Get smart, think small

Local energy systems for New Zealand

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Contents

Preface

Energy is at the heart of our daily lives. It heats the water for our morning cuppa and shower, and on dark mornings lights the way to our mailbox and morning paper. Hot tea and a warm shower are just two services we derive from energy that usually comes from a distant source, such as a South Island hydro dam or a Taranaki gas field.

In our families or local businesses we have little or no control over these sources of energy nor the price of using them. We rely overwhelmingly on the bigger system and those who manage it. Usually this presents no problem but on occasion the system fails with far-reaching results – something downtown Wellington restaurateurs and hoteliers became acutely aware of early in September 2006 when water infiltrated their gas supply pipes leaving many with no gas for hot water or cooking.

From production and use of energy come many of the greenhouse gas emissions that are causing climate change. Human-induced climate change will dominate our future. To reduce the emissions we need to wring more value out of every unit of energy we produce. Climate change will also require us to build more resilient energy systems to withstand increasingly frequent extreme weather.

These concerns, in part, prompted this study. So did the opportunities now arising from the development of new energy technologies. These technologies will allow people to take more control of how they choose to provide their non-transport energy needs.

We refer to these as 'local energy' technologies and they offer a degree of control that's never before been achieved over how we source and manage our energy requirements. These technologies also present another means of improving the security of our electricity system.

As householders, consumers, and business operators, we can play a central role in expanding the development of local energy systems in New Zealand. In the future, decisions about how we use energy will be as important to us as where we live, the size of our houses, our children's schools, and where we go on holiday.

Studies indicate that promotion of energy efficiency is not, on its own, an adequate catalyst for change in the way we relate to energy, and it remains an invisible magic in our homes. Getting us to 'see' it and understand its value appears to require new stimuli. British research indicates that when some or all of the energy used in homes or businesses is sourced locally through technologies such as solar panels and other forms of microgeneration, and there are also technologies present such as smart meters that provide people with real time information, people do switch on and use energy more thoughtfully.[1] As the research concluded:

> *Making energy generation and management part and parcel of people's homes and schools may hold the key to empowering and engaging energy consumers for the first time.*[2]

It is up to us to grasp these opportunities to help transform our energy system, but what will be the catalysts? While this study indicates that significant potential exists for these technologies in New Zealand over the next 30 years, it also identifies many barriers.

Our culture of relying on large-unit, supply-side energy solutions is deeply ingrained. This is not to criticise how we have done things in the past – that approach reflected world best practice and has served us well. However, my plea is that we collectively accept we are rapidly moving into a very different world with new options, and our ideas of how to ensure energy security must change.

The catalysts must come from more than just promoting energy awareness through education programmes. As I discussed in my recent wind power report,[3] being able to invest in our rich endowment of renewable energy sources, particularly at the local level, will be part of re-evaluating how we think about energy and the way we use it.

As in other areas of New Zealand's energy sector, innovative leadership is needed. With appropriate Government support and investment, energy businesses need to promote and develop the new technologies.

Some SOEs, the Electricity Commission, and EECA have initiated programmes that are considering how these technologies will fit into the electricity system and what opportunities they might present. But these initiatives will struggle without an institutional and policy framework that recognises these new technologies do more than just provide energy services – they can also bring improved health, regional job creation, new opportunities for innovation, and reduced energy security risks.

Expanding our portfolio of energy solutions to include local energy requires catalysts for change, investment and, above all, leadership. Given New Zealand's energy challenges, it is not a time to be incremental and timid. While acknowledging current efforts, the recommendations in this report reflect this. I'm confident that, if implemented, they will lead to greater opportunities for many people and the unleashing of considerable energy.

Dr J. Morgan Williams
Parliamentary Commissioner for the Environment

Executive summary

New Zealand's electricity generating system is under pressure as electricity consumption rises each year. The response to this increased demand has been to build more large electricity generating plants. However, there is an alternative. Local energy systems can provide energy services without reliance on remote large-scale electricity generation.

Local energy systems have the potential to displace 16,000 GWh per year of electricity from large power stations in 30 years time, or much sooner if there is government support. This amount is more than the electricity consumed by the entire residential sector in 2005 (12,732 GWh) and about equal to industrial sector use (16,160 GWh) in the same year.

Local energy systems comprise several elements. At the core are technologies that produce electricity or heat, on a small scale, close to where it is used. Generating electricity on this scale is often referred to as microgeneration.

Other elements support this core element, including:

- technologies that control and manage the electricity or heat produced (control systems, meters, inverters, batteries)
- heat-capture technologies that make use of ambient heat for space or water heating
- measures that improve the thermal performance of the buildings where the locally-produced energy is used
- measures and technologies that manage the demand for energy services and maximise energy efficiency
- the attitudes and behaviours of people interacting with local energy systems.

The potential advantages of local energy systems include:

- making use of energy sources, particularly renewable sources, that are not suitable for large electricity generating plants
- reducing the use of non-renewable energy sources, and their related emissions of greenhouse gases
- increasing the overall efficiency and resilience of energy systems by spreading energy generation throughout the network
- improving energy security by making end-users more self-reliant
- promoting economic competition by introducing new technologies into the marketplace

- encouraging regional development by creating jobs in New Zealand for designers, manufacturers, and tradespeople
- raising individuals' awareness of energy use, leading to behavioural changes
- improving health and reducing 'fuel poverty' by delivering warmer homes at lower running costs.

Widespread adoption of local energy systems is held back by a number of factors, including:

- a lack of public awareness and understanding
- the market's failure to fully value all the benefits of local energy, making it comparatively expensive
- specific research gaps
- a lack of capacity in the local energy sector
- an absence of demonstration projects tailored to the New Zealand situation
- various institutional and regulatory barriers.

Overall, the evidence points to a compelling argument in favour of government intervention to kick-start local energy systems in New Zealand. This report sets out that argument, provides a quantitative analysis of the potential for local energy in New Zealand, examines the current barriers to its uptake, and provides recommendations for overcoming these barriers and moving into a local energy future.

CHAPTER 1

Introduction

The nationwide and local electricity grids, metering systems and regulatory arrangements that were created for a world of large-scale centralised power stations will need restructuring over the next 20 years to support the emergence of far more renewables and small-scale distributed electricity generation.[4]

Most New Zealanders enjoy quick and easy access to a reliable supply of energy. Electricity, in particular, is readily available at the flick of a switch. Most of this electricity is generated in large power plants and distributed through an elaborate transmission infrastructure to where it is needed.

However, there are other ways of thinking about how we generate and distribute electricity, and indeed how we use it in our homes, farms, offices, schools, and communities. Today we have an opportunity to reshape New Zealand's energy future by taking advantage of new technologies and techniques for managing our energy services[5] at a local level (see Figure 1.1). This report explores that opportunity.

1.1 What are local energy systems?

The term 'local energy systems' describes methods for providing energy services without depending on remote large-scale electricity generation. The idea of local energy is not new: fire, wind and water power have provided heat, pumped water, and ground grain on a local scale for thousands of years. However, nowadays local production of useful forms of energy, particularly electricity, can be accomplished more efficiently, with less effort, at lower cost, and with a greater degree of control than ever before.

Today, local energy is about:

- using energy resources that are not easily available for use by large electricity generating plants
- avoiding and reducing greenhouse gas emissions
- generating and using energy efficiently
- avoiding the environmental harm caused by large electricity generating plants.

Local energy systems can use technologies that are common today, such as wood burners and diesel generators, as well as new and emerging technologies such as micro wind turbines, micro hydro turbines, solar photovoltaics, Stirling engines, and fuel cells.

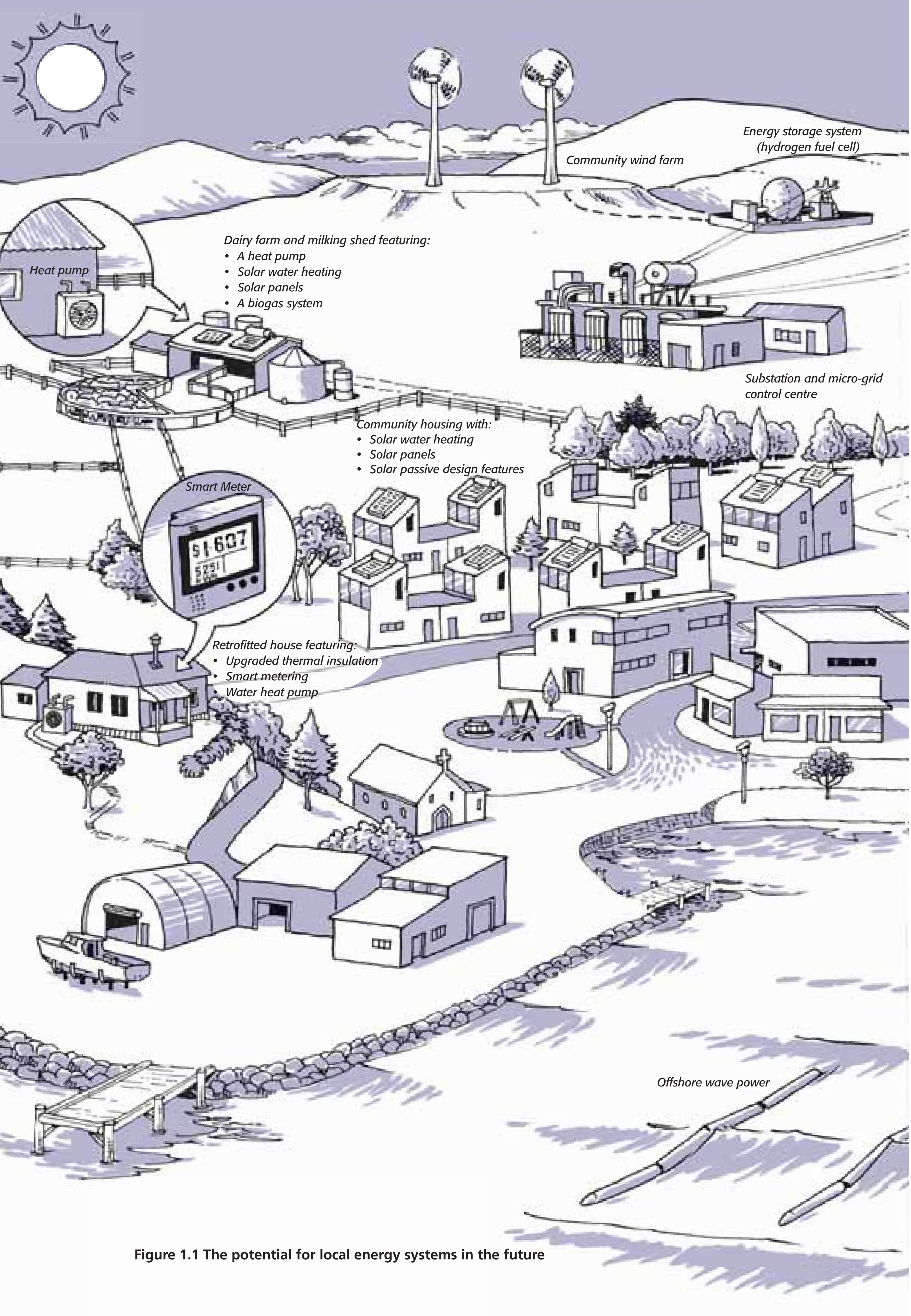
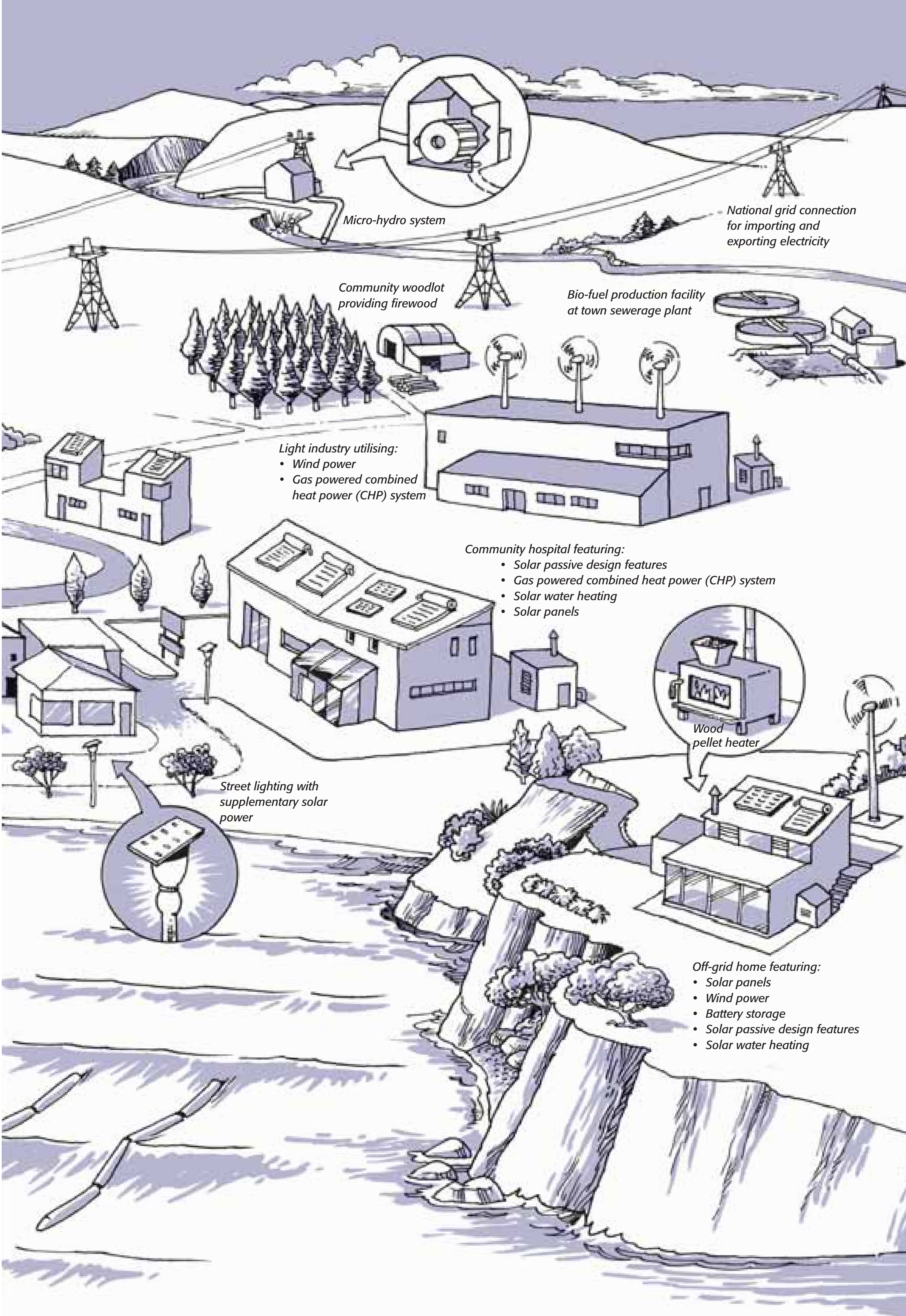


Figure 1.1 The potential for local energy systems in the future


Micro-hydro system
National grid connection for importing and exporting electricity
Community woodlot providing firewood
Bio-fuel production facility at town sewerage plant
Light industry utilising:
• Wind power
• Gas powered combined heat power (CHP) system
Community hospital featuring:
• Solar passive design features
• Gas powered combined heat power (CHP) system
• Solar water heating
• Solar panels
Wood pellet heater
Street lighting with supplementary solar power
Off-grid home featuring:
• Solar panels
• Wind power
• Battery storage
• Solar passive design features
• Solar water heating

A local energy system comprises several elements. At the core of such a system is the small-scale production of electricity, heat, or a combination of electricity and heat, close to where people will use it. The small-scale production of energy is called microgeneration.[6]

Closely associated with microgeneration is a group of technologies that control and manage the flow of energy, particularly electricity. These enabling technologies include smart control systems, energy storage technologies and, in the future when individual systems are linked, micro grids and smart grids.

Local energy systems also use technologies and techniques that support microgeneration either by delivering supplementary energy services, or by making maximum use of each unit of energy produced. These supportive technologies include those that capture ambient heat, such as solar hot water heaters and heat pumps, and measures that improve the thermal and lighting performance of buildings, such as passive solar design of buildings, roof insulation, and double-glazing.

Measures that provide the maximum value or service for each unit of energy produced form the last technical element of local energy systems. These measures improve end-use energy efficiency and enable demand to be managed prudently.

Finally, local energy systems are not just about technologies: they have an important human dimension. To be successful the users of these systems have to be actively involved in their design and operation.

In this report, we use the term 'local energy systems' to convey the idea that while microgeneration technologies are crucial in providing energy services to homes and communities, they are only part of the 'jigsaw', and should not be considered in isolation. This jigsaw concept is discussed further in Sections 2.3 and 2.4.

1.2 Why should we consider local energy systems for New Zealand?

The amount of electricity used in New Zealand has almost doubled over the last 25 years, and during the last decade it has increased by over 20 percent (1.8 percent per year).[7] The Government predicts that electricity use will keep growing by about 1.2 percent each year.[8] Large electricity generating plants using hydro, gas, coal or geothermal energy sources have provided most of this electricity.[9] In the future, however, new ways to satisfy the growing demand for electricity will need to be found.

Today's debate revolves around whether the way to meet this future demand is by building more large generating plants, or whether local energy systems can provide a feasible alternative solution.

Building large electricity generating plants in New Zealand is becoming more challenging.

- The best large hydro sites have already been developed, and most of the remaining big rivers have significant conservation values.[10]
- The known large gas fields (Maui, Pohokura, Kapuni, and Kupe) will run down over the next 25 years.[11]
- Large reserves of coal remain, but burning coal produces greenhouse gases and conflicts with New Zealand's Kyoto Protocol commitments to reduce emissions of these gases.
- Large geothermal plants and wind farms could contribute significantly to future electricity generation.[12] However, growing public opposition to the development of new large projects adds to their cost.

In contrast, local energy systems have the potential to displace a significant proportion of the future electricity demand that would otherwise require investment in new large plants.

This report argues that local energy systems can advance and strengthen New Zealand's energy system by complementing the current centralised energy system and making better use of the wealth of renewable resources available here.

New Zealand stakeholders and research institutions are researching ways of improving our knowledge and use of local energy technologies. However, there has been no serious attempt so far to provide a comprehensive programme to identify appropriate technologies and assess their potential use in New Zealand.

1.3 Why has the PCE prepared this report?

The Parliamentary Commissioner for the Environment (PCE) has ongoing work in the electricity, energy, and environment spheres. Each year we independently assess the environmental performance of New Zealand's electricity sector.[13] We have identified four main objectives for the sector as part of this assessment process:

- managing growth in electricity demand
- promoting renewable energy
- promoting the electricity system's security and efficiency
- minimising environmental impacts.[14]

The PCE considers that local energy systems can contribute significantly to achieving these objectives. This belief is also consistent with:

- the objectives in the Electricity Act 1992
- the Government's stated policy of promoting demand-side management and energy efficiency

- removing the barriers to investment in new generation technologies especially those that are based on renewable sources of energy and distributed generation technologies[15]
- New Zealand moving towards meeting its Kyoto Protocol obligations to reduce greenhouse gas emissions.

Proposals to upgrade the national electricity grid, which is the heart of New Zealand's centralised electricity system, have also caused some concern. Investing in local energy systems may be a way to delay or avoid some of these grid upgrades. However, this report does not specifically examine alternatives to current grid upgrade plans.[16]

Finally, recent advances in microgeneration and energy management technologies (including metering and monitoring systems) mean it is timely to examine the potential for local energy systems in New Zealand.

1.4 What is the scope of this report?

This report is intended for policymakers, businesses, and entrepreneurs in the energy sector. It explores the potential for local energy systems in New Zealand, and gives guidance on how to encourage their development.

It is important to note that the scope of the report is not limited to microgeneration of electricity – an assumption often made when people are discussing how to produce energy. As well as electricity-generating technologies, local energy systems include heat-generation technologies, heat capture through building design, use of energy sources directly (such as using solar energy to heat water), energy efficiency measures, and other techniques for providing energy services to homes and communities.

Local energy systems can be developed on any scale – from homes and small businesses to large offices and community facilities such as schools and hospitals. They can even be used in large industrial facilities, although they are unlikely to make a major contribution to the demands of energy-intensive industries.

