Understanding the electricity ecosystem in Aotearoa New Zealand

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Future Energy Development

The electricity landscape in Aotearoa New Zealand

Overview

Understanding the participants in the electricity landscape in Aotearoa New Zealand is indeed crucial for the success of a community energy project. By understanding the business models, regulatory constraints, and dynamics of these participants in the electricity landscape, you can better navigate the opportunities and challenges for your community energy project. This knowledge can help you identify potential collaborators, assess market conditions, and ensure compliance with relevant regulations. Here are some key players and factors to consider:

Electricity retailers: These are companies that sell electricity directly to consumers. They procure electricity from generators, including renewable energy sources, and offer various pricing plans and services to residential, commercial, and industrial customers.

Electricity generators: Generators produce electricity from various sources such as hydro, geothermal, wind, solar, and thermal (gas or coal). They play a significant role in the overall electricity supply mix in New Zealand.

Transpower: Transpower is the national grid operator responsible for the transmission of electricity across the country. They own and manage the high-voltage transmission lines and associated infrastructure, ensuring electricity is transmitted reliably and efficiently.

Lines companies: These are regional or local companies responsible for the distribution of electricity from the national grid to homes, businesses, and other end-users. They own and maintain the local electricity distribution networks.

Electricity Authority: The Electricity Authority is an independent regulator that oversees the electricity market in New Zealand. They are responsible for promoting competition, ensuring efficient operation, and protecting consumers' interests.

Regulations and policies: The electricity sector in New Zealand is governed by various regulations and policies that aim to ensure fair competition, grid reliability, and environmental sustainability. These include the Electricity Industry Act, the Commerce Act, the Resource Management Act, and the New Zealand Emissions Trading Scheme, among others.

Further details

Retailers

Gentailers, which are companies that both generate and retail electricity, hold a significant market share, accounting for about 90% of the electricity sold to consumers. The remaining 10% is sold by independent retailers who do not own generation assets.

Hedging contracts play a crucial role for retailers and large businesses in managing price risk. By entering into hedging contracts, they can lock in the price of power for a specific period, typically up to three years. This allows them to mitigate the impact of dramatic wholesale price increases. If a retailer is unable to hedge effectively and experiences a substantial increase in wholesale prices, they may be forced to sell electricity at a loss, which can ultimately lead to financial difficulties and potentially going out of business. Gentailers, with their ownership of generation assets, have the advantage of being less affected by wholesale price fluctuations. They can balance losses on the retailing side with profits from their generation activities and vice versa.

When choosing a retailer for a community energy project, it is important to assess whether they have the capability and capital to navigate the complexities of the market. Selecting a retailer who understands the value of your project and is willing to provide fair market access is crucial for the economic viability of the project. This ensures that you can secure a favourable agreement that aligns with your project's goals and financial sustainability.

Generation

In New Zealand, the majority of power generation is conducted by the Gentailers. These companies play a significant role in the power sector, as they generate and sell about 90% of the power consumed by residents.

The remaining portion of the power generation comes from independent entities known as Independent Power Producers (IPPs) and individuals or organisations with small-scale projects such as Community Energy Projects (CEPs) and home generation. These may involve renewable energy sources such as solar panels, wind turbines, or micro-hydro systems. While their individual contributions may be relatively small, collectively, these distributed generation sources can make a positive impact on the overall energy landscape by diversifying the generation mix and promoting sustainability.

The presence of IPPs and small-scale generators adds diversity to the power generation sector, enabling a mix of large-scale and decentralised generation sources in Aotearoa New Zealand. This diversification supports the transition towards a more sustainable and resilient energy system.

Transpower – Transmission Grid and System Operator

Transpower plays a crucial role in the electricity industry of Aotearoa New Zealand as the owner and operator of the transmission grid. It is a state-owned enterprise responsible for ensuring the reliable and efficient transmission of electricity across the country.

As the System Operator, Transpower manages the real-time operation of the transmission grid and the physical operation of the electricity market. Their primary objective is to maintain the security and stability of the grid by balancing electricity supply and demand in real time. One of the outputs of their operation is the determination of the wholesale market spot price, which reflects the current supply and demand conditions.

