for a single household. After analysis of anticipated usage, Cohaus opted to go with the flat rate for energy at just over 11 cents per kWh locked for a two-year period. Lines charges are separate and a pass through. This, in combination with solar, makes the middle of sunny days the best time to use electricity Cohaus will analyse its usage patterns in advance of negotiating the new energy rate toward the end of the 2-year period to determine which rate it should be on. Cohaus might also adjust the internal billing to reflect time of use pricing to encourage residents to shift energy use toward low-cost times. Having control of the billing system and customer network allows flexibility in how they allocate costs and incentivize behaviour of their community.

Storage

A common question is whether energy storage was considered and why it is not included. There are three answers to this. Firstly, energy is stored in the form of super heating the hot water system and through charging EVs. This is just a valid a method of energy storage as stationary batteries and more cost effective. Second, since Cohaus is grid-tied in a relatively resilient part of the grid, the grid effectively acts as storage and Cohaus is part of a broader community of energy users. Third, the financial case for batteries which would include energy arbitrage, ancillary services and resiliency did not stack up because, at the time of construction, these where not a sufficiently important problem to solve or were not available. If this changes, then stationary onsite battery storage can be added in the future.

Final words for those who follow

Cohaus sought to balance economics, ecological stewardship and comfort with each design decision. This required careful consideration of upfront costs and future needs and lifestyle choices. One example was the decision to only have the required storm water storage buffer rather than oversize the system to perhaps double the requirement. The council requires a certain size in order to buffer storm water runoff, but additional tanks could store water for reuse in the garden and other non-potable uses. These subterranean tanks are most economically installed at the start of construction. At the time, the economic cost did not seem justifiable, but in retrospect some residents would have liked to have additional water for the garden or other uses.

There are check meters at each unit and most of the common loads. However, the shared laundry could also benefit from having a check meter to better allocate costs. At present this is all bundled with general lighting and so usage cannot be incentivized or allocated.

When you can amortize costs across a community of 20 units it is easier to make long term infrastructure decisions that require upfront capital cost for longer term payback.

Special thanks

Thanks to Josh Yeats and Thom Gill of Cohaus for their time in discussing the project. Thanks to the Cohaus community for being willing to share their journey with the readers of the guide. Thanks to Shay Brazier of Revolve Energy for making the introduction and taking the time to describe the project and review the case study.

Case Study: Energise Ōtaki

Summary

Energise Ōtaki (EO) has built, and operates, two solar generation projects. Both produce revenue that serves as a financial annuity to fund community grants for community driven initiatives for as long as they operate. This case study focuses mainly on the energy project at the treatment plant, but it worth understanding a little more about EO energise.otaki.net.nz. At its heart, Energise Ōtaki (EO) is about enabling bright futures for the community which they do through sustainable energy related initiatives. EO started about ten years before the energy project was started. This was important because it enabled the members to work together on smaller projects first, get to know one another and establish a track record and credibility.

The people, the people, the people

Like most community projects, Energise Ōtaki started with people:

Leigh Ramsey had worked in the alternative fuels sector and through establishing projects in the Pacific Islands had developed technical, innovation and project management skills and was a business member of the Clean Technology Centre in Otaki

Gael Ferguson had been the senior manager responsible for strategic direction, climate action and sustainability on the local Kapiti Coast District Council (KCDC). She brought many existing relationships that would later prove helpful and she had the project management and negotiation skills. Motivated by a desire to contribute and learn, Gael became the project manager.

Ian Jarrett (Astarra Technology) had experience in solar and battery storage and was a business member of the Clean Technology Centre in Otaki. Ian did the initial sizing and scoping and was able to judge merits of the proposals from suppliers.

The community had several contractors, technical experts and community leaders who could provide advice along the way as needed.