This report focuses on small-scale local energy that could be used by:

- individual households and neighbourhood networks
- farms
- small rural communities
- small- to medium-sized enterprises (SMEs) and community facilities.

Its main focus is on systems where the microgeneration output is typically up to 100 kW. However, this figure is arbitrary, and larger systems are conceivable for many of these applications, such as larger farms and enterprises.

We do not advocate any particular technologies or mix of technologies, as different technologies will be more or less suitable at specific sites for specific needs. We examine a range of well-established and emerging technologies that are (or could be) used in New Zealand.

1.4.1 What the report does not cover

We have excluded the energy demand of the transport sector from the scope of this report. This is because this report has come out of the Electricity, Energy, and the Environment (EEE) work programme of the Commissioner, which focuses on electricity and closely related energy sectors (e.g. the natural gas and coal sectors).[17] Furthermore, the transport sector is, so far, largely distinct from the stationary energy sector; although this is set to change with the increased use of biofuels, fuel cells, plug-in hybrids and other forms of transport using reticulated electricity.

1.4.2 The structure of the report

This introductory chapter has provided an overview of local energy systems, and why it is timely to consider their adoption in New Zealand.

Chapter 2 provides more detail about local energy systems and their associated technologies.

Chapter 3 outlines the benefits of local energy systems compared with using electricity from large generating plants.

Chapter 4 analyses the potential for uptake of these systems in New Zealand, **Chapter 5** discusses the barriers, and **Chapter 6** looks at the institutional and regulatory framework.

Chapter 7 looks ahead with recommendations for action.

CHAPTER 2

The nature of local energy systems

This chapter provides a brief history of the New Zealand energy system, and looks at how local energy can form part of its future (Sections 2.1 and 2.2). It then describes the parts of the local energy jigsaw (Section 2.3), and how these parts fit together as integrated energy service delivery systems (Section 2.4). Two case studies demonstrate how local energy is being used now in New Zealand.

2.1 The evolution of New Zealand's energy system

New Zealand is a country that is richly endowed with energy resources (see Figure 2.1). Before European settlement, Maori used wood and other similar forms of biomass and geothermal energy for their cooking and heating needs.

By the early 20th century, New Zealand's energy system was still mostly based on locally available resources. People burned wood and coal for heat and electric power, and built small hydro schemes in local waterways to generate electricity. Local authorities and private companies initiated small-scale energy generation projects to meet local needs, and many towns had their own coal gas (gasification of coal) production plants.

From the 1920s onwards, a more centralised energy system took shape. The Government made major investments in large-scale electricity infrastructure as New Zealand followed the lead of other industrial countries. Increasingly, electricity was generated by large power plants located near concentrated energy sources such as fast-flowing rivers, geothermal hot spots and accessible coal resources.

The main hydro power plants were developed on the Waitaki and Clutha rivers in the South Island and on the Waikato river system in the North Island between the 1930s and the 1980s. The Manapouri hydro power plant in Fiordland was constructed in the late 1960s. The first coal-fired power plant was built at Meremere in 1958 and decommissioned in 1990. The coal and gas fired Huntly power plant was commissioned in 1983 and, at 1000 MW, remains the largest power plant in New Zealand today. Wairakei, commissioned in 1958, was one of the world's first geothermal power plants.

The late 1990s introduced a period of development based on using high efficiency gas-fired combined cycle power plants for electricity generation (e.g. Southdown in 1997, Taranaki Combined Cycle plant in 1998, and Otahuhu B in 2000). More recently, power development has focused on wind power: the small Hau Nui wind farm in 1996, Tararua I in 2000, and Te Apiti in 2004 (see PCE, 2006b). New wind power projects to generate over 1000 MW are under consideration.

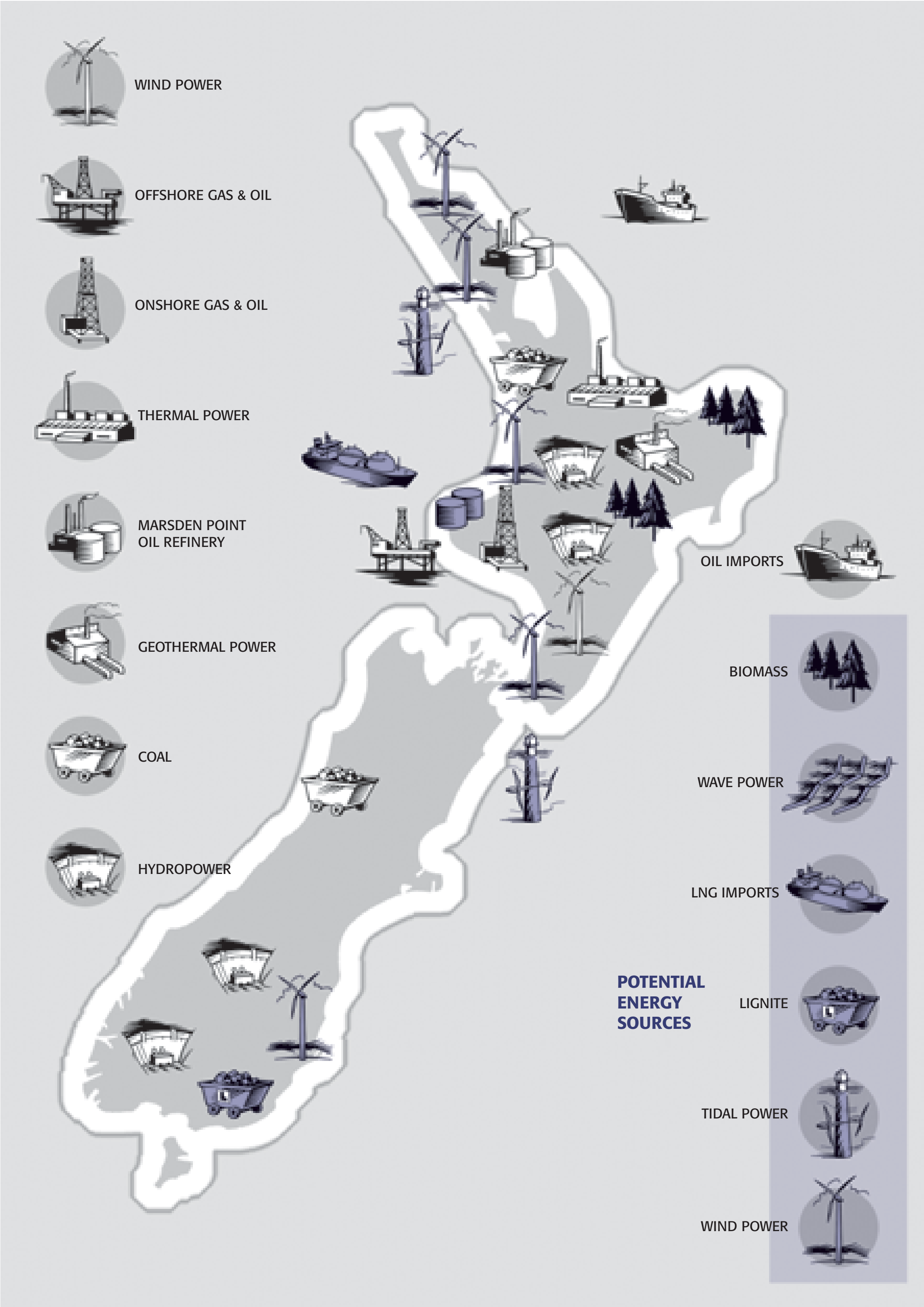


Figure 2.1 Existing and potential energy sources in New Zealand

Towards the end of the 20th century, gas from the large Maui field started to play an influential role in New Zealand's energy system. In the North Island, some of this gas was transmitted at high pressure and distributed at low and medium pressure to homes and businesses for direct use (for cooking, and space and water heating). However, most of the gas (excluding that used in the petrochemicals industry) was used in large North Island power plants to generate electricity. The South Island did not have access to the natural gas source or distribution system but relied on Liquid Petroleum Gas (LPG) that was shipped to ports in Canterbury and Otago.

The result of all these developments is that today New Zealand has a centralised transmission and distribution system, where most electricity and gas is generated or sourced far from where people live and use energy. It is based on large power plants that are connected to an extensive network of long-distance transmission lines feeding local power networks and lines. The electricity network allows the system operator to dispatch generation as required, optimise the flows of electricity, and ensure that there is capacity ready to support the system as required. However, the power flows only in one direction: from a central power station, through transmission lines to local distribution networks, and on to electricity users (see Figure 2.2).

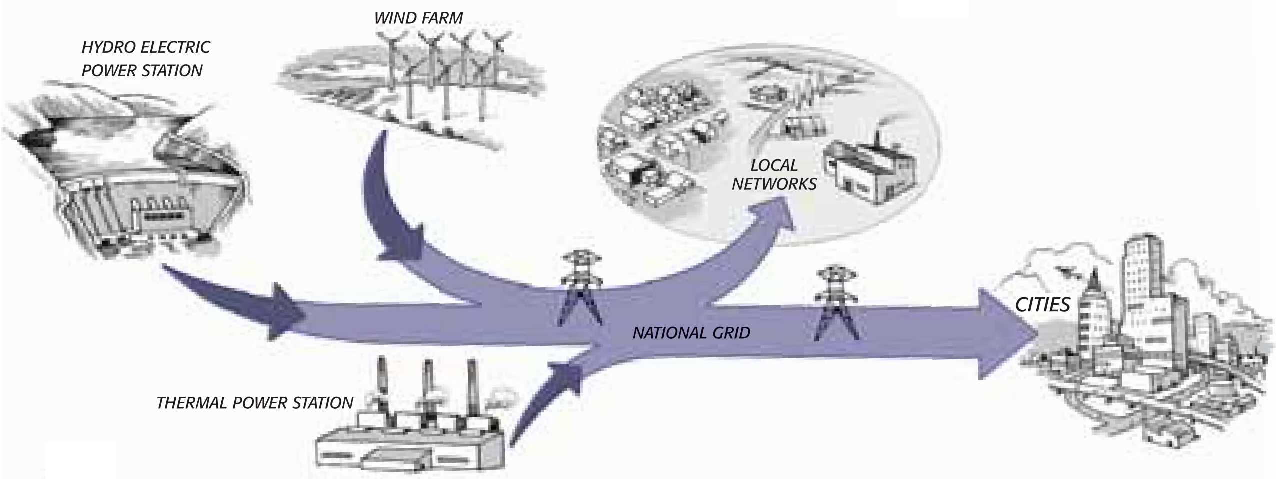


Figure 2.2 Diagram of New Zealand's electricity system

2.2 An alternative future for New Zealand's energy system

Looking to the future, the major trend for New Zealand this century could be decentralisation – that is, the generation, management, and storage of electricity and/or heat close to where it is used. This does not mean going back, nor does it necessarily mean a proliferation of segregated stand-alone systems. It means making the most of what New Zealand already has, and adding newer, more sustainable systems and technologies suited to individual and community needs. Local energy systems could help deliver this alternative future.

2.3 The pieces of the jigsaw

Microgeneration technologies are at the heart of local energy systems. However, they have limited potential when used in isolation. Adopting microgeneration technologies should be supported by various other technologies and measures. These include:

- enabling technologies that provide control and monitoring, and storage services
- heat-capture technologies that use ambient heat
- building design and performance measures that can significantly improve energy-efficiency for heating, cooling, and lighting
- efficient management of energy services, as the management of peak loads is critical, particularly for off-grid systems
- changes in people's attitudes and behaviour that result in more effective use of energy (this helps local energy systems perform up to their full potential)
- whether to have an off-grid or on-grid system
- whether systems will be able to link to form micro grids (small local networks) that permit micro generators to share smart control and energy storage equipment, and thereby have increased security of supply.

It is therefore appropriate to think of a local energy system as a jigsaw: when all the different pieces are fitted together correctly, they create a single integrated and effective system that can deliver appropriately scaled energy services to households, SMEs, and small communities. The pieces are described in Sections 2.3.1 to 2.3.8 below, and Section 2.4 shows how they fit together.

2.3.1 Microgeneration technologies

> *The technology exists to enable a radical overhaul of the way in which energy is generated, distributed and consumed – an overhaul whose impact on the energy industry could match the internet's impact on communications.*[18]

The microgeneration technologies that form the core of local energy systems can be categorised according to whether they generate heat, electricity, or both heat and electricity (combined heat and power). Examples of these technologies are listed in Table 2.1, and the accompanying box also highlights how some of these are being used.

Table 2.1 Examples of existing and emerging microgeneration technologies

Technology	Energy form	Comments
Heat generation		
Wood pellet burner or industrial combustor units	Biomass	New systems are highly efficient burners of biomass to produce heat. Can be used in a domestic situation for water and/or space heating, or small-scale industrial processes
Gas and coal burners; gas water heaters and cookers	Fossil fuels	There are various direct space and water heating applications. Gas is often used for cooking.
Electricity generation		
Reciprocating engine, diesel or biofuel generator	Fossil fuels	Generators can provide electricity in emergencies or when other sources of renewable energy are unavailable. There are many applications and sizes, but they are normally used as a standby power option.
Solar photovoltaics (PV)	Solar	PV can be installed to capture the energy of sunlight and produce electricity through a photochemical reaction.
Micro hydro	Water	These systems utilise nearby water sources to drive a micro turbine to produce electricity; they can provide continuous power depending on water availability.
Micro wind turbine	Wind	Micro wind turbines can be either roof or wall-mounted, or erected on a wind mast. Various sizes of turbine (and output) are available.
Wave power	Waves	Two types of wave power technologies are currently being developed: offshore (e.g. the Pelamis) and land-based (e.g. the Limpet).
Combined heat and power generation		
Fuel cells	Hydrogen	Use hydrogen (produced on-site or imported) to produce both heat and electricity. Currently an emerging technology at the prototype phase.
Stirling engine Micro gas turbines	Natural gas (and other fossil fuels)	Designed to replace a central heating boiler (or water boiler) and supplement electricity supply.

A local energy system in action: the Lawley family

Local energy is an integral part of the lives of the Lawley family in Taranaki. Their rural home near New Plymouth is energy self-sufficient, and their local energy system provides sufficient energy for their two businesses, Eco-Inn Backpacker Lodge and Ecoinnovation.

Ecoinnovation specialises in local energy systems and sells and manufactures various microgeneration components for small-scale renewable energy systems. Ecoinnovation can convert Fisher and Paykel 'smart drive' washing-machine components into generators for small-scale wind and hydropower turbines.

The Lawleys have used a variety of microgeneration technologies on their property, including:

- four sets of solar photovoltaic (PV) panels (totalling 1.2 kW), and solar water heating (including solar water under-floor heating)
- three micro wind turbines
- a mini hydropower system and a water ram for water pumping
- a woodstove for space and water heating.

In addition, they have batteries to store electricity generated from the solar, wind and hydropower microgeneration technologies, and an inverter to convert the battery power to useful electricity. They have also made good use of building insulation, and have a shower with a heat recovery unit and a guest spa pool heated by solar water heating.

Further information on Ecoinnovation and the Eco-Inn is available on the internet at www.ecoinnovation.co.nz and www.ecoinn.co.nz.

2.3.2 Smart control and information technologies

Technologies that provide information on, and the means to control, energy production and use are essential elements for local energy systems. These technologies have the capability to display and store information, communicate that information to the local energy system manager or owner (either on site or remotely), and even allow for the remote control of the system.

Smart (or advanced) electricity meters are the key piece of information technology for on-grid local energy systems. Smart meters have a range of features beyond just measuring the amount of electricity used by the consumer. They can measure electricity flows (imports and exports) and provide both consumers and lines companies with real-time information in a range of formats. For example, electricity use can be shown in kilowatt hours (kWh) or cost figures ($). Smart meters also incorporate data storage (for later analysis) and communication systems with the potential for remote control.

Table 2.2 Examples of energy storage technologies

Class of technology	Examples	Comments
Chemical energy storage	Lead acid batteries Nickel cadmium batteries Nickel metal hydride batteries Lithium ion (Li ion) batteries Lithium polymer batteries (Li Poly or LiPo) Sodium sulphur batteries (NAS)	One of the oldest and most developed battery technologies. It is a low cost and popular storage choice. Its application for energy storage, however, has been very limited due to its short cycle life. Lithium ion and lithium polymer batteries have begun to take over from nickel-based batteries in the market. However, a number of technological challenges must be overcome before these will be suitable for application at the local energy scale. NAS batteries will probably be developed for larger scale applications. There are also safety issues as the sodium is corrosive.
	Flow batteries	A form of battery in which electrolyte is stored outside the battery and then flows through a power cell/reactor where the chemical energy is converted to electricity. The great advantage of this system is that electricity production is limited only by the capacity of the electrolyte storage reservoirs.
	Hydrogen fuel cells	Surplus electricity can be used to electrolyse hydrogen from water. This hydrogen is then stored and later used in a fuel cell to produce electricity.
	Biogas (i.e. methane) from anaerobic digestion	Anaerobic digestion is a low temperature biological process to produce biogas (mainly methane) from non-woody, wet organic material (often animal and human waste). This gas can be stored for later use.
Mechanical energy storage	Compressed air, flywheels	Compressed air and power flywheels are most suitable for energy storage systems at a larger scale than those included within the scope of this study.
	Pumped hydro storage	Pumped storage involves pumping water up hill into a reservoir using surplus electricity. This water can then be used later to generate hydro-electricity when there is high demand.
Energy stored in an electric field	Ultra or super capacitors	Ultra-capacitors are suitable short time, high value energy boost systems. However, they might be suitable for buffering small amounts of fluctuating energy, for example from an individual wind turbine.

Source: Adapted from East Harbour Management Services (EHMS), 2006.

The United Kingdom's microgeneration strategy has highlighted the importance of smart meter technologies in microgeneration systems:

> *It is important that as work continues to develop on the costs and benefits of smart meters the assessment includes the interaction of smart meters with microgeneration technologies.*[19]

Smart meters are considered an essential element in an efficient electricity system.[20] They enable microgeneration technologies to integrate into existing networks, and with appropriate tariffs can make these projects more economically viable.

In summary, smart meters help create competition in the electricity market, bring about energy efficiency, and increase the uptake of microgeneration technologies.

2.3.3 Energy storage

Many local energy sources are intermittent – that is, they are not available for energy generation at all times. For example, electricity generated from micro wind turbines and solar photovoltaic panels is available only when the wind is blowing and the sun is shining. To preserve continuity of supply, the local energy system must either be able to connect to the national grid when local generation is not available, or incorporate some form of energy storage.

There is considerable ongoing research into improving and developing energy storage technologies, and reducing the costs. Table 2.2 summarises these technologies.

2.3.4 Heat capture technologies

Heat capture technologies collect and concentrate energy from ambient heat in the environment. Some are listed in Table 2.3. They are important components of many local energy systems, reducing the demand on microgeneration technologies.

Table 2.3 Examples of heat capture technologies

Technology	Energy source	Comments
Heat generation		
Solar water heater (SWH)	Solar	A SWH system uses the sun's energy directly or indirectly to heat water. Space heating can also be derived from some SWH systems.
Heat pumps	Ambient heat and electricity	A heat pump is a mechanical device used for heating and cooling that operates by using electricity to pump hot or cool air from one area to another for temperature control. Heat pumps can extract heat from air, water, or the earth (ground source heat pump). Heat pumps are normally used for space heating, but can be configured for water heating too.
Ground source heat pump	Geothermal heat and electricity	A ground source heat pump uses the heat from the earth (i.e. geothermal heat) to heat water or liquids injected in a loop down into the ground. This heat can be used for water heating or space heating.

2.3.5 Building design and performance measures

Buildings can be considered as constructions that capture heat to provide a comfortable environment in which to live and work. The building envelope (i.e. the building floor, walls, and roof) regulates the transfer of energy, in the form of heat and light, between external and internal environments. In effect, building envelopes can be considered an integral part of local energy systems, because they help provide the energy services of light, space heating, and space cooling.[21]

However, the building envelope on its own often cannot maintain the desired level of comfort, and needs supplementary sources of energy.

The ability of a building envelope to regulate light and provide space heating and cooling depends on factors such as:

- for light: orientation toward the sun, area and location of glass, degree and type of shading
- for space heating: the use of thermal mass to retain captured heat (i.e. walls and flooring that absorb and release solar heat), and the use of increased levels of insulation to slow heat loss
- for space cooling: shading to prevent overheating, and natural ventilation to allow heat to escape.

Variability in these factors will affect the performance of the building envelope and the requirements from other elements of the local energy system.