For large-scale community energy projects, it may be necessary to directly connect to Transpower's transmission grid, especially if the project generates a significant amount of electricity. This connection allows for the direct transmission of electricity from the project to the grid. However, most community energy projects do not engage directly with Transpower but rather rely on their relationships with electricity distribution businesses and retailers to manage any transmission-related matters.

Electricity Distribution Businesses (EDBs) or Lines companies

Electricity Distribution Businesses (EDBs) play a critical role in the success of community energy projects in Aotearoa New Zealand. EDBs are responsible for the distribution of electricity from the Transpower transmission network to consumers, including businesses, communities, and homeowners, within their respective regions.

The primary function of an EDB is to ensure the safe and reliable delivery of electricity to consumers, ensuring that the "lights stay on". They maintain and operate the distribution network infrastructure, including power lines, substations, and other equipment necessary for the local distribution of electricity.

Aotearoa New Zealand has 29 EDBs, and they vary in size, ownership structure, and operational approach. Some EDBs, such as Vector in Auckland, serve large urban and rural populations, catering to over one million people. Others serve smaller communities, like Buller Electricity, which serves a rural population of fewer than 5,000 people on the West Coast. Roughly half of the EDBs are considered consumer-owned, while a few, like Orion and Aurora, are fully or partially owned by local councils through holding companies.

For community energy projects, EDBs are often responsible for connecting these projects to the local distribution network and ensuring their integration into the electricity grid. They provide the necessary infrastructure and support to enable the flow of electricity generated by community projects to reach consumers reliably.

Establishing a positive relationship with the local EDB is crucial for community energy projects. Collaboration and communication with the EDB can help navigate technical requirements, connection processes, and any regulatory considerations. Working together, community energy projects and EDBs can contribute to a more sustainable and resilient energy system at the local level.

Understanding your EDB

EDBs have the responsibility of maintaining and upgrading the local electricity network to meet the demands of the changing energy landscape. They must ensure that the network can handle both the power injected into it and the power drawn from it by consumers. Proper management and maintenance of the grid are essential to prevent hazards such as fires, property damage, and harm to workers and the public.

Since the early 2000s, the integration of distributed energy resources (DERs) into the distribution network has presented new challenges for EDBs. With energy generation happening at the distribution network level, managing power quality, including voltage and power factor, has become more complex. There is also a risk of energising lines that are supposed to be disconnected during maintenance or outages. Unlike centralised power plants that have contractual agreements for electricity production, DERs often deliver energy on an ad hoc basis, making network management more challenging. This requires EDBs to have more detailed information about the distribution grid and develop complex relationships with a large number of prosumers (consumers who also generate energy).

Additionally, the integration of new and large loads like electric vehicles (EVs) without the EDBs' prior knowledge adds further complexity. Depending on how DERs are configured and managed, they can either help or create difficulties in grid management. This new role has forced EDBs to adopt new technologies, acquire new skills, implement new processes, and adopt new attitudes.

While there is a growing awareness within EDBs about the benefits of DERs and CEPs, they may be constrained by regulations, limitations on what they can do, and financial considerations. Overcoming regulatory and financial constraints may require collaboration and innovative approaches to enable the successful integration of DERs into the network.

The Electricity Authority (EA)[1]

The EA is responsible for regulating the electricity market in order to serve the long-term benefit of consumers. One of their key functions is developing, monitoring, and enforcing the Electricity Industry Participation Code 2010, commonly referred to as "the Code." This Code establishes the rules and obligations for industry participants operating in the electricity market. Understanding the Code can greatly assist in discussions with counterparties. Section 6 of the Code is particularly relevant for CEPs. This section covers specific provisions related to CEPs participating in the wholesale market, addressing their rights, obligations, and any unique requirements they need to fulfil.

The Commerce Commission (ComCom)[2]

ComCom plays a significant role in enforcing the Fair Trading and Commerce Acts. These acts are designed to promote competition and protect consumer interests in various sectors, including the electricity industry. ComCom has a regulatory role in overseeing the transmission and distribution businesses in the electricity sector. These are typically natural monopoly services where there is limited or no competition. ComCom's regulatory oversight aims to ensure these businesses operate efficiently and provide reliable and affordable services to consumers.