Success Factors

Energise Ōtaki describes five factors that were key to their success:

- It was important to have a core team of people who were dedicated, persistent and had the foundational skills to initiate, develop and manage the project. Importantly, they had someone with enough knowledge of power systems to hold their own in discussions with industry players and contractors.
- They had established relationships with key stakeholders such as KCDC who would ultimately purchase the energy and lease them the land. This enabled them to get the first meeting and build on the relationship.
- They had people who could think strategically. Not just about the project, but what the project could mean in the broader context of the community. This was key to securing the financing for the project and the ongoing contribution to the community.
- They were able to figure out who had the requisite skills in the community and were able to enrol them to in contributing to the extent that they could and stay engaged throughout the project.

The Rau Kūmara project on opening day

- They were organized and efficient in the use of resources and people's time. They started as a loose coalition but became a functional organization with clear governance and management roles. They worked as a coherent team.

In combination, these factors gave EO the credibility and gravitas to be taken seriously by outside parties and to be able to execute at a pace that maintained momentum which was most important in dealing with risk adverse stakeholders.

Recipe for Success

They knew that they wanted to create a renewable energy project that would generate revenue for community initiatives. Previous projects had been on a smaller scale with less structure and risk and external stakeholder engagement.

The trick was to get three primary elements all lined up at the same time: the funding, the commitment of the land, the off-taker (purchaser of the energy) and the physical plant construction.

Off-taker or purchaser of the power:

EO did a broad scan of loads (under its intern program) on the local grid to understand location, size and how they were used and managed. There were consumer loads, retail store loads and industrial loads. Consumer loads where too distributed and retail loads individually were too small but industrial loads were large and managed by a single entity that could be readily negotiated with. EO was looking for a "behind the meter" circumstance to reduce complexity and maximize the value of the energy.

Kapiti Coast District Council (KCDC), is the big game in town both in terms of electricity use and land holdings so it made sense that they might have a stable load that an energy project could serve. In addition, EO had a good current and historical relationships with all levels of council (political and operational). Ultimately, the best KCDC load identified ended up being behind the meter at the Otaki Waste Water Treatment Plant (OWWTP). This was ideal for solar as it predominantly runs electrical pumps for the water treatment.

Generation Technology:

EO evaluated several generation technologies but settled relatively quickly on solar versus other technologies. Firstly, it was resource that they had and secondly it was modular so could be built at the right scale. They also decided to do a relatively large installation (over 100kW which at the time of inception was one of the largest in the country) so that they could have significant impact. A key was to model the demand, loads and financial return.

Funding:

EO were searching for a single source rather than cobbling together a coalition of funders although the cobbling option was a fallback if necessary. Ultimately, both energy projects were funded with a $407,000 grant from the Wellington Community Trust.

An absolute key to securing this funding was Energise Otaki's development of a model which would return the revenue to the community via community change focused projects. This is what attracted the Community Trust who could see an on-going return to the community on their investment. In effect the financial model was worked out at the outset as a way to contribute to the community and attract funders. Thinking outside the box on this was key.

This focussed, clear decision making and reduction in complexity, enabled EO to work relatively quickly and build credibility with third parties and stakeholders.

Governance

Initially, for Energise Otaki overall, and well before the solar installation conception, the group functioned as an umbrella reference group for ideas. To get the ball rolling for financial activities, Leigh's existing commercial entity served as an umbrella organization. This involved using a spare bank account and having a separate person monitoring it until EO could be established as a legal entity. EO moved to an Incorporated Society Inc. structure which evolved the people in the reference group into the legal entity. This structure lasted several years until EO outgrew this structure and took legal advice that EO move to a trustee (charitable) structure. EO is now a charitable trust governed by a committee of trustees.

The physical project

In October 2020, Energise Ōtaki commissioned a 23kWp solar PV system at Ōtaki College and a 107 kWp system at the Ōtaki Wastewater Treatment Plant. The energy generated is used at the College and to run the Council's wastewater treatment process. Behind the meter energy is billed to both the college and the council and excess export power is sold back to the retailer. Proceeds from these electricity sales are put into the Whakahiko Ōtaki – Energise Ōtaki Fund to support community-initiated energy projects.

The remainder of this case study focuses only on the system at the water treatment plant.