The measures available to maximise a building envelope's ability to provide light, heating, and cooling depend on whether it is a new building or a retrofit of an existing one. In general, retrofits focus on improving a building's insulation. Other options, such as improving solar collection or adding thermal mass, are usually ruled out by technical difficulties and cost. However, a wider range of measures can be considered when designing a new building.

Some specific measures that can improve the building envelope's role are listed in Table 2.4.[22]

2.3.6 End-use efficiency and energy management

Energy efficiency measures are any measures that increase the net benefits per unit of energy.[23] End-use efficiency measures are those applied at the point where the energy (e.g. electricity, gas, or wood) is converted into the desired energy service (e.g. heat or cooling, light, or motive power).

Examples of such end-use measures include:

- energy-efficient refrigerators
- compact fluorescent lights

Table 2.4 Measures for improved building performance

Type of measure	Examples	Comments
Insulation	Building insulation	Various natural and synthetic insulating materials can be used in ceilings and other cavities (i.e. walls and floors) to prevent heat loss.
	Double glazed windows	Double glazed windows – installed on new buildings or retrofitted on old buildings – reduce heat loss compared with single-glazed windows.
Capture of ambient solar heat and light	Passive solar design features (i.e. building orientation, appropriate design, and building materials)	Most cost-effective when incorporated into the initial design of a building (as opposed to a retrofit).

- correctly sized and maintained electric motors
- liquid crystal display televisions
- low flow shower heads.

Energy management measures are those that manage the use of the system to minimise wastage and reduce peak loads. Such measures can be as simple as changing the time when energy services are required (for example, doing the dishwashing late at night). Another simple example of demand management is using automated lighting, which helps avoid unnecessary use of electric lights. The most common example in New Zealand is 'ripple control' that allows a lines company to switch off hot water heaters at times of peak demand. In return for accepting this limitation, the customer pays a lower tariff. More sophisticated energy management measures include automated monitoring and control of equipment use to optimise power consumption.

Although they are not discussed in detail in this report, energy management measures can, when incorporated into the design of local energy systems, make those systems smaller and cheaper. Such measures are therefore key pieces of the local energy 'jigsaw'.

2.3.7 People's attitudes and behaviour

By their nature, local energy systems require people to be more involved in their planning, design and operation. This is because local energy systems must be tailored to the needs and circumstances of the end-users. Also, the end-user has to be more involved in the operation of the system, even with modern control technologies.

The design of a local energy system needs to consider the:

- energy services required and their associated energy demand profile over different time periods
- local resources and microgeneration technology options available (including energy storage and backup generation options)
- best local energy system for balancing energy demand against the energy production options within the budget available
- capacity and willingness of the end-user to operate and manage their own local energy system.

Local energy systems require that the end-user be directly involved in the design and/or operation of the local energy system. This has been found to develop more awareness of energy requirements. The system's production limitations also require the user to make choices about how they will use the energy that is produced. These factors require creative thinking to identify alternative ways to provide the required energy services. This change in awareness, and subsequent behaviour patterns, are crucial elements that are often cited as an important benefit for sustainability by advocates of local energy systems.

Research in the United Kingdom by the Sustainable Consumption Roundtable,[24] the Department of Trade and Industry,[25] and UK Greenpeace[26] has explored the attitude changes of those choosing to invest in local energy systems. In general, such people have a better understanding and appreciation of energy services. The study found that many people now strongly associated the energy source with the emotional benefits of warmth, comfort, light, entertainment, cooking, and cleanliness. The study also found that energy efficiency behaviours changed as people came to see energy efficiency as directly linked to the value of the energy generated locally.[27]

Some quotes from the study are given in the box, and provide insights into this change of attitude.

2.3.8 Off-grid and on-grid local energy systems, and future micro grids

Local energy systems may be off-grid or on-grid. Off-grid systems are not connected to the wider electricity grid and so end-users rely entirely on their local systems for all energy services. Off-grid systems are usually in remote locations where connection to the wider grid is either not possible or very expensive, or where people choose to have their own systems because they want to be more self-sufficient.

Off-grid systems require both resilience and adaptability in their design. They are likely to make use of different local energy technologies because their energy sources may be intermittent or unavailable in certain circumstances. For example, it may be practical to use an array of microgeneration technologies (e.g. wind turbines, solar photovoltaics, micro hydro systems, and back-up diesel generators) to make use of all

Changes of attitude associated with uptake of local energy systems

When the wind is blowing right up then I turn the electric heaters on – rather than use the gas from the gas bottles. Male, N. Lancashire, with off-grid wind.

As we had spent our own money we really began to take an interest and stopped leaving the TV on standby for example, and we are really careful not to leave the loft lights on any more. Male, Cheltenham, with solar PV and combined heat and power.

It has made me far more aware, when I look at the light bulbs I think that it's me, I am the one generating my own electricity...it's made me really aware of the weather…more connected as to what is happening at ground level. Male, N. Lancashire, with off-grid wind.

The advantage with it is that it makes you think about your energy use more. You value it more… You realise it's easier to save it than make it. That is especially true of the hot water panel, but also with the electricity too. Male, Edinburgh, PV and SWH.

When that red light is on we know we are exporting to the grid – so it's time to put the washing machine on or it's OK to boil the kettle. When that light is not on we make sure that everything is off – nothing is on standby 'cos we know that it's probably really costing us. Older couple, South West Lancashire, wind.

Source: Dobbyn & Thomas, 2005

available energy sources. So when one energy source is unavailable (say, solar energy at night), other sources can be used as substitutes (such as wind or hydro power).

It is more important in off-grid systems to be able to store excess generated energy, and/or to have back-up generators running on fossil fuels or biofuels (and potentially hydrogen fuel cells in the longer term). Off-grid systems require more storage capacity and much higher peak output than on-grid systems, so they are generally much more expensive. Technologies for storing excess energy were discussed in Section 2.3.3.

In 2013 the Electricity Act 1992 will remove the requirement for lines companies to maintain electricity supply to all areas. The potential cost of maintaining rural lines after this time means that off-grid systems are likely to have an increased role in New Zealand after 2013. Indeed, this has been a key driver in establishing the local energy system project at Totara Valley, described in the box.

On-grid local energy systems are connected to the wider grid. These systems provide the benefits of both centralised and decentralised systems: using local energy when feasible, and electricity from the wider grid at other times.

This pattern fits well with the intermittency of some energy sources such as the sun and wind. On-grid systems allow the wider grid to be used as a virtual storage technology, providing 'backup' capacity and removing the need for on-site energy storage. For example, an electric heater can provide backup for a wood fire. In addition, when the local energy system is generating beyond demand, the surplus can be transferred elsewhere through the wider grid (and stored if appropriate).

Local energy potential in rural areas of New Zealand

Research is being conducted on the potential of various microgeneration technologies in the rural farming community of Totara Valley, near Woodville in the Tararua District. The project began in 1999 and combines expertise from Massey University and Industrial Research Limited. It aims to develop a local energy system by testing a range of microgeneration and heat capture technologies in a real-life setting, and examining how the local energy system integrates with local lines networks.

A key driver for the Totara Valley project has been recognition of the potential need for integrated local energy systems after 2013. From that date, under the Electricity Act 1992, lines companies will no longer be required to deliver electricity to uneconomic, remote sites. If this policy is maintained, then many rural communities – like Totara Valley – will be forced to seriously reconsider their energy circumstances, and focus on options such as off-grid local energy systems.

Totara Valley is a typical rural New Zealand hill country community. Sheep and beef farming are prominent and the community involved in the study consists of three farms with six households and associated farm buildings.

Initial research focused on determining electricity use and demand. A resource assessment then determined the renewable energy resources available in the Totara Valley area. This included:

- assessment of sunshine levels, wind speeds, and stream water flow
- electricity demand profiles for the six households and associated farm buildings (e.g. woolshed energy use), showing seasonal and daily variations
- power quality data for the microgeneration technologies, including voltage fluctuations and outages.

Based on the initial assessments, the following microgeneration and heat capture technologies were installed, and are being monitored:

- solar power systems on three houses
- a solar hot water system
- a hot water heat pump system
- a biodiesel generator
- a wind turbine
- a 1.2 kW alkaline fuel cell (battery)
- a micro hydro system.

Meters monitor energy use and production across the community.

Research is looking at the best ways of integrating the local energy technologies into the local lines network (i.e. determining network issues such as voltage fluctuations and outages). This aspect of the project has been supported by a number of lines companies who share a common interest in the findings.

For further information on this project, see the following websites:

- www.irl.cri.nz/industry-sectors/sector-energy/Energy-at-the-cross-roads.aspx
- www.irl.cri.nz/industry-sectors/sector-energy/farmers-tap-into-integrated-distributed-energy-systems.aspx
- www.frst.govt.nz/database/CD04/html/reports/pdfs/c08x0203.pdf

Using the storage capacity of the wider grid imposes extra costs on the network operator. However, these additional grid storage costs can be much lower than the storage costs of off-grid local energy systems.

Some of the differences between off-grid and on-grid systems are summarised in Table 2.5.

Table 2.5 Differences between off-grid and on-grid local energy systems

Off-grid local energy systems	On-grid local energy systems
More likely in remote and rural locations (where connection to the wider grid is impractical or prohibitively costly).	An option wherever grid connection is available – in both rural and urban areas.
Storage of surplus energy, or a diversity of energy sources, is essential to allow for the intermittency of renewable energy sources. Backup on-site generation (e.g. a diesel generator) is also likely to be required.	Users have the option of feeding any surplus electricity back into the wider grid. Users are often able to receive financial reward for exported electricity.
System feedback information is crucial to help end-users decide about tradeoffs between energy supply and demand.	System feedback information is important to help the end-user with their system's interaction with the electricity grid. For example, individuals may choose not to use certain electrical appliances if they can instead feed some of their electricity back into the grid and thereby earn money.
Metering is important to allow the end-users to monitor and optimise their own energy systems (i.e. energy production and storage).	Metering and control is required for payment and for controlling the inflows and outflows of electricity.

Micro grids

A micro grid is an aggregation of connected local energy systems that can be regarded as a single entity, either locally (an off-grid system) or within a larger network (an on-grid system). Micro grids do not exist in New Zealand but with the emergence of local energy systems they have the potential to complement the existing electricity network.

This is illustrated in Figure 2.3. The shaded area shows how electricity flows from the micro grid to the houses and also from the houses into the local micro grid. The enlarged box in Figure 2.3 shows a possible future local energy system using photovoltaic cells, hydrogen production and storage, and a fuel cell operating within a micro grid. At its core is the smart control and information technology that permits it to function as a semi-autonomous power system both importing and exporting electricity.[28]

When a micro grid is connected to a wider grid (i.e. it is on-grid), it can be operated as a single aggregated load, or as a single aggregated supplier of electricity when generation exceeds demand within the micro grid. Alternatively, the excess electricity can be stored within the micro grid.

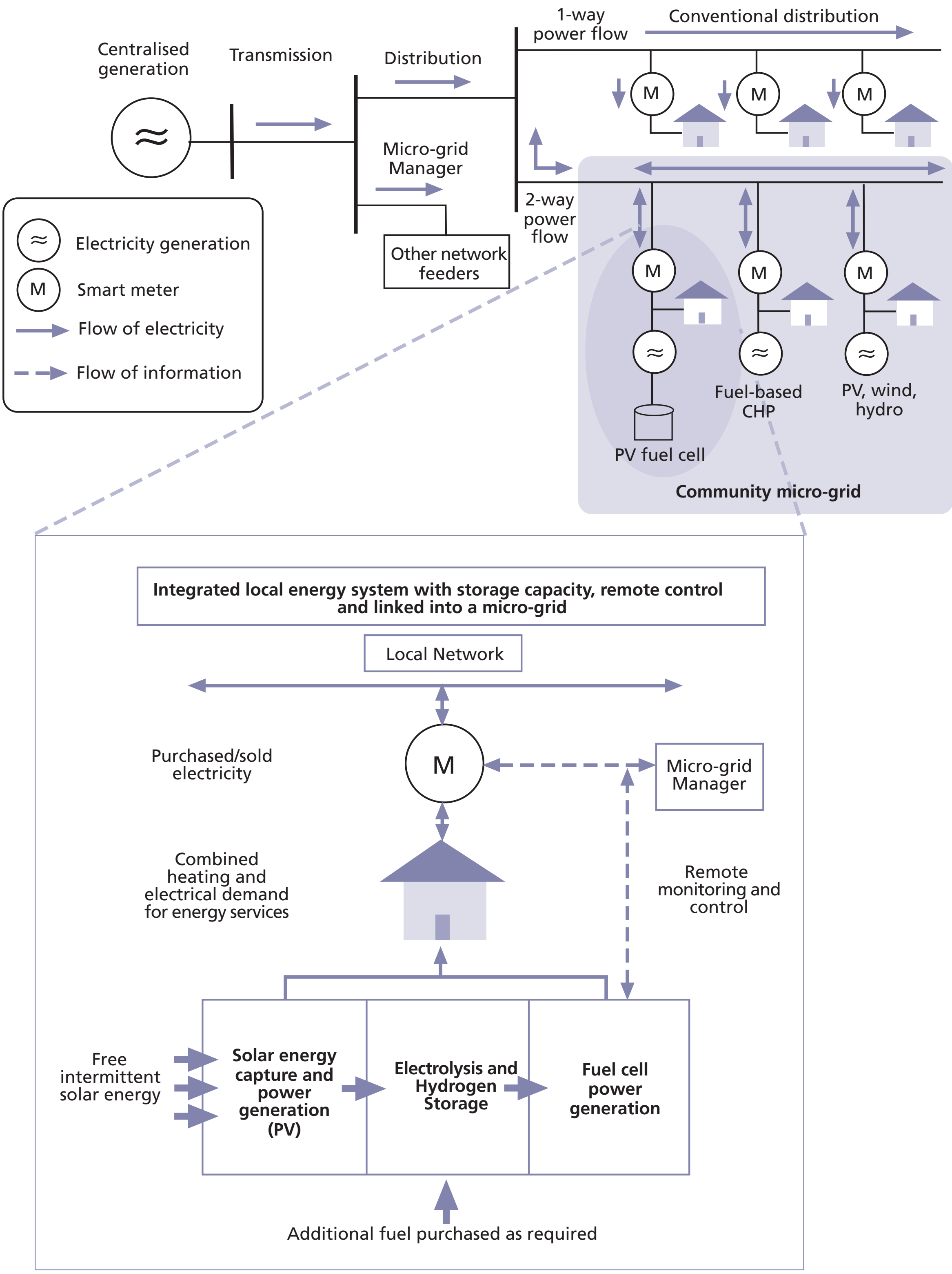


Figure 2.3 A micro grid within an existing electricity network

Source: Adapted from Gardiner, 2005

2.4 Putting the pieces together

A vast spectrum of existing and emerging microgeneration technologies and associated systems is included in the local energy systems concept. These systems come in many shapes and sizes, and can be used in a range of applications.

Figure 2.4 shows a matrix for considering microgeneration technologies and local energy systems on different scales and applications. The vertical axis represents the spectrum of established and emerging technologies. The horizontal axis represents their use in terms of either individual or connected applications.

At present, most local energy systems in New Zealand fall into the upper left quadrant ('status quo'). They mostly focus on heat capture and heat production. There is some activity in the 'path breakers' and 'two-way networks' quadrants (focusing on generation of electricity), but this is largely limited to enthusiasts. The 'smart webs' quadrant (micro grids, smart grids) is only just beginning to develop, with some proposals for pilot programmes in North America.[29]

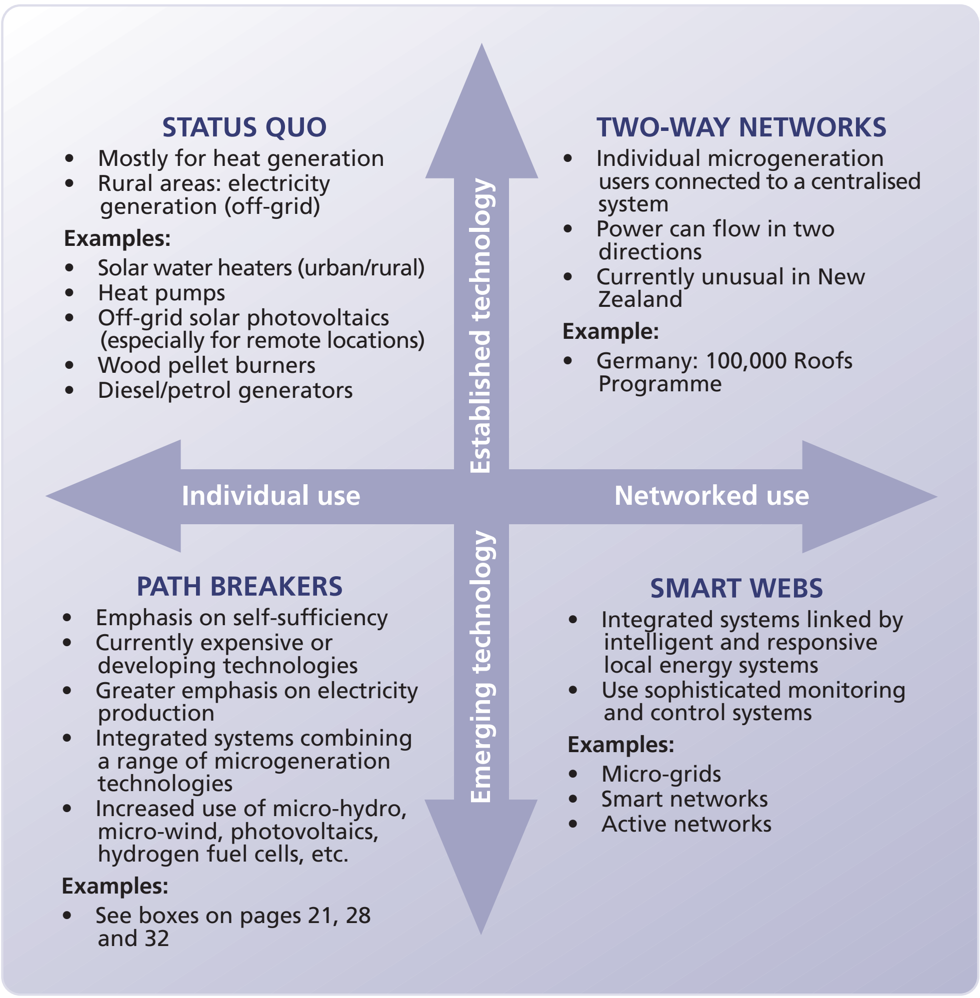


Figure 2.4 A spectrum of local energy systems

In practice, the design of local energy systems requires attention to three factors. The first is what resources are available locally and whether their use is viable.

The second is the intermittency of some forms of renewable energy (e.g. solar and wind energy). Energy storage technologies and alternative backup options may be important; for example, in a remote location.

Thirdly, the required level of reliability of the energy supply needs to be decided. Some end-users may accept a lower level of reliability as a trade-off for reducing the cost of the system by having less generation or storage capacity. Some people may be willing to stop using certain appliances – such as TVs, stereos, or computers – when energy supply is low. On the other hand, in some circumstances the need for reliability will require backup generation at almost any cost to ensure that energy is always available. For example, crucial hospital equipment would definitely require a reliable energy supply.

It is obvious that the design of appropriate local energy systems is a skilled task that requires relatively high levels of technical knowledge and understanding of end-user needs. NIWA's Maori research unit has recently been through this process with two Maori communities, and their experiences are described in the box.[30] Developing a greater capacity within the economy to provide the necessary specialist skills is discussed in Section 5.4.

Local energy systems in rural Maori communities

NIWA's Maori research unit, Te Kuwaha, is conducting local energy system research in two rural Maori communities in Northland (Waipoua) and near Lake Taupo (Waihi). The research aims to provide tailored energy solutions for these two distinctive communities.

The Te Roroa (Waipoua) and Ngati Turumakina (Waihi) communities each have 15 to 20 homes and a marae complex (with associated buildings). These form a cultural base for both residents and members of wider whanau and hapu. Like other rural communities, they face problems with energy infrastructure and its impact on community development. Both communities want to maximise their energy-independence.

NIWA's research has involved four distinct steps:

1. Auditing energy efficiency
2. Assessing energy use and needs
3. Assessing energy resources
4. Deploying energy efficiency and/or microgeneration technologies and running an education programme.