Ministry of Business, Innovation and Employment (MBIE)[3]

MBIE serves the electricity sector, along with 18 other sectors. It goes beyond the regulatory responsibilities as they actively engage in promoting innovation and supporting the development of the sector through grants, funding opportunities, and initiatives.

An example of MBIE's support is their recent provision of grants to Māori communities for building Community Energy Projects (CEPs). These grants aim to empower Māori communities in their renewable energy initiatives and contribute to the development of sustainable energy solutions.

For your CEP, there might be potential opportunities to obtain funding or other forms of assistance from MBIE, depending on whether they have initiatives that align with your project's profile at the time. Monitoring MBIE's website, reports, and announcements can provide valuable information regarding their ongoing initiatives, funding programs, and available resources that may be relevant to your CEP.

Energy Efficiency and Conservation Authority (EECA)[4]

EECA is a Government agency that plays a crucial role in promoting energy efficiency, energy conservation, and the use of renewable energy sources. Since its establishment in 1992, EECA has focused on delivering energy efficiency programs primarily targeted at low-income homeowners and businesses.

EECA's programs aim to improve energy efficiency in buildings, appliances, and industrial processes. They set standards for energy efficiency in residential, commercial, and industrial products sold in New Zealand, ensuring that energy-efficient options are available to consumers.

In addition to their focus on energy efficiency, EECA also implements initiatives related to electric and low-emission vehicles. They provide funds and support for the adoption of electric vehicles and the development of charging infrastructure.

While EECA provides information and guidance on renewable energy, they generally do not provide direct financial assistance to Community Energy Projects (CEPs). However, even though direct financial assistance may not be available from EECA for CEPs, their expertise and resources in promoting energy efficiency and renewable energy can still be valuable.

Utility Disputes[5]

The Utility Disputes Commission (UDC) is an independent body that provides a free and fair resolution process for disputes between consumers and utilities, including electricity providers. The UDC specialises in handling disputes related to billing practices, customer service issues, and other matters concerning utility services.

If you encounter difficulties in resolving a dispute with an electricity industry player and are unable to reach an agreement through direct negotiations, engaging the UDC could be a viable escalation path. The UDC's mandate is to provide an impartial and independent forum for resolving such disputes, ensuring that both consumers and industry players have a fair opportunity to present their cases.

1 ea.govt.nz
2 comcom.govt.nz
3 mbie.govt.nz
4 eeca.govt.nz
5 udl.co.nz

Becoming fluent in electricity terminology

Power and Energy

Power refers to the ability to do work, while energy is the amount of work done over time.

In the context of electricity, power is typically measured in watts (W) or kilowatts (kW), where 1 kilowatt is equivalent to 1,000 watts. To compare power to a familiar unit, one horsepower is approximately 750 watts. However, when considering electricity consumption, it's not only the power that matters but also the length of time it is used. Therefore, electricity usage is measured in kilowatt-hours (kWh), where 1 kilowatt-hour is equivalent to using 1 kilowatt of power for 1 hour. In the electricity industry, kWh is commonly referred to as "units."

To illustrate the difference between power and energy, an efficient light bulb may have a power rating of 6 watts (6W), while a large heat pump can have a power rating of 6 kilowatts (6 kW), which is a thousand times larger. However, if both devices operate for the same duration, the heat pump would consume a significantly larger amount of energy (measured in kilowatt-hours) than the light bulb.

In any project, it is important to consider both power and energy requirements. The power rating indicates the maximum power that can be drawn from or supplied to the electrical grid, measured in kilowatts (kW). The energy consumption or usage is determined by the amount of power used over a specific period, measured in kilowatt-hours (kWh).

The CEP as a Distributed Energy Resource (DER)

In the context of Community Energy Projects (CEPs), they are often referred to as Distributed Energy Resources (DERs). Unlike large centralised power stations that are typically connected to the transmission grid, DERs are smaller-scale energy resources that are connected to the distribution network and located close to the customers they serve.

The US DOE Department of Energy defines DER (Distributed Energy Resource)[6]:
"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."

This definition highlights that DERs, including CEPs, have the capability to not only meet the energy needs of local customers but also contribute to the overall functioning of the distribution network. They can be utilised to reduce demand during peak periods, provide additional supply when needed, and contribute to the overall stability and reliability of the distribution system.