Key features or the system at the Ōtaki Wastewater Treatment Plant

- A ground-mounted solar farm facing north at a 25° angle
- 240 photovoltaic solar panels of 445W each (total of 106.8kWp) with four 3-phase Fronius Symo 80kW inverters.
- A peppercorn lease with KCDC for the land being used for the solar farm. This was a negotiation with council that had to be worked through as the land is owned by district-wide ratepayers. It was determined by council that the land was landlocked, that the OWWTP would not be needing the land for future expansion and it was part of an old landfill not fit for better use.

Contribution to the community

Starting in 2021, the Whakahiko Ōtaki – Energise Ōtaki fund is to be dispersed annually, according to funding criteria, to community energy projects. Governance of this fund is via an Energise Ōtaki sub-committee with representatives from Nga Hapu ō Ōtaki, Wellington Community Trust, Kāpiti Coast District Council and Energise Ōtaki. There is an estimated minimum $23k annual revenue from the two installations for reinvestment in community-initiated energy projects.

Engaging with funders

Energise Otaki knew that they needed to be able show a return on investment that was relevant to the funder. This meant a financial return, but they also needed to show how the money, that would be generated annually, would be used. Specifically, since their funder was the Wellington Community Trust (WCT) they needed to show that there would be a return to the community in ways that the WCT would ordinarily have funded anyway.

The financial model (how much value would be generated) was as important as the physical model (how the electricity would be generated).

The basic economics are that a $407,000 upfront investment generates $23,000 per year. On a straight-line basis this would pay back in 18 years. Since the project has a life of 20 to 25 years, they can expect to generate about $575,000 over the life of the project for the community. Therefore, WCT can deliver 50% more value by doing this project than by investing directly in the community projects. Of course, there are variables that would make this number go up or down but there is a demonstrable payback. In addition, since the proceeds are distributed to projects decided by the community, WCT can be assured that this is the highest and best use of the funds in the eyes of the community.

In many ways the EO model is ingenious in its simplicity and directness with which it serves the community – that is to build an asset that generates revenue and then use that revenue annuity to fund community led initiatives for the commercial life of the project.

However, to fully commit the funding, WCT needed to see that they had signed contracts with the landowner. This was difficult to do as they could not sign without knowing the funding was assured. This was eventually solved by lining everything up so that it was all agreed and signed at the same time and by making each contingent on the other. This required a degree of trust of the key stakeholders.

Engaging with off-taker (and in this case the land owner)

Since the project was to be built on local council (KCDC) land and KCDC would also be buying the power, EO needed the council to say yes to three key things:

- Yes, that they could lease the land on a peppercorn lease of $1 per year.
- Yes, that they would take the power and that they would pay the same price for the power as they were currently paying from their existing retailer.
- Yes, that they would allow EO to assess and count the export value of energy going through their ICP connection.

First, EO got the operational team to say yes and then they got the elected officials to say yes to the project in concept. Getting the sequence right is important as elected officials rely on the operational team to understand the details and act in the commercial interest of the constituents. The conceptual yes, aligned the operational team to negotiate in good faith.

Since the land is ring fenced (land locked), adjacent to the waste water treatment plant and a former dump site it was of little alternative value so it was relatively non-controversial that EO would be able to lease it for a nominal $1 per year. In addition, the substation is close by. The land was zoned for industrial, so EO needed to change the designation to simplify the consenting process. A resource consent was not required as solar farms are considered a controlled entity in the district.

The negotiation on the power off-take and price was more difficult. The council argued that there should be a discount on the price otherwise why would they switch. EO argued that this was for the benefit of the community which the council also serves. Of course, there are differences in the definition of the community for each and the council can't be seen to be biasing positive or negative toward one segment of the community. Ultimately, the impasse was resolved by allocating the green credits from the solar project to the KCDC as a non-financial deal sweetener. Since the EO project is less than 1 MW they do not need to pay the Electricity Authority (EA) registration fee so could pass that savings on to the KCDC.

Although the chances of electricity costs declining significantly are slim, EO carries some downside risk. If the price that council is paying for electricity from its retailer is reduced then council will pay the reduced rate to Energise Otaki. Since the project was grant funded, they are not servicing any debt so this merely impacts their ability to fund grants.