For Step 1, Te Kuwaha canvassed community perspectives on energy use and energy-related concerns, and identified opportunities for energy efficiency in homes and buildings. A survey also provided an understanding of normal energy use and the priority 'energy services' of each community (Step 2). These two initial steps were crucial. Accommodating the human aspects of energy use and needs are vital for the successful integration of local energy systems in communities and households.

Assessment of energy resources (Step 3) identified and evaluated the options available to each community (such as solar, wind, hydro, and wave energy potential). This information provides the basis for Step 4: deciding on the most suitable local energy system and deploying it.

Solar panels at Tapeka Marae, Waihi

The Te Roroa community (Waipoua) is not connected to the national electricity grid, and relied heavily on wood and fossil fuels for providing their energy services. They focused on finding energy solutions for refrigeration, clothes washing, lighting, appliance use, and summer hot water. As a result, a small hydroelectricity system, solar power systems, a micro wind turbine, and a domestic solar hot water unit were installed.

The Ngati Turumakina community (Waihi) is on the electricity grid and wanted to reduce inefficient energy use, and gain more effective and efficient water heating and refrigeration through the research programme. A small grid-connected solar power system and solar water heating units were installed, and the potential for a micro hydro electricity system is being assessed.

The research has identified that local energy systems and solutions are site-dependent. Preliminary energy auditing, energy use and needs assessment, energy resources assessment, and socio-economic factors are key elements in the design of any local energy system.

The research has shown that active community involvement (learning by doing) through helping communities to understand and control their energy options is important. The project has highlighted that the 'human' and 'technological' elements of local energy systems are co-dependent.

Further details on this NIWA work are available on its website:

www.niwascience.co.nz/pubs/wa/13-4/maori

Underfloor insulation installation in the Waihi community

CHAPTER 3

The impacts of local energy systems

This chapter discusses the benefits, both private and public, of local energy systems (Section 3.1). It also summarises some of the key challenges that could arise from the widespread adoption of local energy systems (Section 3.2).

3.1 The benefits of local energy systems

Local energy systems can potentially provide benefits other than those of providing energy services to the user. Many of these benefits often cannot be easily valued in monetary terms. They may also not be received by the user but are transferred free to the wider community. These types of benefits are called positive externalities, and are summarised in four groups:

- national energy system benefits (Section 3.1.1)
- environmental benefits (Section 3.1.2)
- economic benefits (Section 3.1.3)
- social and cultural benefits (Section 3.1.4).

3.1.1 National energy system benefits

Increased efficiency

Local energy systems could make New Zealand's energy system more efficient. Producing useful energy at or near the point of use reduces the losses associated with some centralised energy systems. This reduction is particularly notable if the energy is produced at peak load times when losses are highest.

Whenever energy sources are converted into energy and transported, some of this energy is lost in the form of waste heat. Figure 3.1 shows how much energy is wasted in the process of providing light, using gas or coal as an energy source. In this example, gas or coal generates electricity at the Huntly power plant. The electricity is transported through the high voltage transmission grid and the lower voltage local distribution network, and then used in an incandescent light bulb.

The diagram shows that most of the energy loss occurs during electricity generation at the power station, and when the energy is converted into light. The diagram also shows there is an approximate 11 percent loss of energy (as heat) during the transmission and distribution of the electricity through the network.

High losses occur when electricity has to travel long distances between generation sites and main load centres. In New Zealand the main generation sites are in the South

Island, which is a considerable distance from the main load centre in Auckland. New Zealand's transmission grid is so elongated that it is often called 'stringy'.

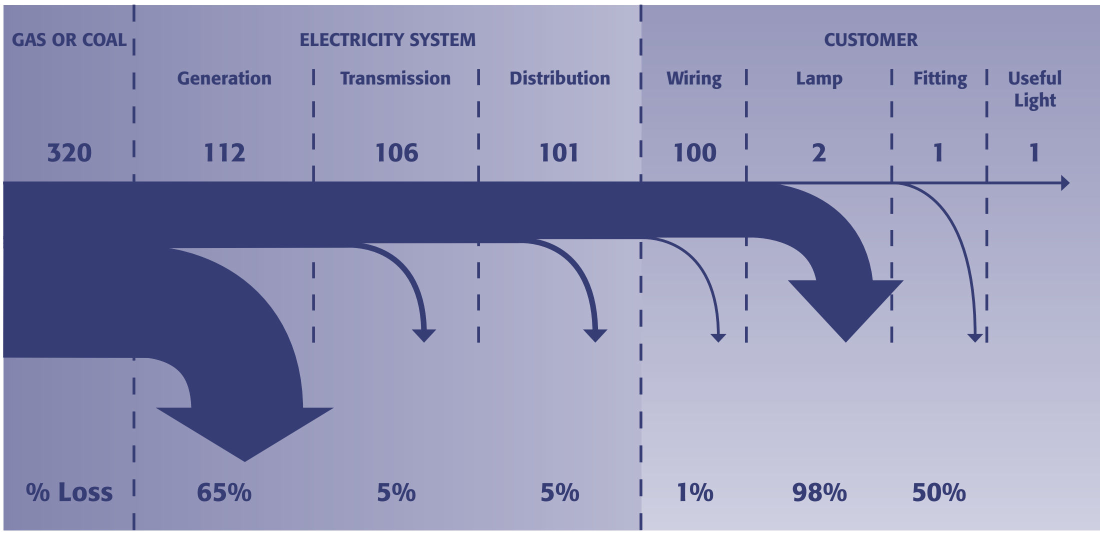


Figure 3.1 Energy losses for an incandescent bulb powered by Huntly power plant

Source: Cleland, 2005

Provided that local energy systems are at least as efficient as the large electricity generating plants, the efficiency of the whole energy system is improved.

Transmission and distribution losses also occur when the system is near its maximum capacity in terms of voltage. The most common way of addressing this problem is by upgrading the lines to a higher voltage – for example, by replacing a 220 kV line with a 400 kV line. However, local energy systems can provide an alternative. Their use can reduce the amount of power needed to be transmitted to a location, and can extend the life of the existing transmission assets.

A final cause of supply loss is when the power system has poor power factor performance. Poor power factor requires the supply industry to invest in extra capacity, resulting in extra costs that may not be recovered from consumers. Micro generated electricity can potentially be used to improve power factor performance of the wider energy system by providing reactive power near to end-users. Reducing the current flow in the wider energy system will also reduce reactive losses, which increase with increased current. (See the glossary for an explanation of power factor and reactive current losses.)

Lastly, efficiency improvements are possible when end-users are encouraged to design their systems for maximum efficiency and cost effectiveness (as discussed in Section 2.4). Context-specific design not only results in more efficient local energy systems, but can also change end-users' attitudes and behaviour, leading to increased energy efficiency and conservation (see Section 2.3.7).

Improved grid resilience

Improved grid resilience is one of the most commonly stated benefits of on-grid local energy systems. Grid resilience is the ability of a network to withstand sudden disturbances, like a supply outage or grid constraint. The box describes two well-known international incidents that had significant impacts.

There have also been recent network outages in New Zealand. The first left Auckland without power for up to eight hours as a result of poor grid maintenance.[31] The second, caused by heavy snowfall, affected large areas of the South Island and lasted several weeks for some.[32]

Local energy contributes to greater grid resilience in two ways. First, simultaneous failure is far less likely with a large number of microgeneration units than with a smaller number of large generating plants.[33] Secondly, microgeneration capacity can strengthen distribution networks by reducing peak demand when these networks are under most stress and prone to fail.

Cascade failure – the risk of centralised grids

The fragility of centralised transmission grids became apparent in 2003 when there were major 'cascade failures' in North America and Italy. (See the glossary for a definition of cascade failure.)

In August 2003, 50 million Americans and Canadians were plunged into darkness. The outage lasted up to 24 hours in some areas with an estimated cost to users of US $4–10 billion in the United States and C$2.3 billion in Ontario.[34] The blackout was initially attributed to the failure of one line (due to a fallen tree) at a time when the grid was operating at maximum capacity. The system operators failed to recognise the problem and shut off some of the demand. At this point the system began to undergo cascade failure as more and more lines failed under the load. The blackout affected water supplies, the cellular network, financial markets, and transportation systems.

The Italian failure occurred in September of the same year and lasted nine hours. Blackouts affected all of Italy. The failure was due to storm damage to one 400 kV line from Switzerland which then resulted in two more 400 kV line outages. At this point the operator lost control and the system went into cascade failure. The blackout occurred at 3 a.m. but still trapped several hundred people in underground trains. Trains throughout Italy were cancelled, leaving around 30,000 people stranded.

Increased energy security

Energy security refers to how well people can access energy services when and where they need them. Energy security may be negatively affected by events such as a rise in the price of fuels (like coal or gas), natural disasters (such as floods and hurricanes), human error, failure of the national grid, geopolitical or industrial disruptions (e.g. oil shocks, industrial disputes), and depletion or shortage of resources (e.g. peak oil). These events have the potential to affect both large electricity generating plants and local energy systems. However, local energy systems offer increased security for several reasons:

- They are often based on renewable energy sources like the wind and sun, which provide a vast, intermittent supply of energy
- If based on renewable and ambient energy sources, these systems have zero (or minimal) fuel costs, reducing vulnerability to fluctuations in the price and availability of fuels like gas, coal, diesel or oil
- Failures in centralised electricity generation plants and transmission/distribution networks have limited effect because energy can be generated on-site (and, in the case of off-grid systems, have no effect)
- They often involve the use of more than one resource or conversion system and therefore provide the end-user with the option of switching between them during times of shortage or disruption.

3.1.2 Environmental benefits

Reduced use of non-renewable energy resources

Energy systems based on finite non-renewable resources (e.g. fossil fuels such as gas and coal) are by definition unsustainable. Local energy systems, however, can make use of renewable energy sources that are not available to large electricity generating plants. Such sources could include smaller streams and less windy or less sunny locations, which are unsuitable for large-scale electricity generation. Use of these energy sources, alone or in combination, offsets the need to use fossil fuels in New Zealand and provides the added benefit of reducing greenhouse gas emissions (as described below).

Increased energy efficiency

Compared with large power stations, local energy systems can provide more efficient energy services because:

- they are often more efficient, especially when using fossil fuels, in converting the energy into a useful form (i.e. they can deliver more useful energy for each unit of energy input)
- there is a greater focus on end-use energy efficiency.

Figure 3.1 shows that a lot of energy is lost in the process of generating electricity from fossil fuels. In general, it is more efficient to use energy sources directly than convert them into electricity.

For example, it is more efficient to use coal or gas directly for space heating than to generate electricity in a large power plant, transport that electricity, and then use it in an electric heater. Alternatively, if conversion to electricity is necessary, it is more efficient to do so in a way that delivers as many useful services as possible through the process.

Local energy systems can do this by using combined heat and power (CHP) technologies. For example, the WhisperTech CHP plant uses natural gas in a Stirling cycle engine to produce heat for water and space heating, and at the same time generates electricity.

Local energy systems can improve energy efficiency by reducing demand. An essential part of designing appropriate local energy systems is assessing energy demand (as discussed in Section 2.4). Improvements in building design, use of energy efficient equipment and appropriate management, and changes in people's attitudes and behaviour (as discussed in Sections 2.3.5 to 2.3.7) can all increase energy efficiency.

Reduced greenhouse gas emissions

Large electricity generating plants using coal and gas as fuel contribute around 26 percent of New Zealand's total electricity supply and 10 percent of its total greenhouse gas emissions.[35] By displacing electricity generated from these sources, local energy systems can reduce the net emissions of greenhouse gases. This is possible because local energy systems can provide energy services in a highly efficient manner (as outlined above) and utilise local renewable energy sources, which have no or negligible greenhouse gas emissions.

Improved environmental outcomes

Local energy systems, because of their small scale, locally sourced, renewable energy and high system efficiencies, reduce or eliminate many of the environmental impacts normally associated with energy projects. The microgeneration technologies used in local energy systems do have some environmental impacts, and examples are given in Table 3.1. In general, though, these can be regarded as relatively minor compared with the impacts of building and operating new large electricity generating plants.

3.1.3 Economic benefits

Increased competition in the market

Local energy systems provide an alternative for consumers to the traditional sources of energy services (e.g. electricity from the national grid, or reticulated gas). The existence of these alternatives has the potential to transform the energy market.

Improved investment in the electricity system

Investment in new electricity infrastructure tends to occur in large chunks that take a long time to reach fruition. The longer the time between the initial project proposal and project completion, the more opportunity for unforeseen delays.

To maximise the financial return on the investment, the investor will encourage uptake of excess supply as quickly as possible. Demand increases quickly until the system once again approaches its physical capacity and becomes constrained. Economists know this type of investment as a 'lumpy investment' problem.

Table 3.1 Examples of potential environmental impacts associated with microgeneration technologies

Technology	Energy source	Potential environmental impacts
Heat generation		
Wood pellet burner or industrial combustor units	Biomass	Localised air pollution
Passive solar design	Solar	N/A
Solar water heater (SWH)	Solar	Visual impacts
Ground source heat pump	Geothermal	N/A
Heat pumps	Electricity	Noise plus any existing adverse environmental impacts arising from the electricity generation and transmission system
Gas and coal burners	Fossil fuels	Greenhouse gas emissions and localised air pollution
Electricity generation		
Reciprocating engine	Fossil fuels	Greenhouse gas emissions, noise, localised air pollution
Petrol, diesel or biofuel generator	Fossil fuels	Greenhouse gas emissions, noise, localised air pollution
Micro gas turbine	Fossil fuels	Greenhouse gas emissions, noise, localised air pollution
Solar photovoltaics (PV)	Solar	Visual impacts
Micro hydro	Water	Dependent on type of system, but could have an impact on stream ecology, and downstream water use
Micro wind turbine	Wind	Noise and visual impacts, particularly in urban environments
Wave power technologies	Wave	Visual, and coastal ecological impacts (if an onshore system)
Combined heat and power generation		
Fuel cells	Hydrogen	Greenhouse gas emissions if sourced from fossil fuels
Stirling engine micro-turbines	Natural gas (and other fossil fuels)	Greenhouse gas emissions, localised air pollution

Local energy systems avoid lumpy investment, as they are small-scale, modular, and relatively quick to commission. Generation capacity can be added on a just-in-time basis closely following growth in demand. This helps eliminate the periods of significant over-capacity associated with large-scale developments.[36]

Efficient use of existing capacity

Introducing local energy systems into the energy market can delay, and in some cases remove, the need for contentious and expensive upgrades to centralised energy systems (e.g. transmission and network upgrades). Local energy systems can help reduce the size of peak loads, so grid and generation capacity does not have to accommodate them. As a result, existing systems can be more fully utilised.

Orion New Zealand Ltd is using this approach to delay investment in new capacity in its distribution network. Orion has negotiated with businesses that have the ability to generate electricity to use (where possible) their generating capacity to manage peak loads, and thereby reduce the demand on the network at these times.

A model developed by the World Alliance for Decentralized Energy (WADE) compared the long-term cost-competitiveness of a centralised power system with more decentralised systems using microgeneration technologies.[37] It concluded that the long-term retail price of electricity would be significantly cheaper from a decentralised system, mainly because of the reduced need for transmission and distribution investment.

Local economic development

Increasing use of local energy systems in New Zealand could create a market for installation and ongoing maintenance support activities, which could lead to the creation of local industries. It could also lead to the upskilling of electricians, plumbers, engineers, and others involved in the installation and maintenance of local energy systems.

This has been demonstrated in Germany where a focus on renewable energy and microgeneration has led to a significant domestic market. Positive spin-offs have included a growth in related research and development, production and export of associated local energy products, and the creation of careers and employment opportunities in the industry.[38]

Some local energy system equipment could be designed and constructed in New Zealand. Solar hot water heating, micro hydro, and micro combined heat and power systems are already being manufactured here. New Zealand also has a strong electronics industry, and power electronics are a key element in microgeneration.

In contrast, equipment for large, centralised energy systems is almost exclusively imported, and multi-national companies often provide the maintenance support. Increased demand in New Zealand for local energy systems has the potential to create positive economic spin-offs similar to those realised in other countries, such as Germany.

3.1.4 Social and cultural benefits

More socially acceptable development

The development and operation of a large electricity generating plant has very significant impacts on local communities.[39] Proposals for new developments are often met with public resistance, leading to increased costs and uncertainties in the project's planning phases. This is particularly the case when the project's negative impacts are experienced at the local or regional level, and most of the benefits (i.e. use of the generated electricity) go to people geographically remote from the plant's location.

In contrast, the people who will experience any negative impacts from local energy systems are mainly the same people who will benefit from the systems.

Empowered users

> *The language of "energy efficiency in the home" is currently going over the heads of householders who do not make the links between their TVs, dishwashers and thermostats and their active concern about global climate change. Making energy generation part and parcel of people's homes and schools may hold the key to empowering and engaging energy consumers for the first time.*[40]

The real value of a local energy system does not lie just in its energy generation role. It can also act as a catalyst for change. Research for the United Kingdom's Sustainable Consumption Roundtable shows that local energy can be a very effective 'hook' to engage people in energy and climate change issues and to influence behaviour.[41] Some of the findings have already been discussed in Section 2.3.7 and the research concludes that:

> *A whole host of attitudinal and behavioural shifts do seem to be fostered (though not automatically created) by the presence of on-site micro-generation… Thus the findings from this research indicate that the qualitative impacts of micro-generation technology can be substantial, presenting a living, breathing and emotionally engaging face to energy consumption issues. In short, micro-generation can help bring the invisible to life.*[42]

Those who choose local energy systems have more control over their energy use and can reduce their dependence on the wider energy sector. Jeremy Rifkin (2002), referring to his vision of a distributed energy system based on the hydrogen fuel cell as the storage and control mechanism, calls this trend the "democratised energy web". It has the potential to empower users and increase their self-reliance, and reinforces a 'can do' mentality.[43]

Engaging communities on energy issues

At a community level, local energy technologies, such as micro wind turbines on the tops of school buildings, can provide a tangible educational tool for developing understanding of energy and climate change issues. They can form part of education for sustainability programmes in schools, and thereby act as a model for a local community.

Opportunities exist for engaging communities throughout New Zealand by locating local energy technologies on public buildings like libraries, council offices, and hospitals (see box on Waitakere Hospital). Local energy could be an option for marae and associated buildings around New Zealand (see box in Section 2.4).

Hoffman & High-Pippert (2005) looked at how the development of community energy initiatives affected community decision-making and involvement. They concluded that:

> *In this respect, community energy might well perform the sort of civic function described by Skocpol (2003), that is, a vehicle that provides a means for political activity on the part of the broad mass of citizens who join not just for social interaction but also to be actively involved in the making of public policy.*

Improved health and safety

A third of New Zealand homes are kept at temperatures below those recommended by health authorities and the World Health Organisation (between 18°C and 21°C); in Auckland the mean household temperature is 16.5°C.[44] Well-designed local energy systems incorporate measures that produce heat more efficiently (e.g. with heat pumps) and improve the thermal performance of buildings. The Wellington School of Medicine and Health Studies has showed that installing insulation improved thermal performance and adult and child health and well-being.[45] Additional information on the linkages between energy use and health and well-being is included in the PCE report *Healthy, wealthy, and wise* (PCE, 2006c).

Passive solar design can also improve health and well-being. Passive solar design means designing buildings to make maximum use of the sun's energy for heating, cooling and lighting purposes. Various design options have already been outlined in Section 2.3.5. The recently constructed Waitakere Hospital is an example that has both energy efficiency and health benefits (see box).

Off-grid local energy systems can improve safety in areas previously without an electricity supply. When cheap, reliable electric lighting replaces lanterns and candles, it reduces the risk of fires. Electric lighting of dark passageways and steps reduces the risk of injury.

Waitakere Hospital: Smart design and energy efficiency

The recently developed Waitakere Hospital is the product of a design team committed to building a sustainable hospital, with energy efficiency as a core aim. The hospital incorporates a number of simple and innovative features:

- Passive solar design: The building is positioned to maximise exposure to the sun's freely available light and heat. The hospital also uses natural ventilation and upgraded insulation to maximise indoor comfort, and uses air-conditioning only in certain areas of the hospital (such as operating rooms). These measures help prevent excessive temperature variations and minimise the energy used for space heating or cooling in the hospital.
- Energy efficient lighting: The hospital makes full use of natural light, has window glazing and shading, and energy-efficient lighting systems that comprise:
  - tailoring lighting levels
  - localised switching and using low loss ballasts[46]
  - fitting high-frequency dimmable ballasts to selected areas (such as corridors and courtyards) to allow daylight to complement artificial lighting
  - installing occupancy sensors in some areas.
- Energy efficient water and air systems and management: The hospital has high efficiency motors and low-pressure loss water and air handling systems. A computerised building-management system also helps control core water and air systems in the hospital to maximise energy efficiency.
- Solar water heating services the Cultural Health Area of the hospital.