6 Interoperability Glossary - NARUC

The major categories of Distributed Energy Resources (DER)

The four major categories of Distributed Energy Resources (DERs): Energy Efficiency, Controllable Load, Storage, and Generation. These categories encompass the different aspects of energy assets that can contribute to a Community Energy Project (CEP). When designing a CEP, considering these categories in the order of impact can lead to more optimal outcomes. Starting with energy efficiency and controllable load can help reduce overall energy demand and make the most of available resources before considering additional generation or storage capacity.

As the complexity of the CEP increases, involving specialists or utilising energy modelling tools becomes more important to ensure a thorough analysis and informed decision-making. By carefully considering the interplay between energy efficiency, controllable load, storage, and generation, CEPs can maximise their impact, achieve better energy outcomes, and contribute to a more sustainable and resilient energy system.

Energy Efficiency – "The greenest energy is the energy we don't use"

Energy efficiency is often regarded as the lowest-cost energy option because reducing energy consumption through efficiency measures avoids the need to generate, transmit, or store additional energy. Every kilowatt-hour (kWh) of energy saved through energy efficiency measures directly translates into a reduction in energy demand and associated costs.

Optimising energy use through energy efficiency measures should be prioritised before considering additional generation or storage options. By addressing energy efficiency first, you can achieve significant energy savings and cost reductions.

Energy efficiency measures have the advantage of being applicable to a wide range of devices and systems that consume electricity. Examples include upgrading lighting to more efficient technologies, improving insulation to reduce heat loss, using heat pumps for space heating instead of conventional heaters, implementing heat pump hot water cylinders or solar hot water systems, and many more.

It's important to create a comprehensive list of energy efficiency possibilities and prioritise them based on your specific circumstances. Some energy efficiency measures may also provide the benefit of controllability, allowing you to manage and optimise your energy use, which can further enhance their value.

Controllable load

Controllable loads, such as smart appliances, hot water heaters, pumps, or electric vehicles (EVs), offer flexibility in their operation, allowing you to adjust their usage based on factors like electricity prices or availability of renewable energy.

By taking advantage of controllable loads, you can align your energy consumption with periods of lower electricity costs or higher availability of renewable energy. For example, running your dishwasher during the day when solar power is being generated or scheduling it to operate during off-peak hours when grid energy costs are lower can help optimise your energy usage.

Modern appliances often come with features that support load control. These may include timers, the ability to respond to price signals, or remote management capabilities. By leveraging these functionalities, you can automate the operation of your appliances to maximise cost savings.

Controllable loads can be internally controlled by you or externally controlled by an energy distribution business (EDB) or a Distributed Energy Resource (DER) aggregator. The choice between internal and external control depends on the trade-off you're willing to accept in terms of limiting your access to electricity for cost savings or having more personal control over your appliances.

It's important to ensure that controllable loads do not compromise safety, productivity, or comfort. For instance, restricting the use of lights only to daylight hours when solar energy is available may not be practical, or delaying the use of a heater until late at night for lower prices might not be worth sacrificing your health and comfort.

When considering the purchase of an EV and an EV charger, it's worth thinking about how you want the charging to be managed. Installing a charger with communication capabilities allows for future management by the CEP, DER aggregators, or the EDB. This enables optimised charging times and rates based on factors like grid conditions, electricity prices, or renewable energy availability.

Electricity Generation

There are many ways to generate electricity. This guide will focus predominately on solar PV as it is the most common and the most likely technology to be used in a CEP.

Solar PV

PV stands for photovoltaic, and it relies on the process of converting sunlight (photons) into electricity. The performance of a solar panel is indeed influenced by various factors, including the amount of direct sunlight (direct irradiance), diffused irradiance on cloudy days, and shading effects.

Shading can have a significant impact on the overall electricity generation of a solar panel or an entire string of panels. When a cell or portion of a panel is shaded, it creates a high resistance that reduces the electrical current flow through all cells. However, modern PV panels are designed with bypass diodes to mitigate this issue. Bypass diodes effectively divide the panel into two halves, so if shading occurs on one half, the other non-shaded half can still perform well. This arrangement allows panels to perform optimally even when some cells are shaded.

In residential settings, panel optimisers or micro-inverters are used to further enhance the performance of solar panels. Panel optimisers can mitigate the impact of shading by maximising the energy output of each individual panel. Micro-inverters, on the other hand, provide each panel with its own dedicated inverter, ensuring that shading or performance issues in one panel do not affect the output of other panels.