To enable the electricity to be procured by KCDC, EO and the council had to be with the same retailer (Meridian). Rather than use a formal Power Purchase Agreement (PPA), a contract for the energy sale to KCDC was drafted from scratch by EO and negotiated.

A check meter at the solar site and another at pumping station ensure that there is accurate accounting on a 30-minute basis for what is produced and used. The meters compare the energy generated by the on-site solar to the energy used at the pumping station. This amount of energy is then multiplied by the corresponding time of use rate (there are 3 tiers.) This is tallied and invoiced at the end of each month.

The excess energy is exported through the meter at the pumping plant. Since any export must have come from the solar project this is allocated to Meridian via a direct passthrough from the KCDC electric bill. KCDC has direct access to the spot market through Meridian, the retailer. For each 30-minute period they get the market price multiplied by the kWh exported.

The negotiations and complex workings of this required both parties and the retailer to work in good-faith and EO developed IP for this financial model to be put in place.

Engaging with the lines company

Electra, the local lines company, engaged to enable the project to get connected. As part of the interconnection, EO had to install an import/export meter and run a cable to the switchboard but no upgrade was needed to the substation.

Over time the relationship has strengthened and EO and Electra are looking at more creative approaches for future projects.

Engaging with contractors

Led by Ian Jarrett, EO put together a bid package for the project and ran a contestable RFP process to solicit proposals for the solar array. One of the challenges was that they received a very wide range of bids in terms of quality, detail and price. It is still common for contractors to simply provide a total cost estimate and be opaque or non-committal about the type of equipment they will use, to break out parts and labour and to show where cost reductions might be possible. There might also have been an incorrect assumption that, because EO was a community group, they might lack expertise or savvy and could be taken advantage of. One of the clearest and most detailed proposals came from Infratec who have done extensive work on energy projects in the Pacific Islands. It broke down the costs in several categories with labour rates, cost for civil works, panels etc., Their price was toward higher end however. After further discussion between EO and Infratec, in order to ensure fairness, they settled on doing the project open book with a reasonable margin for Infratec. Infratec did the array design and was the overall project manager and dealt with the interconnection, Electra, access to the grid for export and all the physical construction third parties including the two subcontractors. EO managed any consenting matters of which there were few. Because the land was within a designation EO simply had to provide information that the installation was consistent with the designation. No RMA consent process was required beyond that.

Infratec also set up all the guarantees from the various parties to ensure that the work was done correctly. Hoskins Energy Systems built the array and Pritchard civil did the civil works pritchardcivil.co.nz. There were some geotech surprizes as the land was found to have hard rock below the river silts. This increased the cost of the civil works but did not affect the size of the array. The key issue was to ensure that the ground works did not affect the PV supplier guarantee, which ultimately was unaffected. The final plant was 106.8kW – a bit smaller than the original plan. One of the benefits of solar is that it can be scaled up or down depending on the budget and hiccups along the way.

EO decided to go for top quality components like Fronius invertors so that they could be assured that it would work over the long term.

The project went operational in 2021 and is expected to deliver revenue to the community for the next 25 years.

Operations

To deliver the revenue according to forecast, the plant needs to be operated and maintained and the running costs kept in check. This requires a manager, at least part time, to reconcile revenue and ensure the grounds are maintained and the panels kept clean. One of the surprises was the cost of insurance. Few insurers had experience with solar and assessed a premium for it being ground mounted even though it is in a difficult to access, fenced-in location that should present very little increased risk compared to roof mounted. Understanding the ongoing maintenance costs is also import to creating an accurate assessment of the net cash flow that will be delivered from the project.

Future plans

EO plans to expand the system to potentially megawatts size and also incorporate of end-of-life EV batteries to provide stationary power storage all of which are positively welcomed by the stakeholders.

Ara Ake
Future
Energy
Development

Address: 8 Young Street, New Plymouth 4310
Email: info@araake.co.nz
www.araake.co.nz