The hospital has other innovative sustainable and eco-friendly features including waste minimisation and water management initiatives.

Lessons learned during the hospital's design, construction, and operation provide insight into the value of 'smart design' for energy efficiency. The redevelopment can provide inspiration for future design and building projects.

For further information on this project, check these websites:

- www.waitakere.govt.nz/abtcit/ec/ecoinit/hospital.asp
- www.mfe.govt.nz/publications/sus-dev/value-case-sustainable-building-feb06/html/page6d.html

Waitakere Hospital

Addressing fuel poverty

> *We often encounter homes being poorly heated by electric resistance heaters and LPG gas costing 17-21 cents per kWh to heat by these means. By installing a heat pump, heat is provided at the equivalent of about 6c/kWh, with a far more efficient use of energy through both the heat pump and the insulation. The ability to increase heating to provide healthy indoor temperatures is also vastly improved.*[47]

Fuel poverty is defined as being unable to afford sufficient fuel for one's domestic needs, particularly for heating.[48] The UK Government identifies households vulnerable to fuel poverty as those that spend more than 10 percent of their income keeping the house at a reasonable temperature.[49]

The usual means of addressing fuel poverty is to provide ongoing financial assistance through the welfare system. This has a number of disadvantages. For the householder, these include having to live with the uncertainty of whether this assistance will continue. For the government funders, they include financial exposure to fluctuations in energy prices, and the numbers of households qualifying for assistance.

Although local energy systems often have higher establishment costs, their higher levels of system efficiency (and use of free resources in some circumstances) mean their running costs are significantly lower. In the case of systems that improve the thermal performance of buildings (making them easier to heat), the running costs are zero. Such systems can reduce the uncertainties for both householders and governments associated with providing ongoing top-up assistance.

Groups such as Grey Power point to fuel poverty as an issue for elderly people who often limit their home heating to save money.[50] Local energy systems can help address this fuel poverty problem.[51]

3.2 The challenges of local energy systems

As well as their benefits, local energy systems do present challenges for, and impose costs on, some stakeholders in the energy sector under certain circumstances. Some challenges and their associated costs are listed here:

- Significant uptake of local energy systems could reduce the amount of electricity purchased from the grid. Electricity generators and operators of networks could have surplus capacity and be less profitable. These assets would become 'stranded'.
- Local energy systems that rely on intermittent sources of energy may not always deliver energy at times of peak load. If there is no mechanism for controlling the effects of the intermittency, the network will have to make up the shortfall. In effect, the network operator will not be able to rely on the local energy systems to share the peak load.

- While individual local energy systems have negligible environmental effects, large numbers concentrated in specific areas could result in significant cumulative impacts.
- Local energy systems are as dangerous as any other electrical installation, particularly when the equipment needs repair or minor adjustment. There is a danger that unqualified end-users may attempt do-it-yourself solutions.

CHAPTER 4

Local energy potential in New Zealand

During preparation of this report it became apparent there was little analysis of the possible role of local energy systems in New Zealand's energy sector. To fill this gap the PCE commissioned East Harbour Management Services Limited (EHMS) to assess the potential for adoption of these systems in New Zealand.[52]

The study defines the resources and technologies that will probably comprise local energy systems, estimates their potential uptake, and calculates the energy that they can produce and displace.

To provide some results within the available timeframe and budget, we used a set of simplifying assumptions. As a consequence, the study cannot be considered definitive. However, we hope this preliminary study will encourage others to undertake further work.

The study and its results are summarised in Section 4.1. Section 4.2 outlines similar studies from other countries, and Section 4.3 discusses the implications of the EHMS study for adoption of local energy systems in New Zealand. The full EHMS report can be downloaded from the PCE's website.[53]

Please note that the EHMS study summarised in this chapter uses the term 'microgeneration' rather than 'local energy systems' to refer to microgeneration, heat capture, improved building performance, and energy efficiency measures. For the sake of consistency the term 'local energy systems' will be used in this chapter as in the other chapters.

4.1 The EHMS study of the potential for local energy technologies in New Zealand

This section provides an overview of the EHMS study and its results. It outlines the objectives and focus of the study (Section 4.1.1) and the key assumptions (Section 4.1.2), and discusses four key findings (Sections 4.1.3 to 4.1.6).

4.1.1 Introduction to the study

The study aimed to assess the potential in New Zealand of the technologies that can be used in local energy systems, and more specifically to:

- identify which technologies could currently be used
- calculate realistic and defendable estimates of the potential for adoption of these technologies in the short (0–5 years), medium (0–10 years) and long term (up to 30 years).

The focus was on local energy systems and providing energy services for households, small communities, farms and other rural businesses, and small- to medium-sized enterprises (SMEs). The study considered a range of microgeneration and heat capture technologies that could generate up to the equivalent of one megawatt (MW) of heat and/or approximately 300 to 500 kilowatts (kW) of electricity.

It also considered smart control and information technologies for buildings, energy storage technologies, and measures to modify building performance. In this section, the term ‘technology’ includes measures to modify building performance, as well as the more obvious technologies.

The analysis included:

- Microgenerating technologies including combined heat and power (CHP) systems, photovoltaic solar panels, micro wind turbines, micro hydro systems, wood burners, pellet burners, Stirling engines, and fossil fuel generators.
- Heat capture technologies: direct generation of heat or cooling from energy sources. This category includes solar water heaters and heat pumps.
- Building performance measures: these include passive solar design, ceiling and hot water cylinder insulation, and double-glazing.
- Pumping: technologies that deliver energy used directly for pumping fluids (essentially, motive power that is not transport-related). Specific non-pumping mechanical applications (e.g. wind- or water-powered flour mills) are not included as these are considered ‘boutique’ applications.
- Energy management and equipment efficiency: technologies or concepts that mostly focus on reducing primary energy use. This category includes low energy-use light bulbs and lighting systems, automated controls on equipment, and energy-efficient appliances.

4.1.2 Key assumptions of the study

The EHMS study had to make a number of assumptions to calculate the potential of microgeneration technologies. The most important ones are outlined here.

The study accounted for potential economies of scale (from increased uptake) and technology developments such as ongoing technological improvements or changes. Micro heat generation technologies such as wood burners are currently more common than micro electricity generation technologies, and the study has probably more accurately estimated the adoption of these technologies.

The study assumed that all current energy-related government policies and strategies are implemented and the expected outcomes are achieved. Specific government strategies and policies include:

- the National Energy Efficiency and Conservation Strategy (and associated objectives)
- the Home Energy Rating Scheme (HERS) to be adopted in some form by 2010.

The study did not account for any new government policies to promote local energy.

The study calculations assume that the price of energy in real terms will stay the same over the 30-year period. In reality, prices are very likely to increase over this period, and this will impact on the adoption of local energy technologies, particularly those that generate electricity. Estimating the future price path of electricity was beyond the scope of the study, but the Commissioner believes that such an analysis should be done.

The EHMS study did not take into account any of the benefits arising from local energy systems identified in Chapter 3.

4.1.3 Results: Cost of different local energy technologies in New Zealand

A key factor in estimating the adoption of local energy technologies is the current and projected price of energy. To indicate the relative cost of energy from different technologies, the average cost of energy from each technology was calculated. The calculation was based on present-day costs and included analysis of:

- initial capital costs
- running costs (e.g. maintenance and/or fuel costs)
- technology efficiencies
- expected system lifetime (based in part on warranty details).

However, it should be noted that the analysis did not attempt to take into account the value of any non-market benefits of local energy technologies (as identified in Chapter 3).

The calculated cost of energy supplied (or saved) by each of the different technologies is shown in Figure 4.1. This figure also shows the average urban and rural retail prices of electricity as two horizontal lines. It is clear that some technologies are economical at present when compared with these electricity prices.

Note the following points in relation to Figure 4.1.

- The 'Water heating efficiency' column refers to net costs of insulating suitable hot water cylinders (i.e. the cost of supplying and fitting the insulation, minus the cost of energy saved over the lifetime of the insulated cylinder, compared with an uninsulated one).
- There are two columns for both 'Passive solar design' and 'Window double glazing'. The columns differentiate between the net costs of the technologies

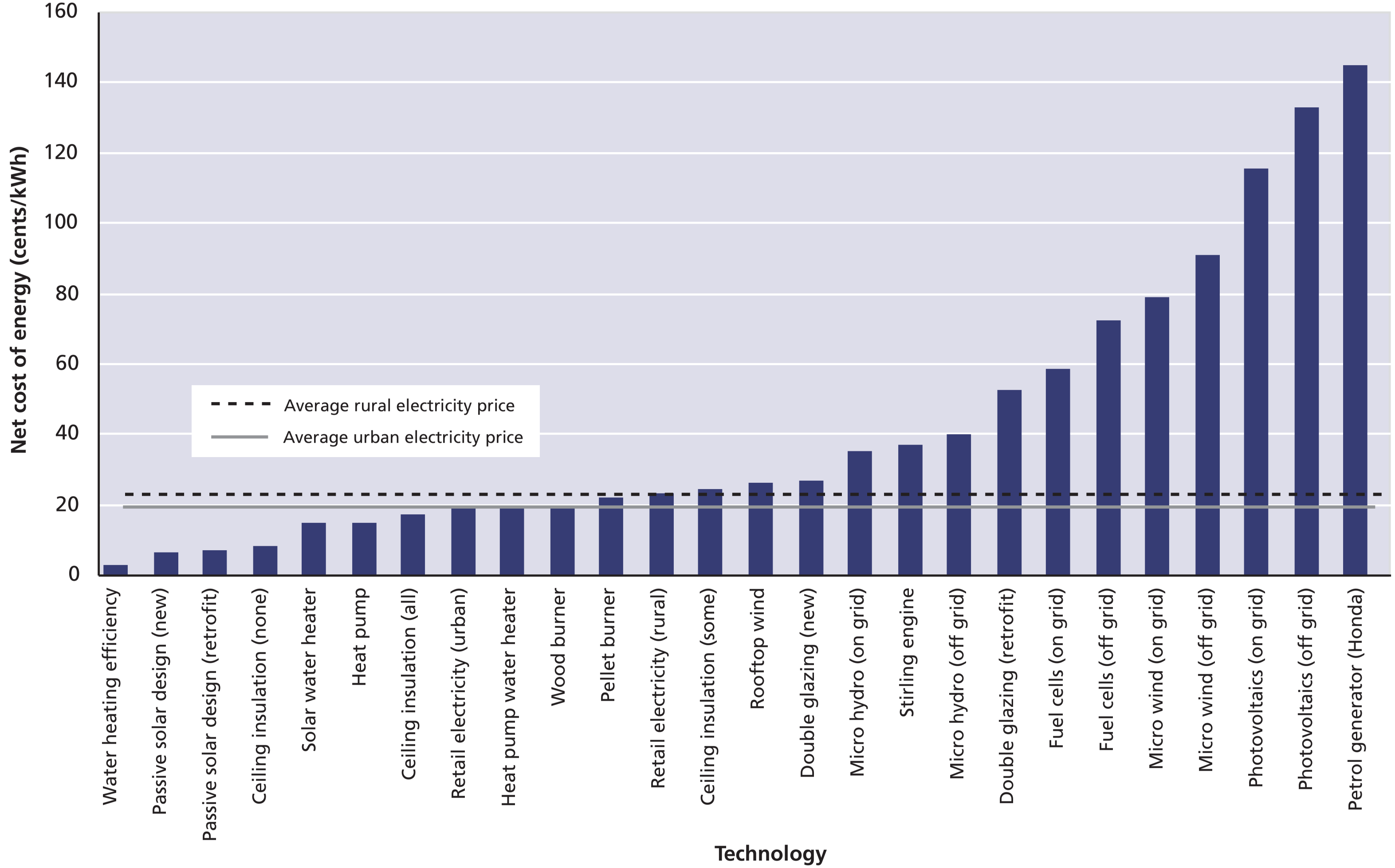


Figure 4.1 Net cost of energy supplied by different local energy technologies compared with current rural and urban electricity prices

Source: EHMS, 2006.

according to whether they are part of a new building or retrofitted later. Figure 4.1 shows that both measures cost more if they are retrofitted.

- There are three different columns for 'Ceiling insulation' – 'none', 'some', and 'all'. Two of these columns give the net cost of energy in buildings with no insulation (none), and buildings with insulation at a level below the requirements of the building regulations (some). The third column (all) gives the average net cost of ceiling insulation for all houses where improvements can be made.

Figure 4.1 shows that the most cost-effective technologies are those that modify energy demand (i.e. use energy more efficiently or effectively) and those that generate heat. The cost of many of the electricity-generating technologies – particularly micro wind turbines, fuel cells, and PVs – is well above current electricity costs. Obviously this will have a major influence on their uptake.

In the study, future reticulated electricity costs were projected to increase in line with current trends in the analysis. However, there may in fact be significantly higher real price increases in the future. In addition the report does not consider that technologies may become more effective or efficient, or less costly, in the future. So it is possible that local energy technologies, which are currently relatively expensive, may become more affordable.

4.1.4 Results: Projected energy generated and saved by different local energy technologies

Based on the assumptions outlined in Section 4.1.2, this section describes the potential adoption of the various local energy technologies, and the total amount of energy produced or saved by each technology (GWh/year). Some technologies have been left out of this discussion because of their low expected uptake. Stirling and Honda generators are also left out.

Figure 4.2 shows the projected energy generated and saved by the different technologies in the residential sector (homes and small communities) over three time periods:

- short term (0–5 years)
- medium term (0–10 years)
- long term (0–30 years).

Figure 4.2 shows that the most significant technologies in the residential sector are likely to be:

- solar water heating
- heat pumps for space heating
- passive solar design incorporated in new buildings

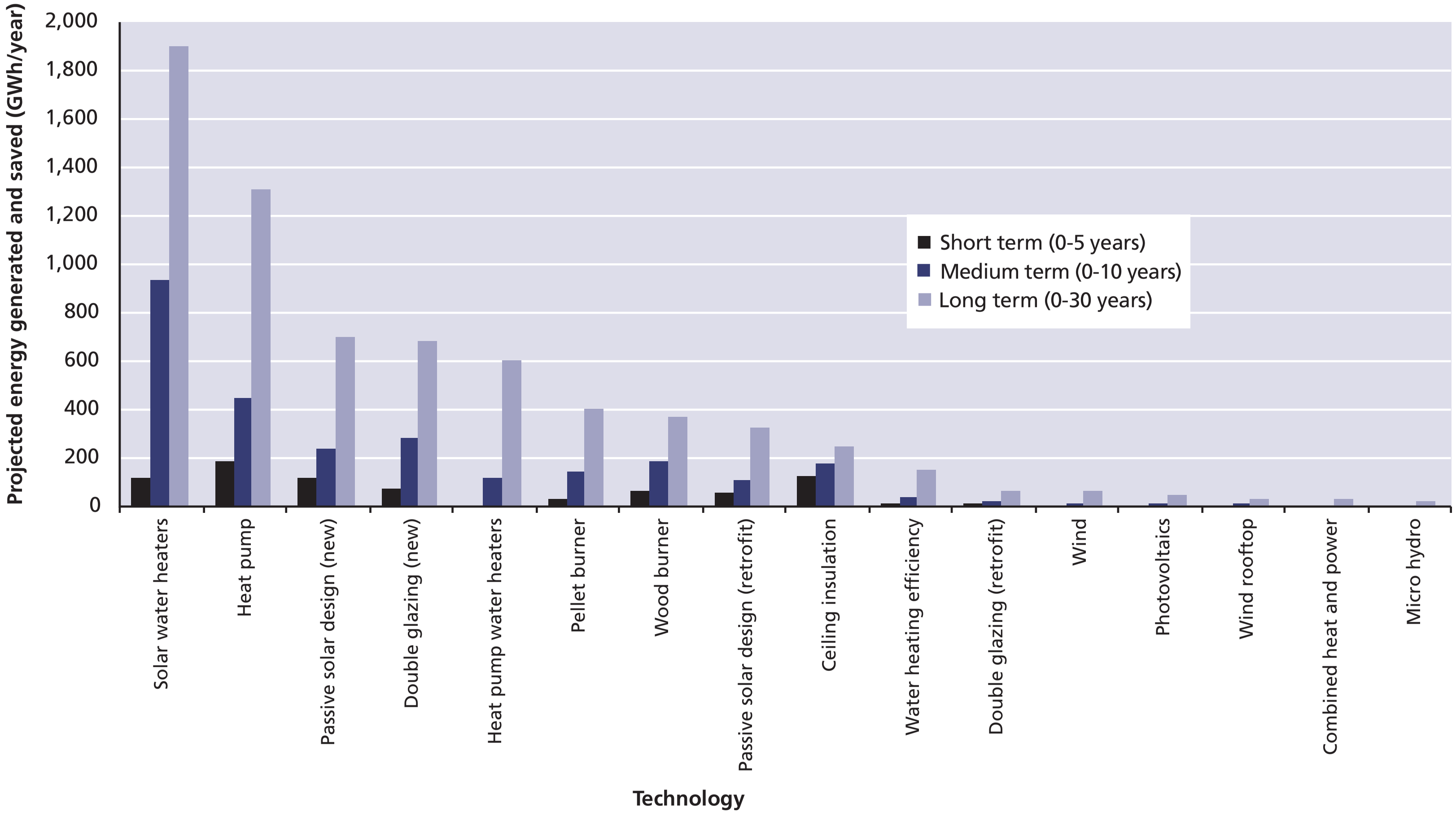


Figure 4.2 Projected energy generated and saved by local energy technologies for the residential sector

Source: EHMS, 2006.

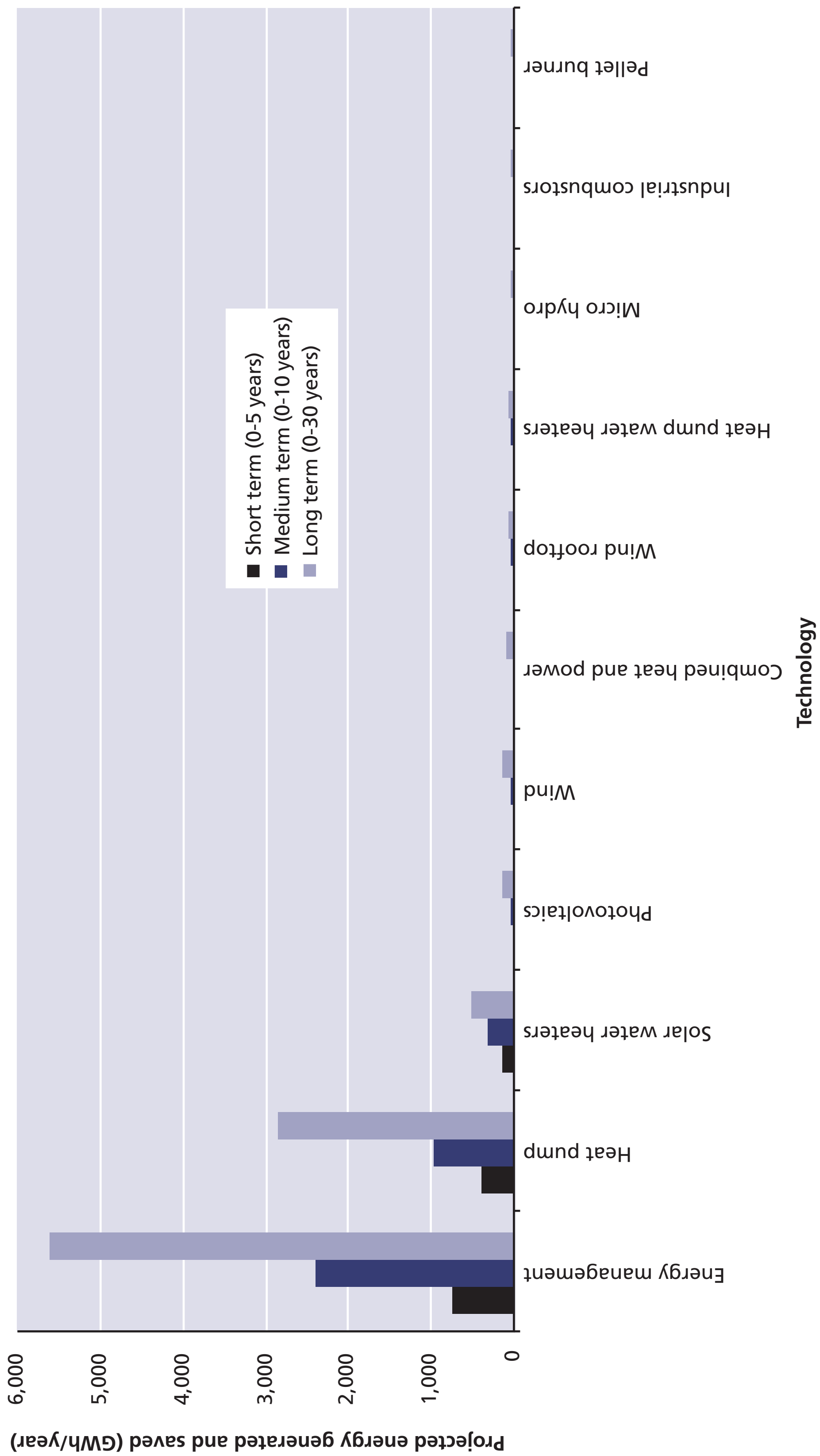


Figure 4.3 Potential adoption of local energy technologies for the SME sector

Source: EHMS, 2006.