The daily solar production profile typically follows the path of the sun, gradually increasing in the morning, peaking around midday, and tapering off in the evening. The actual profile can vary based on factors such as cloud cover frequency and density. Additionally, the seasonal variation in solar production is influenced by local conditions. While solar production generally peaks in summer and decreases in mid-winter, specific regional factors like fog or clear cold winter days can influence the difference between summer and winter production rates.

Maximising the economic benefit of solar

Orientation

The optimal orientation for solar panels in Aotearoa is typically facing north at about a 30-degree angle from level ground. This orientation maximises overall energy production throughout the year. However, if you specifically want to maximise winter production, adjusting the tilt angle to 50 degrees can be more beneficial.

The orientation of the panels can impact energy production. Panels facing northeast or northwest generate slightly less energy (about 3% less) compared to panels facing due north. Panels facing due east or west experience a more significant reduction in production (about 20% less). If panels face south, the reduction in production is substantial, and in such cases, it may be better to have the panels installed flat.

In certain cases, you may have specific requirements or considerations that require an orientation other than north, such as if you want to generate more energy in the morning or evening. These nuances can be explored during the detailed design phase of the project.

To further investigate and estimate the energy production based on different tilts and orientations, you can utilise tools like the EECA GEN LESS Solar Power Calculator[7]. This calculator allows users to input various parameters and provides estimates on solar energy generation based on the inputs provided.

However, for residential and commercial installations, the determining factors for panel orientation are often the roof slope (which determines the panel tilt) and the roof orientation (which determines the PV array orientation). These practical considerations play a crucial role in determining the optimal orientation of the solar panels.

7 genless.govt.nz/for-everyone/at-home/explore-solar-energy/solar-power-calculator/

Other factors

It is generally more economically beneficial to consume the solar energy you generate rather than exporting it back to the grid. The value of self-consumption can be higher than the export rate provided by retailers. The decision to export or self-consume will depend on factors like your PV system's capacity and whether the local network can accommodate the amount of export.

By optimising self-consumption, you can increase the percentage of solar electricity that you use directly rather than exporting it. While most people typically self-consume around 30-40% of the solar electricity they produce, it is possible to increase this to 50-60% or even higher through various means. This can include using diverters and changing behaviour to align energy usage with solar generation. Additionally, integrating battery storage systems can further increase the amount of solar energy that you can utilise for self-consumption.

Shifting your energy usage to align with solar generation can result in cost savings. The varying sizes of loads and the significance of knowing your largest and most flexible loads are important when optimising the economics of solar energy. Here are some key considerations:

- **Load size variation:** Different loads have varying power requirements, with some loads, such as EV charging, being significantly larger than smaller loads like LED lights. Understanding the magnitude of your largest loads is crucial in determining the potential for load shifting and maximising the benefits of solar energy.
- **Shifting consumption vs. shifting generation:** By identifying the periods when your panels are most effective and aligning your energy usage accordingly, you can optimise self-consumption and reduce reliance on grid electricity during peak rate periods.
- **Fixed panel orientation:** If you're unable to shift your energy demand to when your panels are most efficient, you may consider orienting your panels in a fixed position that aligns with your highest power usage times. For example, if you primarily consume electricity in the afternoon after returning home, you could orientate your panels north-west to capture more afternoon sunlight. While this may result in slightly lower overall solar production, the increased production during your high-consumption periods can potentially lead to greater self-consumption.

Oversizing your solar array in relation to your inverter is another system design option that can have benefits. Inverters are typically sized based on the rated capacity of the solar array they are connected to. By oversizing the array in relation to the inverter, you can take better advantage of the inverter's capacity. For example, you may have a

6.5kW solar array but choose to use a 5kW inverter. This allows the inverter to operate closer to its maximum capacity more frequently. By oversizing the array, you increase the chances of producing power closer to the inverter's rated capacity, even in less-than-ideal conditions. This can result in more power generation over time.

Oversizing a solar array in relation to the inverter typically incurs minimal additional costs. The expense of adding a few extra panels is relatively small compared to the overall system cost. It's worth noting that oversizing the array should be done within the limits allowed by local regulations and the specifications of your chosen inverter.