- double glazing on new buildings
- heat pumps for water heating.

These technologies are relatively well known, 'low-tech' examples of local energy technologies. Many houses already have them.

Figure 4.3 shows the same data for small- to medium-sized enterprises (SMEs).

It shows that the most significant technologies for the SME sector are likely to be:

- energy management and equipment efficiency
- heat pumps for space heating
- solar water heating.

Again, these examples are relatively well-known 'low-tech' examples of local energy technologies. They are already being used, or are emerging, in many SMEs and in the community sector (for example, see the case study on Waitakere Hospital in Section 3.1.4).

Figures 4.2 and 4.3 show that technologies for improving heat provision (either by replacing electricity or by using heat more efficiently and effectively) will be adopted more readily than electricity-generating technologies. Figure 4.3 also shows that significant gains are possible by improving energy management and control systems, and using energy-efficient equipment in the SME sector.

The findings for heat pumps and solar water heating are consistent with recent studies in Europe. They show that space and water heating are drivers in the uptake of microgeneration in Europe.[55]

4.1.5 Results: Total projected energy generated and saved by different user sectors

Table 4.1 summarises the total potential energy generated and saved by the different groups of local energy technologies in the residential and SME sectors. Separate tables identifying the specific technologies for each sector are included in Appendix A.

In 30 years' time, a total of 16,356 GWh/year of energy (electricity and heat) could be generated or saved by adopting local energy technologies. This amount is made up of:

- 580 GWh/year micro electricity generation
- 8,021 GWh/year micro heat generation
- 7,755 GWh/year of electricity consumption avoided by energy efficiency measures (Table 4.1).

Compare this amount with New Zealand's net electricity generation of 41,622 GWh in 2004.[56] Local energy systems comprising microgeneration and heat capture technologies can therefore provide a significant proportion of New Zealand's future energy services, even if net use of energy increases over this time.

Table 4.1 Summary of total energy generated and saved by local energy systems for the residential and SMEs sectors

	Short term (0-5 years) GWh/year	Medium term (0-10 years) GWh/year	Long term (0-30 years) GWh/year
Micro electricity generation: Residential	4	23	172
Micro electricity generation: SMEs	7	52	408
Total micro electricity generation	**11**	**75**	**580**
Micro heat generation: Residential	387	1,800	4,568
Micro heat generation: SMEs	510	1,270	3,453
Total micro heat generation	**897**	**3,070**	**8,021**
Energy efficiency: Residential	382	852	2,152
Energy efficiency: SMEs	719	2,388	5,603
Total energy efficiency	**1,101**	**3,240**	**7,755**
TOTAL	***2,009***	***6,385***	***16,356***

There is good potential for technologies that provide or regulate heat. High-efficiency space and water heaters will lead the uptake of local energy technologies in the residential sector. In the SME sector, the need for process heat, particularly in the food and wood processing sectors, is expected to lead to increased uptake of heat pumps and solar water heating. The SME sector also has significant potential for energy efficiency improvements.

However, as long as the cost of reticulated electricity remains low compared to the costs of installing and running micro electricity technologies, adoption of these technologies in both the residential and SME sectors will remain low.

4.1.6 Results: Adoption of local energy technologies in urban and rural areas

The EHMS study identified that the adoption of electricity microgeneration technologies is likely to be different between urban and rural areas. Under current policies there will not be a significant uptake of these technologies in urban New Zealand in the foreseeable future.

However, some uptake may occur in rural areas because:

- the concentration of electricity distribution systems in urban areas means the price of electricity is significantly higher in rural areas, making microgeneration more attractive.

- any (negative) environmental impacts of local energy systems are less significant in rural areas because the population is less dense and fewer pre-existing environmental impacts arise from other activities (e.g. transport, home heating, industry, etc).

Another significant factor that will affect rural uptake is the 2013 removal of the requirement for lines companies to maintain electricity supply to all areas. See Section 2.3.8.

4.2 Similar studies in other countries

International examples of initiatives on local energy (also described as microgeneration or distributed generation) are available in many countries, particularly in Europe. For example, the German Government has promoted microgeneration as part of a broader renewable energy programme. The German work is summarised in the PCE's publication *Future currents.*[57] The German initiatives are also discussed in Section 5.2.3 of the present report.

The United Kingdom's Department of Trade and Industry (DTI) has been studying the potential of microgeneration in the UK, and recently released a report entitled *Potential for microgeneration: Study and analysis*.[58] The report examined this potential under a range of different scenarios. Various government interventions were considered, including:

- use of Energy Export Equivalence (EEE), where excess electricity is sold to the grid at the same price as electricity bought from the grid
- a subsidy of 25 percent for purchase of microgeneration equipment to reduce capitals costs
- Renewable Obligation Certificates (ROCs) which could allow microgenerators to enter agreements for selling their renewable energy to electricity suppliers
- regulations promoting microgeneration use in all new buildings.

The report found that microgeneration could provide 30 to 40 percent of the UK's electricity needs, and help to reduce household carbon emissions by 15 percent a year. However, without government interventions there would be no significant uptake of microgeneration technologies until between 2030 and 2050. Even then, EEE (selling excess energy at the same price as bought energy) was still crucial for technologies such as micro wind turbines and solar photovoltaics.

The report also highlighted that microgeneration could deliver significant energy efficiency and carbon dioxide benefits (from, for example, increased use of renewables, and use of waste heat from electricity generation or renewable heating fuels). Microgeneration could also avoid losses in the electricity transmission and distribution system.

The report noted that microgeneration would need significant uptake to have an impact on the UK's electricity system. That would require a new approach to energy planning and policy, and a greater understanding of the likely interaction between microgeneration technologies and potential end-users (the general public).

In March 2006 the UK Government followed up this study with a microgeneration strategy, *Our energy challenge: Power from the people*.[59] The objective is to create the conditions for microgeneration to be a viable supplementary energy generation option for householders, communities, and small businesses.

4.3 Summary

The EHMS study is the first comprehensive attempt to quantify the potential for local energy systems in New Zealand. This work is an important element in the discussion about the role of these systems in New Zealand's energy future, even allowing for the inherent limitations of its assumptions.

The study has indicated that, under current policy and price settings, local energy technologies are most likely to be taken up for water and space heating, and for energy efficiency and management. In contrast, micro electricity generating technologies will have significantly lower rates of uptake – primarily because of their high cost.

The EHMS study did not assess the impact of different types of government intervention. In effect, it assumed that the present institutional environment remains largely constant over the next 30 years. Under such conditions, certain barriers will prevent New Zealand from realising the full potential of local energy systems. These barriers are the subjects of the next two chapters.

CHAPTER 5

Barriers to the adoption of local energy systems in New Zealand

This chapter and Chapter 6 discuss the main factors identified during the PCE's investigation that are inhibiting adoption of local energy systems. Identifying the barriers involved researching the issues facing the development and uptake of local energy systems in other countries, and talking to people researching, promoting, and using local energy technologies and systems in New Zealand. It also involved discussing them with people in the wider energy sector whose activities affect the adoption of these systems.

Seven recurrent topics and themes emerged from this research and the related discussions. This chapter covers five aspects of local energy systems:

- awareness and understanding of them (Section 5.1)
- their costs and value (Section 5.2)
- technical challenges (Section 5.3)
- capacity for designing, installing and maintaining them (Section 5.4)
- knowledge of them (Section 5.5).

This chapter describes the present situation for each of these areas and identifies key issues. It also discusses possible ways forward and examples of initiatives in other countries.

The other two themes – institutional frameworks, and regulations and standards – are discussed in Chapter 6.

5.1 Awareness and understanding of local energy systems

5.1.1 The present situation

There is a general lack of awareness and understanding of the contribution local energy can make to New Zealand's energy future. During the investigation, this was particularly evident among potential end-users and at a wider community level. However, there were no outright objections to the concept.

This section summarises the present level of awareness and understanding among four key stakeholder groups: end-users, the energy sector, the installation and maintenance sector, and the research sector.

Awareness and understanding among potential end-users

The general public are aware of some of the technologies that make up local energy systems. However, they rarely understand that:

- local energy solutions are about more than just generating electricity
- homes and workplaces need a lot of energy, and local energy systems have the potential to contribute to that
- microgeneration technologies are relatively expensive when compared to reticulated electricity
- local energy technologies need an integrated system.

People often expressed surprise that wood burners, solar water heaters, and the passive thermal capacity of houses can be integral to the success of a microgeneration system. Generally, they thought microgeneration was about producing electricity. They often overlooked heat production and the 'demand side' aspects of local energy (such as energy efficiency, good systems design, and maximising use of available energy).

Our research also suggests that many potential end-users do not understand how much energy is used in a modern home or workplace, the effect of meeting peak loads on the cost of local energy systems, and the amount of energy that these systems can realistically deliver.

Few people realise that solar photovoltaics, the most widely known of the microgeneration technologies, is one of the most expensive. They have limited awareness of the cost competitiveness of other forms of local energy such as solar water heating and using insulation to improve heat provision.

Finally, our research found few people understand that local energy technologies require an integrated system of energy sources, control systems, demand management, and storage capability (or access to the wider grid). There is little awareness of the benefits of using several microgeneration technologies, rather than relying on just one local energy source.

Generally, the only people who have any awareness or understanding of local energy systems are researchers, people promoting specific technologies, and some interested individuals.

Awareness and understanding within the energy sector

As might be expected, there is a higher level of awareness of local energy systems in the energy sector.

In the electricity industry, the lines companies[60] seem most aware of the opportunities and risks of microgeneration of electricity, although they tend to focus on larger scale distributed generation (DG). DG plants are often situated close to end-users who require larger amounts of energy (such as hospitals or large industrial plants). Also, DG is primarily focused on the generation of electricity. The production and utilisation of heat is of secondary importance.

Our research suggests that lines companies are interested in DG because they can use it to strengthen their networks without investing in new line capacity. Orion is one example of a lines company that uses DG, in the form of diesel generator sets, to compensate for line constraints at times of peak load within their network in Canterbury.

Distributed generation also provides a way for lines companies to diversify out of the highly regulated core business of distribution networks where there are limited options to seek new profit opportunities. Unison's and Eastland Energy's wind farm proposals are examples of this type of diversification.

Some forward-looking lines companies are beginning to plan for the possibility of their customers adopting microgeneration. For example, Orion has developed standardised application forms for customers interested in grid-connected micro electricity generation. MainPower (another Canterbury lines company) is assessing the potential of various microgeneration technologies (solar photovoltaics, micro wind, and micro hydro).[61]

Orion and MainPower see local energy systems and larger scale distributed generation as potentially complementary to their core business. However, they also think that the existing regulatory framework actively discourages lines companies from making this a reality. The Ministry of Economic Development recently released a discussion document, *Facilitating investment in generation by lines companies*, which explores this issue.[62]

The attitudes of the combined generator-retail companies (the 'gentailers') are more difficult to determine. Gentailers are most involved when a household or business with microgeneration capability wishes to sell their surplus electricity back into the network. How easily this transaction can be undertaken is an indicator of how well a gentailer is engaging with the concept of microgeneration.

For example, Contact Energy offers contracts to electricity microgenerators on its network. It also has an agreement with the NZ Photovoltaic Association (NZPVA) to buy surplus electricity from NZPVA members at the full retail price (i.e. the price the customer pays for their normal electricity).[63]

TrustPower has had a microgeneration policy in place since July 2003. It gives customers metering and pays them $50/MWh + GST for all exported electricity. Other gentailers, such as Meridian Energy, are considering how they can integrate customer microgeneration into their business.

A small proportion of gentailers doubt the viability and usefulness of microgeneration. One suggested that lobbying for microgeneration comes from a minority group of hobbyists and zealots looking for subsidies. They suggested that microgeneration has very few institutional and market barriers in New Zealand, and that the only real barriers are related to cost. This was based on the observation that, despite allowing trading of surplus electricity at favourable prices, they had seen little uptake of microgeneration among end-users. These views do not reflect those of the entire electricity industry, but this mindset of some in the sector is a potential barrier.

In summary, most of the electricity industry is aware of local energy systems, and specifically microgeneration of electricity. However, some see these technologies as a marginal part of the energy sector for the foreseeable future.[64]

Awareness and understanding in the installation and maintenance sector

The installation and maintenance of local energy equipment requires various tradespeople. Our investigation found that some promoters and retailers of microgeneration and heat capture technologies often had trouble installing local energy equipment because many tradespeople did not have the necessary skills, and those that do are often busy on other work.

However, this situation has improved in the last few years, particularly for the more common technologies (such as heat pumps and solar water heating). Industry advocates have played an important role in raising awareness and understanding among tradespeople. This issue is related to building capacity for design, installation, and maintenance of local energy systems (see Section 5.4).

The installation and maintenance of local energy equipment is also linked to local government planning and authorisation processes. Staff at territorial authorities were sometimes unaware or uncertain of planning and authorisation requirements (particularly those related to the Resource Management Act 1991 and the Building Act 2004). Regulations and standards are discussed in Section 6.2.

Awareness and understanding in the research sector

Many initiatives at university and Crown Research Institute (CRI) level include research on local energy systems. Although much of this research is not focused specifically on microgeneration or other local energy technologies, it is still useful for local energy systems. Some of the key stakeholders and their local-energy related projects are listed in Appendix B.

Issue 1: Limited awareness and understanding of microgeneration and local energy systems

Those in the energy sector are aware of local energy systems, especially those technologies that generate electricity, and the research sector has projects focusing on many aspects of local energy. However, there is a lack of awareness and understanding of local energy systems at the community level and, in particular, by the potential end-users. This lack of awareness and understanding significantly affects the uptake of local energy systems.

5.1.2 The way forward

At present there is no specific government effort to promote local energy systems in New Zealand. The Energy Efficiency and Conservation Authority (EECA) does support some forms of local energy, such as solar hot water heaters and domestic heating efficiency, as part of other programmes. However, EECA does not have a specific programme that promotes, or raises awareness of, the concept of local energy systems.

The Centre for Advanced Engineering is the main non-government organisation that promotes awareness of small-scale energy production. Its focus is on microgeneration and distributed generation. The Centre publishes *Energy21 News: The news journal for distributed energy resources.*[65]

An integrated education and awareness programme led by government and industry would help potential users. The programme could raise awareness and understanding of local energy systems and the various technologies, highlight their costs and benefits, and outline the role they could play in New Zealand's energy future.

5.1.3 Initiatives in other countries

The United Kingdom's Department of Trade and Industry (DTI) has taken some steps to raise awareness of the concept of microgeneration. Recently it developed a microgeneration strategy entitled *Our energy challenge – Power from the people.*

Another DTI project, the Clear Skies Programme, supported the adoption of 6,976 local energy technologies in England, Wales, and Northern Ireland from 2003 to 2006, with funding of almost £5 million. The programme aims to increase the uptake of microgeneration equipment by households and community organisations. At present around 184 schools in England, Wales, and Northern Ireland operate small-scale renewable technology installations to provide their energy services.[66]

5.2 The costs and value of local energy systems

5.2.1 The present situation

> *In order for renewable policies to be fully effective, they need to send the right signals to the market. Market stability facilitates investment confidence, which encourages entry.*[67]

The East Harbour Management Services (EHMS) study summarised in Chapter 4 clearly demonstrates that the cost of buying, installing, and maintaining local energy technologies, combined with the relatively low cost of reticulated electricity, make many local energy options uneconomical. In particular, technologies such as solar photovoltaics, micro wind turbines, and micro hydro systems are too expensive in most situations.

However, the EHMS study does not account for all the benefits provided by local energy systems (described in Chapter 3). As a result, their true value is not effectively represented in the marketplace.

It is often difficult for governments to justify intervening in any marketplace. However, in local energy's case there is a strong argument for intervention because energy prices currently do not capture many of the costs imposed on the environment and society. Pricing also neglects many of the benefits provided by alternative energy systems, including local energy systems. International experience has shown that pricing these costs and benefits accurately requires government intervention.

Issue 2: Properly valuing the benefits and costs of local energy technologies

The cost of some local energy technologies, particularly some electricity generating technologies (e.g. wind and solar photovoltaics), puts people off adopting them. However, these costs and related energy pricing systems do not reflect the true value of local energy systems (i.e. the inherent public benefits such as reduced greenhouse gas emissions, increased energy security, and more efficient use of existing capacity).

5.2.2 The way forward

Economic instruments can reduce the typically high costs of some local energy technologies. The range of options includes:

- tax relief on the cost of equipment
- capital grants to subsidise the relatively high initial purchase costs
- rebates to partially refund purchase and installation costs
- combined incentive schemes that use several economic instruments to achieve the desired outcome.

Other economic instruments can remove some of the market barriers, particularly by helping end-users sell their surplus energy (see Section 6.2). The three most common approaches are:

- net metering and net billing
- standard offer contracts (feed-in tariffs) that offer customers a predetermined fixed price for electricity that they export back to the grid
- mandatory requirements for energy retailers to provide a set quantity or percentage of their electricity from renewable energy sources. This aims to stimulate market growth by creating a mandatory demand for renewably generated electricity.

More details on net metering, net billing, and standard offer contracts are given in Appendix C.

5.2.3 Initiatives in other countries

Other countries have introduced economic policies that make local energy systems more cost-competitive with traditional sources of energy services. Some examples are given below.

Tax relief

In the United Kingdom, VAT (the UK equivalent of GST) has been lowered as an incentive for people to buy micro wind turbines, solar thermal technologies, solar PV panels, ground source heat pumps, and air-sourced heat pumps.[68] The reduced VAT rate is 5 percent, whilst the standard rate is 17.5 percent. This means a solar panel normally costing £11,750 can be bought for £10,500, saving £1,250.

Capital grants

The British Department of Trade and Industry and the Energy Saving Trust undertook the Solar PV Grant Programme from 2002 to 2006 with a budget of £26 million. The size of the grants varied with the type of building and size of solar panels, but could be up to 50 percent of the total cost of installation.

Japan implemented the Ten Thousand Roofs programme in 1994, where the Government paid one-third of the installation cost of solar PVs on household roofs, funded through an electricity surcharge. Local utilities were also obliged to purchase excess power generated by these solar PV systems at the retail price of electricity. The scheme ran until September 1997 when it was replaced by other schemes for PV and other renewable sources of energy.

These schemes have boosted domestic demand so much that Japan has become a world leader in solar capacity and PV cell manufacturing. In 2003, Japanese PV companies manufactured just over 50 percent (588 MW) of the global supply of PV modules, of which 45 percent was sold to the local market.[69]

Rebates

The Australian Government implemented the Photovoltaic Rebate Programme in January 2000.[70] The A$50 million programme offers cash rebates to homeowners who install solar PV systems. The programme is also available to community buildings, schools, display homes, and housing developments.[71]

The cash rebate was originally set at A$4 per peak watt installed and capped at A$4,000. In January 2006 this was reduced to A$3.50 per peak watt for residential installations. The solar PV systems have to be at least 450-watt peak output. As an example, if a 1 kW solar panel retails for around A$10,000, a cash rebate of A$4,000 is provided (i.e. 1,000 times A$4), reducing the retail price to A$6,000. Many retailers involved in the scheme charge customers the discounted rate for the PV system and get the reimbursement from the Government themselves, as this saves extra hassle for the customer. The programme is expected to run until June 2007.

Combined incentive schemes

The most comprehensive incentive scheme known for local energy systems is Germany's 100,000 Roofs Programme.[72] Launched on 1 January 1999, it provided interest-free loans (and low-interest loans) for solar PV units of 1 kW or less. The loans covered the entire retail cost of the units, and were made available through the customer's own bank. The 10-year loan had to be paid back in eight annual instalments, with no repayment required in the first 2 years.

The programme was so successful that it ended in 2003 – 18 months earlier than planned – when the target of 100,000 installations was met. Around 10 percent of instalments were commercial, and the rest were households and community groups. In April 2000, the scheme was integrated within their Renewable Energy Law. (More details of this scheme are given in Appendix D.)

Germany now has the second largest solar PV capacity in the world after Japan, with around 150,000 solar PV installations. This market expansion has boosted the local manufacturing industry: in 1999, all PV units installed in Germany were imported but by 2004 more than half were locally made. The price of solar PV units fell 20 percent during this time, as economies of scale were reached in production of solar units and mounting systems.

Standard offer contracts

By 2005, at least 32 countries and five states or provinces had introduced standard offer contracts, including 16 European nations as well as Brazil, Sri Lanka, Thailand, China, and India.[73]

Mandatory requirement schemes

By 2005, mandatory requirement schemes had been set up in 11 countries including Australia, Japan, the USA, and various European countries.[74] These schemes come in a variety of forms with different names, such as mandatory quota systems, renewable portfolio standards, and renewable obligations.

Most schemes have focused on developing large-scale renewable generation, although there are some exceptions. For example, introduction of the Renewable Portfolio Standard (RPS) in New Mexico required utilities to purchase 10 percent of their electricity from renewable sources. The power companies could choose either to build their own renewable generators, or to incentivise their customers to build their own.

Power New Mexico (PNM) chose the latter option, and implemented its Solar PV Program. When customers connect to PNM, with an installed solar PV panel of 10 kW or smaller, they receive a payment or credit of 13 cents for every kWh the panel produces, regardless of their consumption. In addition, a net-metering arrangement is offered, where customers can sell surplus electricity back to the grid for the same price that they buy it.

5.3 Technical challenges

5.3.1 The present situation

Local energy systems include established technologies (e.g. solar hot water heating, building insulation, high efficiency wood burners) and emerging technologies, mostly electrical, that require further development (such as fuel cells, some types of micro hydro, wave, and tidal power systems, and some bioenergy systems). For the established technologies, research is continuing on reducing costs, increasing reliability, and widening their applicability. Much of this research is happening overseas and, for many of the technologies, New Zealand will be in a receiver role, a 'technology taker', rather than an instigator or developer. However, where New Zealand has special expertise it should play an important role in the development of specific technologies (see Section 5.3.2).

During this investigation it became apparent that the real technical challenges for New Zealand could best be described as contextual (i.e. how certain technologies should be applied in each context rather than what specific types of microgeneration and related technologies need to be developed). In particular, the following areas require more attention.

Site-specific design of local energy systems

As discussed in Section 2.4, designing a local energy system requires attention to a number of site-specific factors, including:

- the energy services required
- the local energy resources available
- energy storage options
- the reliability of the systems
- the budget available
- the role of the end-user.

The implications of local energy systems for the centralised electricity network

As on-grid local energy systems become more common, they will begin to affect the operation and integrity of wider distribution networks. These networks will need to adjust to accommodate multiple flows of electricity as more people invest in local energy systems. The additional flows will affect voltage, frequency, and the incidence of system faults.

The network companies are also concerned about the impact of local energy systems on their business and profitability. Electricity generated (or saved) through the use of local energy systems could reduce the demand for electricity to be transported through some parts of the electricity network.

Smart metering

The lack of smart metering systems in New Zealand's electricity system is not just a major technical barrier to the adoption of on-grid local energy systems, but also a major source of inefficiency in the electricity market. Indeed, the Parliamentary Commissioner for the Environment's recent assessment of the environmental performance of the electricity sector also supports developing policies that require smart meters for efficiency.[75]

Storage technologies

At present, many energy storage systems are expensive, have short functional lifetimes, are only suitable for specific applications, and are often high-maintenance. The lack of cheap, reliable, versatile, and low-maintenance energy storage systems is a major constraint to promoting off-grid systems in particular. Renewable off-grid systems based on wind and sunlight must incorporate a storage system (or alternative back-up generators using fossil fuels) because of the intermittent nature of these energy sources.[76]

For on-grid systems that include a storage component, lines companies and/or energy retailers could import microgenerated electricity into their networks at times of high demand. This arrangement would allow end-users to receive a premium price for the surplus energy that they export to the wider grid. Therefore, as local energy technologies based on intermittent renewable sources of energy become more common, the need to develop better storage systems for use in both off-grid and on-grid systems will increase.

Issue 3: Overcoming the technical challenges associated with design, installation, and operation of local energy systems

A range of enabling technologies and methods is required to integrate microgeneration technologies effectively into local energy systems. These include methods for designing site-specific local energy systems, modelling the interactions between on-grid systems and the wider electricity network, smart metering systems, and improved storage technologies.

5.3.2 The way forward

Site-specific design of microgeneration systems

Designing a local energy system that takes account of all relevant site-specific factors is a complicated process. Ongoing research at Massey University and Industrial Research Limited (IRL) is examining how to undertake in-depth assessments of the physical resources and end-user requirements prior to designing local energy systems. A Massey PhD student has recently developed a comprehensive decision-support system that combines local energy system performance and economic predictive tools with social and environmental parameters. The objective is to enable end-users to select their energy choices using a triple bottom line approach.[77] The work suggests that this important aspect of local energy systems requires further research in New Zealand.

Implications of local energy systems for the centralised electricity network

As on-grid local energy systems become more common, lines companies (and possibly even Transpower) will need to change the way they plan their investment, and learn new techniques for operating the grid in a secure manner. IRL has undertaken work in this area, but there is a need to further develop these models to help lines companies and policymakers understand the short and long term implications for distribution networks of increasing amounts of on-grid microgenerated electricity. These models will enable lines companies to incorporate the growth of microgeneration into their network planning.

Smart meters

Smart meters have been described in Section 2.3.2. An essential element of an efficient electricity system, they enable consumers to analyse their electricity use meaningfully. Research has shown that this information influences consumers' behaviour, causing them to use energy more wisely and to consider alternatives such as energy efficiency improvements or a local energy system (if they don't have one already).[78]

In August 2006 Arcinnovations, a subsidiary of Meridian Energy, announced the start of an Advanced Meter Management Programme. This is a 2-year programme to introduce smart meters to over 100,000 Christchurch homes. Initially the focus is on the commercial benefits of reducing costs through remote accurate meter-reading. Other benefits have been promised to customers, including:

- eliminating the need for meter readers to have regular access to consumers' properties
- greater accuracy in billing detail
- comparative information to guide customer decisions about electricity use

- more detailed time-of-day pricing and incentives to increase energy efficiency and reduce energy bills
- energy management tools, potentially including remote control of household appliances or workplace equipment
- diverse payment options, potentially including consumer-selected bill dates
- new service models with options allowing consumers to directly tailor and manage their energy requirements.[79]

Smart meters could potentially allow energy retailers or lines companies, with the micro generator's agreement, to exercise some degree of control over the local energy system, possibly using a predetermined price as the trigger. This would provide a mechanism for ensuring that network stability is enhanced by local energy systems (see Section 3.1.1), and that any surplus energy generated from intermittent renewable sources is not wasted.

Storage technologies

The most widely used form of energy storage is the lead acid battery. However, these batteries are relatively costly and need careful management because of their concentrated acid content. There are now other types of batteries, such as the lithium ion battery, which cost more but are cheaper to operate. All electrochemical batteries have limited lifetimes (because of the limited number of times that they can be fully discharged).

Storage technologies that are available or in development, other than batteries, include super capacitors, fuel cells, fly wheels, compressed air storage, and pumped hydro storage. There is significant effort going into the development of these energy storage systems but the focus is mostly on the larger scale rather than the local energy scale. There is a need to develop energy storage systems that are compatible with local energy systems.

5.3.3 Initiatives in other countries

Other countries are looking at how to address some of the technical challenges of local energy systems.

Implications of local energy systems for the centralised electricity network

Analysis for the UK's DTI found that the initial impact of local energy systems on networks would be minimal, although heavy concentration in small areas could possibly lead to issues. The study found that an unacceptable level of voltage variation occurred within the network when 50 percent of the houses had microgeneration capacity (i.e. 50 percent of houses had a 1.1 kW generator, or 550W per house).

The analysis also found that reverse power flow, which occurs when more electricity is generated than consumed and power is spilled back into the network, would probably become a problem when local energy penetration is around 1.4 kW per house. Most distribution system transformers are only designed to take power in one direction (towards the building). The study concluded that these issues could easily be resolved, and questioned whether they were economic matters rather than technical limitations.[80]

The Australian Government is now attempting to understand the impact of local energy systems through the Solar Cities project. It will create an urban-scale model combining solar PV, energy efficiency, load management, smart meters, and cost-reflective pricing. At least four major cities will be involved, each competing on a tendering basis for the funding. Installations will be completed in each city by around 2008–2009. The project will monitor the effect of this large-scale 'real world' application of smart meters and cost-reflective pricing on energy consumption patterns, attitudinal and behavioural changes, the need for network upgrading, and greenhouse gas emission levels.[81]

BC Hydro, the utility that serves all British Columbia in Canada, is concerned about the sheer complexity of managing networks of smart devices including distributed generators (although these generators are at a larger scale than the focus of this report). BC Hydro's Powertech Labs are developing software to model power grid stability, including the impacts of large numbers of distributed generators.[82]

Storage technologies

This is an area where work is being done in New Zealand. For example, IRL is assessing the use of fuel cells in local energy systems, and Auckland University is looking at the use of ultra capacitors in smaller scale applications.

In Canada, BC Hydro is exploring practical issues around integrating fuel cells into its own grid operations. Working with the Canadian National Research Council's Institute for Fuel Cell Innovation and British Columbia-based Ballard Energy Systems, it is testing how 1 kW Ballard fuel cells perform as replacements for batteries on the BC Hydro grid. The utility has 600 sites where batteries provide emergency power, including substations and telecommunications sites used in BC Hydro's own control system. Field tests started in 2004.[83]

5.4 Capacity for design, installation, and maintenance of local energy systems

5.4.1 The present situation

A major barrier to local energy systems in New Zealand is the shortage of people who can provide expert advice on design, installation, and maintenance. Development of New Zealand's capability in this field will require appropriately trained and qualified:

- engineers specialising in local energy technologies and systems (to adapt or develop technologies for New Zealand conditions)

- architects with knowledge of passive solar design and energy efficiency in buildings
- developers and property managers (who understand the benefits and costs of local energy systems and how to incorporate them into the specifications for new and existing buildings)
- builders (for installation of local energy systems)
- plumbers (for installation and repair of technologies such as solar water heaters)
- electricians (for installation and repair of local energy systems)
- accreditors (for checking that local energy systems and installations meet and continue to meet legislative requirements)
- inspectors (for certifying installed local energy systems).

Over time this will lead to a local energy services industry. Training will also be needed for people in the real estate, valuation, and mortgage sectors to assess 'added value' of infrastructure with local energy capability.

During the PCE's investigation, it became clear that only some design, civil engineering, and building firms will promote the benefits of highly energy efficient buildings to their clients, even though most have been trained in applying energy efficiency concepts. The demand is currently for larger houses with lots of features, and energy performance is a minor consideration, if considered at all.

Until clients demand the 'eco' house rather than the 'ego' house, designers and builders will not implement energy performance measures or develop the relevant skills. This lack of awareness and understanding among potential end-users was discussed in Section 5.1.1.

The Solar Industries Association (SIA) is concerned that the shortage of qualified plumbers and electricians is already inhibiting the uptake of solar hot water heaters. In this situation, there is always a danger that 'cowboys' will undermine what is otherwise a valid energy option by poor installation or by recommending systems that are not appropriate. Certification, quality assurance programmes, and greater brand awareness are required to minimise this problem.

Another problem for someone wishing to install a local energy system is that installation and servicing may require several tradespeople. For example, installing solar hot water heaters requires a plumber and often an electrician. This adds another layer of complexity and planning which may deter some people.

Experience with solar water heater installations indicates that in some regions it is hard to get tradespeople to do the work because of competition for their services. Clients must compete with others wanting these same tradespeople to undertake other more traditional tasks.

Issue 4: A lack of capacity in the local energy sector

Inadequate training, qualification and accreditation schemes associated with the emerging local energy industry could act as a deterrent to the adoption of local energy systems. Potential end-users require reliable and accessible information about them. In addition, the installation and maintenance industry requires robust product information, installation and maintenance training, and accreditation to support them in using and promoting local energy systems to potential end-users.

5.4.2 The way forward

Professional training for engineers and architects should cover the potential of local energy systems and the availability of various technologies and approaches. Experience in the United Kingdom has shown that post-graduate training is a useful approach.

Integrated and comprehensive training and certification schemes are required for local councils officers, employees of lines companies, trade certifiers, electricians, and plumbers so that they are qualified to approve or install local energy systems. An example of one initiative is a short course run by the Waikato Institute of Technology. The course, leading to a qualification, is for plumbers who wish to develop skills to install and maintain solar water heaters.

Qualifications for local energy technologies would address the problem of it taking multiple tradespeople to install microgeneration technologies. Appropriately qualified tradespeople could install and repair particular types of technologies (e.g. solar hot water heaters, photovoltaics, micro wind turbines) even though this work may require the skills of more than one of the traditional trades (e.g. the electrical and plumbing trades).

5.4.3 Initiatives in other countries

The shortage of qualified professionals and tradespeople is not unique to New Zealand. For example, the UK Microgeneration Strategy identifies a possible shortage of qualified people in some traditional occupations (such as plumbers and electricians) if the demand for local energy technologies increases. The strategy proposes that:

> *DTI will explore with the Sector Skills Councils what more can be done to ensure that the skills base develops to support the levels of demand that will hopefully be created for microgeneration technologies. The other significant issue for industry development is the education of the related industries mentioned above.*[84]

Other countries have – or are starting to – put in place both government and privately funded programmes to fill these gaps. The Energy Institute in the United Kingdom, for example, holds one-day courses throughout the year specifically to update the knowledge of energy professionals on all aspects of local energy systems and energy management.[85]

The USA's Zero Net Energy Buildings Outreach and Action Plan offers an example of coordination among different professionals and tradespeople. Initiated in 2000 by the US Department of Energy, the plan involves creating a number of homebuilder teams. These teams bring together construction companies, architects, engineers, and builders, with the aim of designing, building and showcasing 'zero-energy houses'.[86] The plan aims to build over 100,000 affordable zero-energy houses by 2020.[87]

5.5 Developing knowledge about local energy technologies

The investigation for this report identified a variety of research needs across the disciplines of engineering, economics, systems modelling, and social science. However, the subject most often discussed was the development of promising technologies and combinations of technologies relevant to the New Zealand situation.

5.5.1 The present situation

Developing knowledge about energy technologies involves three stages.

1. Research: from the initial research into the concept, through to the experimental or bench-top stage to show that the technology works in practice
2. Development: developing the concept from the bench-top to the pilot stage
3. Pilot: discovering whether the technology works as expected under realistic conditions.

A subsequent stage, not usually considered part of the research and development process, is also essential to successful uptake. This is the early commercial stage where the technology is brought to the attention of target audiences, often through demonstration projects run in cooperation with selected potential end-users.

During this investigation, stakeholders expressed concern about the difficulty of obtaining funding for this stage; in particular, for demonstrating technologies and for other pre-commercial projects. Without such activities it is difficult to attract interest and investment into the sector.

Anecdote suggests that there is a shortage of venture capital for local energy in New Zealand. The lack of any significant existing industry in this area further restricts investment potential. In summary, a classic 'catch-22' situation exists, as it does in the UK, where microgeneration is curtailed by investment wariness.[88]

Some stakeholders also raised concerns about the difficulty of obtaining funding for research and development of local energy technologies in general. (See Appendix E for more about current funding of energy research.) However, the Minister for Research, Science and Technology announced in a 2006 Budget speech that $11.7 million in new funding would be invested over four years on energy research:

This new energy research funding will assist New Zealand to move toward a more sustainable energy future so we can more effectively respond to pressures on energy supplies and security. In particular, the research will be aimed at assisting New Zealand to:

- *more fully understand our indigenous energy resources and opportunities, in particular using renewable energy resources;*
- *develop new energy technologies, and be better placed to adapt and adopt new overseas technologies, for use in New Zealand;*
- *understand and implement opportunities to use energy more efficiently in homes and businesses.*

These initiatives sit alongside other ongoing streams of work, including the National Energy Strategy.[89]

Although not specifically mentioned, development of local energy technologies would be consistent with these objectives. If funding is to be directed to them, it is important that the National Energy Strategy clearly identifies local energy systems as an important work stream.

Finally, those involved in research into local energy felt that a more coordinated research strategy would assist in strengthening the overall effect of individual research efforts. This will help to avoid potential overlaps in research, and focus it towards areas of most benefit.

Issue 5: Need for a coordinated local energy research programme and funding for demonstration projects

The concept of local energy systems is not yet fully recognised in New Zealand science, technology, and research policy development. Without a coordinated programme there could be overlaps and gaps in research, reducing the potential benefits. There is also a shortage of funding for demonstration projects that show the feasibility of local energy systems to potential end-users.

5.5.2 The way forward

This investigation has identified some important areas where research is needed, such as the economics of local energy systems (including evaluation of the public benefits), their impact on electricity networks, and how people interact with them.

However, the most significant research need is for a research programme specifically focused on local energy systems. This should identify, as a minimum:

- demonstration projects that can show the feasibility of local energy systems to target audiences

- gaps in information where research is required
- areas of future local energy research potential
- the important components of overseas research applicable to New Zealand
- opportunities for collaboration among research stakeholders nationally and abroad.

This programme should be part of a wider strategy for local energy systems (see Chapter 7).

5.5.3 Initiatives in other countries

The UK's microgeneration strategy states that the:

> *DTI will produce a map of available funding, building on the Research Atlas being developed by the UK Energy Research Centre, together with guidance on how to apply. This will then inform further assessment as to whether R&D funding is being appropriately targeted.*[90]

A 2006 UK Government Budget speech also announced:

> *…a new fund, initially £50 million, for microgeneration technologies which make it possible for homes and businesses to generate their own renewable energy. The purpose of this £50 million fund is to show how we can make these technologies from wind turbines to solar heating, affordable to schools, housing associations, businesses including local authority tenants – initially 25,000 buildings…*[91]

The Canadian Government has a Technology and Innovation Initiative with a Decentralized Energy Production (DEP) component with funding of C$20 million over five years. The DEP team's strategic plan included defining boundaries with other government-funded research and development programmes, and integration with other technology and innovation areas.[92]

5.6 Summary

This chapter has identified five factors that are inhibiting the adoption of local energy systems in New Zealand, from which five key issues can be distilled:

Issue 1: Limited awareness and understanding of local energy systems.

Issue 2: Valuing local energy technologies properly.

Issue 3: Overcoming the technical challenges associated with design, installation, and operation of local energy systems.

Issue 4: A lack of capacity in the local energy sector.

Issue 5: Need for a coordinated local energy research programme and funding for demonstration projects.

We have suggested possible ways forward for each of these issues, and given examples of initiatives in other countries. However, none of these measures will succeed unless the institutional and regulatory barriers to microgeneration are removed. This is the subject of the next chapter.

CHAPTER 6

The institutional and regulatory framework

6.1 Institutional framework

The existing institutional framework that oversees and provides energy services in New Zealand is complex, reflecting 20 years of ongoing reform. Table 6.1 summarises the key players and their roles in relation to local energy systems.