Additionally, the effectiveness of oversizing will depend on factors such as the solar resource availability in your area and the specific conditions of your installation.

Automating energy-consuming devices and appliances can greatly enhance the optimisation of solar energy usage. Here are some examples related to electric hot water cylinders:

- **Electric hot water cylinder timer:** By using a timer, you can schedule the operation of your electric hot water cylinder to coincide with periods of high solar generation. This ensures that the cylinder primarily heats water when solar power is available, maximising self-consumption of solar energy. Additionally, you can program the timer to heat water during off-peak hours when electricity rates are lower.
- **Hot water diverter:** A hot water diverter is another solution that automatically redirects excess solar energy to heat the water in your cylinder. This device senses the surplus solar power being generated and diverts it to the hot water cylinder, reducing the need for grid electricity for water heating. Hot water diverters are designed to optimise the use of solar energy while ensuring that the temperature of the water is maintained at a desired level.

By considering these factors and implementing strategies to maximise self-consumption, you can enhance the economic benefits of your solar energy system.

Non-Solar PV Generator (overview)

Wind

Wind energy is generated by harnessing the kinetic energy of the wind to rotate the blades of a wind turbine, which in turn drives a generator to produce electricity.

Small wind turbines, typically up to 5kW in capacity, are suitable for individual households or small-scale applications. While they may not be as economically competitive as solar PV in many cases, they can complement solar energy by operating at different times, such as during the night or in periods of low solar generation. Small wind turbines can be useful for charging batteries, pumping water, or meeting specific energy needs.

Large wind turbines, with capacities ranging from several hundred kilowatts to multiple megawatts, are typically part of wind farms. Wind farms consist of multiple turbines operating together to generate electricity at a utility-scale level. Large wind turbines and wind farms are most economically viable when there is a favourable wind resource, as the energy production is directly dependent on wind availability. They require specialised skills and equipment for operation and maintenance (O&M), which are typically best suited for larger-scale wind installations.

Before considering the installation of a wind turbine, it is important to assess the wind resource at the specific location. This can be done by deploying a meteorological mast (met mast) to measure wind patterns and speeds over a period of at least two years. This data provides accurate information to evaluate the economic feasibility of a wind project. Alternatively, wind resource specialists can analyse historical wind data (hindcast) to estimate the wind resource at a particular site.

Hydro

Hydroelectric power harnesses the energy of flowing or falling water to generate electricity. In hydroelectric power systems, the energy of water is utilised to turn a rotor, which is connected to a generator, thereby converting the mechanical energy of the water into electrical energy. The water can come from various sources, such as rivers, streams, or stored reservoirs. If the water source, such as a river or spring, provides a consistent flow throughout the year, hydro power can offer a continuous and reliable source of electricity. This is particularly advantageous when compared to intermittent renewable energy sources like solar or wind.

Geothermal

Geothermal power harnesses the heat stored in the Earth's crust to generate electricity. Geothermal power plants extract heat from underground reservoirs of hot water or steam. The extracted hot water or steam is used to drive a turbine, which in turn drives a generator to produce electricity.

One of the advantages of geothermal power generation is the surplus heat that can be utilised for various purposes. The residual heat from the geothermal process can be used for direct heating in industrial processes, buildings, and homes.

Geothermal power plants require significant scale and investment due to the complex drilling and infrastructure needed to access the geothermal resource. The development costs for geothermal projects are typically in the tens of millions of dollars. Additionally, obtaining the necessary consents and permits for geothermal development can be a complex and lengthy process. Considering the scale, investment, and consenting issues associated with geothermal power generation, it may not be feasible for small community energy projects to consider geothermal as a viable option.

Biomass digestor

A biomass digester, also known as a biogas plant or anaerobic digester, is a system that utilises bacteria to break down organic biomass materials and produce biogas, primarily consisting of methane (CH4) and carbon dioxide (CO2).

The biomass digestor operates in an oxygen-free environment, where microorganisms decompose the biomass through anaerobic digestion. This process involves the breakdown of organic matter by bacteria, resulting in the production of biogas.

Biomass digesters use various organic materials as feedstock, including animal waste (such as manure), crop residues, food waste, and other organic byproducts. This makes them suitable for implementation in rural areas, agricultural settings, or locations with significant organic waste streams, such as landfill sites. The bacteria in the biomass digestor break down the feedstock, producing biogas as a byproduct. Biogas primarily consists of methane, which can be used as a renewable energy source. It can be combusted to generate heat or electricity, replacing fossil fuels and reducing greenhouse gas emissions.

In addition to electricity generation, biogas can also be utilised for combined heat and power (CHP) applications. The heat produced during the combustion process can be captured and used for heating purposes, increasing the overall efficiency of the system.

As part of the anaerobic digestion process, biomass digesters also produce a nutrient-rich digestate, which can be used as a natural fertiliser for agricultural purposes. This adds to the sustainability aspect of the technology by providing a valuable byproduct for soil enrichment.

Biomass digesters offer a way to convert organic waste into renewable energy while simultaneously providing a waste management solution and producing a valuable fertilizer. Their implementation is particularly suitable in rural areas, agricultural operations, and locations with ample organic waste resources.

Storage

Pumped Hydro

Pumped hydro storage is a form of energy storage that utilises the potential energy of water to store and generate electricity. It requires two reservoirs, one located at a higher elevation than the other. The upper reservoir acts as the storage reservoir, while the lower reservoir serves as the receiving reservoir. During periods of excess electricity generation, such as during the day when solar power is abundant, water is pumped from the lower reservoir to the upper reservoir using electric pumps. When electricity demand is high or during periods when renewable energy generation is low, the stored water in the upper reservoir is released, flowing down through turbines. The potential energy of the falling water is converted into electrical energy by the turbines, which drive generators to produce electricity.

Pumped hydro storage essentially allows for time-shifting of energy generation. Excess electricity generated during low-demand periods is used to pump water uphill and store it as potential energy. This stored energy can be released and used during high-demand periods or when renewable energy generation is limited.

Pumped hydro storage systems are known for their high energy efficiency, typically ranging from 70% to 85%. However, the construction and operation of pumped hydro storage systems require specific geographic conditions with suitable elevations, available water sources, and adequate land availability. Therefore, it is considered more suitable for specific locations with the right geographical features.

Pumped hydro storage is a proven and reliable energy storage technology that has been used for many years. It provides a means to store surplus energy from renewable sources and release it when needed, helping to balance grid demand and supply. However, due to its unique requirements and costs associated with infrastructure development, it is typically implemented on a larger scale and in areas with favourable geographic conditions.

Hot Water

Utilising a hot water system for energy storage can be an effective strategy to optimise energy usage and reduce costs. During periods of low-cost grid power or when self-generation from renewable sources is abundant, the hot water system is heated using electricity or another heat source (e.g., solar thermal). The hot water is stored in insulated tanks or reservoirs.

When electricity costs are high or when there is a demand for hot water, the stored hot water is used for various purposes such as space heating, domestic hot water supply or any other application that requires hot water. By utilising the stored thermal energy, the system reduces or eliminates the need for electricity to heat water during peak demand periods.

Storing energy as heat in the hot water system allows you to take advantage of lower-cost energy during off-peak hours or when self-generation is available. This can result in significant cost savings by avoiding the use of electricity during high-demand or peak-rate periods.

It's important to note that the stored thermal energy in the hot water system cannot be converted back into electricity. However, by utilising this stored energy for its intended purposes, you can effectively manage and optimise energy consumption, reducing the reliance on electrical heating elements and minimising peak electricity demand.

Batteries

Many solar installations are augmented with batteries, enabling storage of excess energy to be utilised when solar generation is low or not occurring. In a national grid perspective, of the installed renewable electricity capacity in Aotearoa New Zealand, 20% is associated with intermittent renewable energy systems (IRES) with little to no capacity for energy storage. There is potential to overcome this issue by combining IRES with stationary energy storage systems (i.e. batteries). With this kind of hybrid system, any excess energy produced by the plant at times of low demand may be stored to subsequently supply the grid at times of high demand, whilst also minimising the use of fossil fuels when attempting to match peak demand and overcome network constraints. The same principles are applicable to community energy projects.

Ara Ake has investigated different battery technologies and their report is downloadable at no cost.[8]

8 Stationary Battery Energy Storage Systems Analysis Report » Ara Ake

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