Table 6.1 The key local energy stakeholders and their roles

Institution	Role in relation to local energy systems
Government agencies	
Ministry of Economic Development (MED)	MED develops and oversees energy related policies and legislation including: • energy strategies • energy-related legislation and regulations • government policy statements on energy • regulation of safety in the electricity and gas industry. Current work: MED is developing a New Zealand Energy Strategy; it could include local energy policies. MED is also developing distributed generation regulations (including the microgeneration of electricity).
Energy Efficiency and Conservation Authority (EECA)	EECA is responsible for promoting energy efficiency and renewable energy. It is also responsible for developing the Government's National Energy Efficiency and Conservation Strategy (NEECS). Current work: Some local energy technologies are included in the renewable and energy efficiency programmes (e.g. solar hot water heating promotion). EECA is currently reviewing the NEECS, which could be amended to include local energy objectives.
Ministry for the Environment (MfE)	MfE is responsible for the climate change programme. Current work: MfE is currently reviewing the Government's climate change policy, including any economic instrument that places a price on carbon. Such an instrument would support the uptake of local energy.

Department of Building and Housing (DBH)	DBH develops and oversees the Building Code and Building Act 2004. From 2007 the Building Practitioners Board will licence professional builders. Current work: DBH is currently reviewing the energy efficiency provisions of the Building Code. This review will influence building requirements and aspects of local energy systems.
Ministry of Research, Science and Technology (MRST)	MRST develops the Government's research and innovation funding policy. It also has a key role in managing the Government's programmes of research, science and technology across all sectors, including energy.
Foundation for Research, Science and Technology (FRST)	FRST develops operational funding policy and allocates the Government's research funding. Current work: FRST is currently reviewing its energy funding criteria.
Commerce Commission (CC)	The CC ensures the commercial compliance of electricity lines companies, Transpower, and natural gas distributors with the provisions in the Commerce Act 1986 (electricity lines companies and Transpower have specific provisions in Part 4A of the Act).
Regional Councils	Regional Councils set rules and regulate the taking and discharge of water; this may have an impact on some micro hydro schemes.
Territorial Authorities (TAs)	TAs set rules that regulate the use of land, noise effects, and access to sunlight. The TAs' building inspectors also ensure that alterations to buildings comply with the rules in plans and the Building Act and Code.
Electricity sector	
Electricity Commission	Regulates the electricity market. Does not set prices but sets the rules by which the market operates. The Commission must achieve a number of objectives including seeking to achieve specific outcomes: "The electricity sector contributes to achieving the Government's climate change objectives by minimising hydro spill, efficiently managing transmission and distribution losses and constraints, promoting demand-side management and energy efficiency, and removing barriers to investment in new generation technologies, renewables, and distributed generation."[93]
Gentailers	Generate electricity and, either directly or through their own retail arms, sell it to end-users; they may also own electricity meters.
Lines companies	Build and maintain the local distribution networks; they may also own electricity meters.

Transpower	Builds and operates the national grid and maintains grid security.
Meter companies	The major metering company NGC wants to introduce smart electricity meters into the market. The company was separate from the other players in the electricity market but is now owned by Vector, a lines company.
M-co (The Marketplace Company)	Operates the wholesale electricity and electricity contracts market.
Providers of non-electrical energy resources	
Gas production companies	Unlike the electricity generating companies, they do not have much presence in the retailing industry. An exception is Todd Energy, which also has an interest in a number of electricity generating and retailing enterprises.
Gas supply companies	These are the equivalent of electricity retailers and, in many cases, are part of a major electricity company. They on-sell natural or, in some cases, landfill gas to consumers.
Gas lines companies	Similar to electricity lines companies, and operate under a similar regulatory environment.
Vector	Formerly NGC, operates the main gas network.
Coal and wood providers	This sector comprises one large company, Solid Energy (which provides coal and wood pellets), and many small businesses.
Microgeneration providers	
Individual microgeneration companies	Individual and small companies that sell, install, and repair microgeneration technologies. They are often also importers, and in some cases developers and manufacturers of these technologies. Many of these providers have formed associations to raise their profile. These associations often work with EECA to undertake promotional activities. This group also includes architects and builders who specialise in the provision of passive solar buildings, and energy-efficient building methods.

The key stakeholders that can hinder or support initiatives for local energy systems are the Government and its agencies, electricity retailers, Transpower, and the lines companies. Their roles are outlined below.

The Government and its agencies

The energy sector is institutionally and physically set up to provide energy (primarily electricity and gas) in large quantities from remote locations to dispersed end-users (as described in Chapter 2). Government institutions are designed to ensure that this happens as efficiently, cheaply, and reliably as possible.

Small-scale energy generation for local use does not fit this institutional model. Therefore there is a danger that the current institutional framework in New Zealand could hinder the adoption of local energy systems.

The Ministry of Economic Development and the Electricity Commission are undertaking some work in this area, but their primary focus is on the barriers facing larger-scale distributed generation projects. Local energy is seen as a subset. There has been little Government research to identify the scale of the opportunities arising from local energy systems.

Local energy features in some Government programmes but has no specific strategy or programme of its own. Government promotion of local energy is part of distributed generation and energy efficiency programmes. One example is EECA's solar water heating initiative, which is part of the Government's energy efficiency programme. In addition, an important part of EECA's current effort to promote renewable energy is through making submissions in support of large-scale projects such as wind farms.

Electricity retailers

The electricity retailers have a role to play in buying surplus electricity from on-grid electricity microgeneration. Table 6.2 summarises the policies of some electricity retailers for buying microgenerated electricity.

As the technology becomes more prevalent it is likely that more microgenerators will choose to stay on the grid so that they receive the benefits of back-up supply and the ability to sell any surplus electricity. However, there is little commercial incentive for the electricity retailers to buy this power, as it directly competes with their own business. If the retailer does buy this electricity, then there is a strong reason to pay only the price it pays its other suppliers (the wholesale price). This price does not reflect the wider benefits that microgeneration offers, both to the grid (by delaying the need for more investment) and the other areas described in Chapter 3.

Table 6.2 Summary of the microgeneration purchase policies of some electricity retailers

Retailer	Owned by	Microgeneration purchase policy
TrustPower Ltd	TrustPower Ltd	Buys surplus microgeneration electricity at $50/MWh + GST.
Empower Ltd	Contact Energy	Buys surplus PV electricity at the retail price from New Zealand Photovoltaics Association (NZPVA) members only. Other purchase agreements are case dependent.
Meridian Energy Ltd	Meridian Energy Ltd	Meridian offers net metering to customers with small microgeneration capacity. This does not include the lines component of any tariff.

Transpower and the lines companies

Although Transpower has no apparent concerns about local energy at this time, it does have an ongoing policy of questioning any initiatives that could result in its assets becoming stranded (redundant). Sufficient adoption of local energy systems in high-demand areas (e.g. Auckland and Christchurch) could lead to parts of its grid being under-utilised. This could pose a risk to Transpower's business, as its revenue is proportional to the amount of electricity carried by their power lines. However, the adoption of local energy systems would have to be significant for this scenario to become a reality.

The only major players in the electricity market that currently have an incentive to promote local energy are the lines companies. There are several reasons for this difference:

- Local energy can be used to delay new investment in lines, and this has economic value for a lines company
- The core business of the lines companies is strictly regulated, and local energy provides an opportunity to develop new markets
- Most lines companies still operate within their original power board areas. These companies often retain a close relationship with the local community, and may see local energy as another opportunity to work with these communities.

However, the lines companies made it clear in discussions that they find the current regulatory framework overly restrictive resulting in less efficient outcomes. This is discussed further in Section 6.2.1.

Issue 6: The complex institutional framework of the energy sector is a potential barrier for local energy systems.

The energy sector, particularly the electricity industry, has a complex management and institutional framework based on the centralised model of energy provision. This could be a barrier to development of the local energy marketplace.

6.1.1 The way forward

An integrated strategy on local energy could help resolve some of the issues outlined above. The strategy could provide a comprehensive overview of the local energy sector, and highlight issues and priorities for further work.

As an example, a local energy strategy (based on stakeholder consultation) could identify the key institutional barriers to it, and devise tailored solutions. Such a strategy could identify legislation and policies that require amending (or development) to facilitate the adoption of local energy. Some possible directions are outlined in Section 6.2.

6.1.2 Initiatives in other countries

In March 2006 the UK Government launched its Microgeneration Strategy, *Our energy challenge – Power from the people.*[94] The strategy has the following objective:

> *…to create conditions under which microgeneration becomes a realistic alternative and supplementary energy generation source for the householder, for the community and for small business.*[95]

It points out that a range of constraints is currently affecting the wide-scale deployment of microgeneration, including financial, information, technical, and regulatory constraints. The strategy recognises that a range of actions is required to achieve its stated objective, particularly by the Government and other key stakeholders. This approach provides a model for other nations interested in supporting local energy.

Stakeholder feedback following the strategy's release was largely supportive, with praise for the measures suggested as a good first step for overcoming the barriers, and support for the suggested policy framework.[96]

6.2 Regulations and standards

6.2.1 The present situation

This section describes some of the key regulatory barriers to the adoption of local energy systems:

- the Electricity Industry Reform Act 1998
- standardised approvals
- rights of access to renewable energy sources
- the Building Act 2004 and the Building Code
- technical standards.

Electricity Industry Reform Act 1998 (EIRA)

The Electricity Industry Reform Act 1998 (EIRA) divided the electricity sector into two parts: the owners of the lines and infrastructure, and the sellers and/or generators of electricity. The Act imposed strict controls and regulations on cross-ownership, and provided for full corporate separation through mirror trusts and arms-length management. This was in response to concern that local electricity companies, being both vertically integrated and natural monopolies, could be involved in practices that were anti-competitive, preventing the electricity market operating effectively.

The EIRA was amended in 2001 and 2004. The 2001 amendment eased the prohibition on lines companies owning generation. The justification was that lines companies should be able, where it made economic sense, to invest in distributed generation rather than upgrading lines networks. The amendment allowed lines companies to own distributed generation up to the greater of 5 MW or 2 percent of their maximum demand, and to sell the power from such generation.

The 2001 amendment also allowed lines companies to generate electricity from renewable energy sources to an unlimited level. If capacity exceeded 5 MW or 2 percent of their peak load then full corporate separation and arms-length rules would apply.

The 2004 amendment raised the limit on lines companies' ownership of non-renewable generation to 50 MW or 20 percent of peak load, and an unlimited amount of reserve generation contracted to the Electricity Commission. However, the provisions relating to full corporate separation and arms-length rules still applied for any generation capacity above 5 MW or 2 percent of peak demand.

Many lines companies consider that the current regulatory environment is still overly restrictive. An example of the tension was highlighted by the Commerce Commission's recent decision to decline Eastland Networks' application for exemption from the arms-length rules and the restriction on selling electricity directly to its line customers. The decision to decline was based on concerns about the opportunities the exemption would create for lines companies to use their line monopoly to favour their own electricity generation activities at the expense of other competing electricity generators and retailers.[97]

Recognising this concern among lines companies, the Ministry of Economic Development (MED) in April 2006 issued a discussion paper titled *Investment in electricity generation by lines companies*.[98] The paper considers areas where there may be unnecessary barriers to lines companies' investment in large- and small-scale generation. It acknowledges that lines companies are technically able to generate unlimited amounts of energy for new renewable energy projects, and limited amounts for non-renewable energy projects. However, the paper suggests that legal constraints create financial barriers to the viability of such projects.

In particular, the paper identifies the following constraints:

- Lines companies are prohibited from hedging the financial risks of selling energy. They must sell either at spot prices or to other parties who are able to manage the variations in power production and market prices. This usually means a competing energy generator/retailer or one of the few large energy users that are active in the electricity market.
- The compliance costs associated with operating holdings with full corporate separation and compliance with arms-length rules (required for any generation by lines companies above 5 MW or 2 percent of peak demand) may be too high to justify for smaller projects.

It appears from the paper's conclusions that further legislative changes to facilitate lines companies' investment in generation are likely to occur.

Streamlined approvals for installing and operating local energy systems

An individual or business wishing to install some form of local energy technology will in most instances require regulatory approvals or contractual agreements with one or more agencies. Depending on the type of local energy system, the applicant may need approvals from regional and territorial authorities, lines companies and electricity retailers, and/or licensed workers. Getting these approvals is often felt to be unnecessarily complicated and expensive, and discourages uptake of local energy technologies.

Regional council and territorial authority approvals

Regional councils and territorial authorities are consent authorities under the Resource Management Act 1991 (RMA). Technologies that use water – such as micro hydro systems – may require resource consent from a regional council to use, dam, or divert the water. Also, resource consent may be required from a territorial authority if the local energy system:

- produces excessive noise
- impacts on visual amenity
- involves land use such as the construction of an unauthorised structure.

An example could be the proposed installation of a micro-wind turbine in an urban environment.

The RMA allows councils to include provisions in their regional or district plans that make certain activities permitted (with or without conditions). Permitted activities do not require resource consent. Usually the effects of such activities are known and considered minor.

However, most local energy technologies are relatively uncommon in New Zealand, and council officials have limited experience with them. Officials often err on the side of caution and require additional conditions to reduce risk (and adverse impacts). Proponents of local energy technologies consider that some resource consent conditions are unnecessary and can add significant costs to some systems.

Regional and territorial authorities also use their powers and functions under the Building Act 2004 to ensure that local energy systems comply with the Building Code. Any system that impinges on the structural integrity of a building may require such an approval. Solar hot water heaters, heat pumps, roof-based wind turbines and photovoltaics are technologies that fall into this category. Regional councils are also responsible under the Building Act 2004 for matters pertaining to dams.

Building inspectors are required to determine the adequacy of building work. However, industry participants have advised that, as in setting environmental performance standards for local energy technologies, unfamiliarity with these technologies often means councils and inspectors err on the side of caution. So there is considerable variability in the way the Building Code is applied, sometimes even within the same council. This issue raises questions about the need for extra staff training in this area (see Section 5.4).

Alternative options for approving local energy systems include:

- councils undertaking the verification, as they do with buildings and building alterations
- an independent third party verifying installation
- the owner bearing the risk (with or without insurance).

Some other questions are relevant in setting up an approvals mechanism for the installation of local energy systems:

- Who pays the costs associated with approval of an installation – the public or the applicant? At present each council makes this decision through their cost recovery policies.
- Who carries liability if anything goes wrong? This could be a significant issue restricting local energy uptake, particularly as bad installation and liability issues could deter customers from entering the local energy market.

Lines companies and electricity retailer approvals

Any local energy system that is intended to export electricity into the local network will require approval from the local lines company under the Electricity Act 1992 and Electricity Regulations 1997. The applicant will need to comply with the local lines company's network connection requirements for on-grid systems, which cover safety provisions. In addition, the lines company may also require some form of payment for lines connection.

The applicant will also need to find a buyer for the electricity. In most cases this will involve a contract to sell and purchase, between a local energy system end-user and a dedicated supplier or electricity retailer.[99] Examples of these types of arrangement are Windflow Technology's supply agreement with the Christchurch City Council, and Energy^3's agreement to sell electricity to Meridian Energy (an electricity retailer).[100]

The Energy Efficiency and Conservation Authority (EECA) has identified two barriers to the development of very small (up to 5 kW) renewable generation, namely:

> *…the lack of standard connection agreements for connecting such generators to lines networks and the lack of standard agreements for electricity retailers to purchase surplus electricity. Its work [EECA] is to determine model agreements to overcome these barriers.*[101]

Some line companies, for example Orion, offer standard connection contracts for microgenerators. Contact Energy also offers a standard purchase contract for small amounts of electricity. However, these arrangements are not common across the industry and conditions vary.

Two initiatives under way, one by the Ministry of Economic Development (MED) and the other by the Electricity Commission (EC), attempt to address the uncertainties surrounding connection to the network and sale/purchase of small amounts of surplus electricity.

MED has recently developed draft distributed generation regulations and released these for consultation in September 2006. Submissions were due by 10 October 2006.

The regulations follow on from a 2003 discussion document that proposed how to set the price chargeable by lines companies to microgenerators for connecting to the network. The document defined two categories of generation: less than 10 kW generation capacity and 10,000 kWh generated per year, and over 10 kW 'connected behind load' (i.e. primarily for use on the site where generation occurs). Both categories are applicable to the types of local energy considered in this report.[102]

The recently released *Draft Electricity Governance (Connection of Distributed Generation) Regulations 2006* now only distinguishes between two categories: less than or equal to 10kW, and above 10kW generation capacity. The 'behind load' concept is no longer included.

For less than 10kW generation there is no cost of connecting to the local lines network because:

> *…there is an expectation of sufficient network capacity, and the distributor is therefore expected to approve connection at no cost (other than for additional metering and for processing the application) provided that there is sufficient connection capacity at the existing point of connection and the distributed generation meets relevant connection standards.*[103]

The Ministry considers there will be no impact from the uptake of these small microgeneration systems on line capacity in the medium term and therefore no need for lines companies to recover capital and operating costs though fixed charges. The Ministry will, however, continue to monitor the situation.

For more than 10kW generation the regulations propose that distributors may charge generators an amount that recovers reasonable capital and operating costs, but only those necessary for the connection of the distributed generation.

The costs that can be considered are for:

- connection from the power plant to the network
- up-rating of lines, transformers, and switchgear
- changes to fault protection and voltage control systems.

However, pricing provisions also include the expectation that generators will be recognised for the benefits they provide to the network by avoiding the need for a line to be upgraded.

The Electricity Commission (EC) is developing model retail contracts to standardise some of the conditions applying to the sale and purchase of electricity. The suite of model contracts being developed includes provisions for buying small surpluses of electricity generation from distributed generation. The provisions relating to the purchase of electricity from small-scale distributed generation (i.e. local energy systems) are included as Schedule 1 to the *Model Domestic Contract For Delivered Electricity (Interposed).*[104]

The schedule, however, is optional for retailers, and applies only to those microgenerators with equipment that generates less than 40,000 kWh per year. The schedule also requires the installation of an approved export meter (net metering is not permitted), and each retail company sets their own price for the purchase of any electricity.

At present it is uncertain whether electricity retailers will use this schedule of the model contract and what price plans the model contracts might contain. It appears the retailers are awaiting the outcome of the Electricity Commission's work on producing a common industry model before releasing or developing further policy.

Approvals under the Electricity Act 1992 and the Electricity Regulations 1997

Any microgeneration technology that produces voltages above 50v AC or 120v DC will require certification by a licensed worker (electrician) under the Electricity Act 1992 and the Electricity Regulations 1997. The certification confirms that the electricity generating equipment is safe to connect to the electricity lines network. One advantage of smaller microgeneration systems is that they can operate below these voltages and avoid this requirement. However, their usefulness is limited to off-grid systems that do not require the operation of standard electrical appliances.

Rights of access to renewable energy sources

As local energy systems using renewable sources of energy become more prevalent it is likely that there will be conflicts over rights of access to energy sources. For example, conflicts could arise when:

- a farmer has a micro hydro scheme and another farmer upstream wants to take water for irrigation

- a house in Auckland has photovoltaic cells on the roof, and the next-door neighbour constructs a building that blocks the sun for part of the day
- a house in Wellington has a micro wind turbine on the roof, and the next-door neighbour plants trees that eventually grow and disturb the wind flow.

Local and central government will have to consider how such conflicts are managed if local energy is taken up more widely. Specific rules may need to be developed, and consideration given to permitted activity rules under local government planning frameworks, particularly those pertaining to the RMA.

Building Act 2004 and the Building Code

The purpose of the Building Act is to regulate building work to ensure that buildings meet set standards of safety, contribute to health and well being, and "are designed, constructed, and able to be used in ways that promote sustainable development".[105]

The Building Code is a set of regulations made under the Building Act that prescribe both the functional requirements for buildings, and the performance criteria that buildings must meet in their intended use.[106] The Department of Building and Housing administers the code. The Act requires that the code be reviewed by 30 November 2007, and the Department of Building and Housing is currently consulting stakeholders as part of this review.

Regional and territorial authorities are building consent authorities under the Act. They administer the requirements of both the Building Act and the Building Code. When building consent authorities are performing functions under the Act they must (among other things) take into account "the need to facilitate the efficient use of energy and energy conservation and the use of renewable sources of energy in buildings".[107]

To help builders comply with the code, a number of 'acceptable solutions' are provided. The code does not currently contain any acceptable solutions for local energy technologies, although it considers solar hot water heating as an acceptable solution to the H1 energy efficiency requirements in the Building Code.

For those local energy systems that will fall within the scope of the Building Code, such as roof-mounted wind turbines and photovoltaic arrays, clear guidance would be useful. This would mean specific provisions and possibly even some 'acceptable solutions' for these technologies.

The code also sets the minimum standards for energy efficiency of buildings, through the H1 compliance document. The review of the code will:

> *…examine how it could be more user-friendly, and ensure that performance standards for buildings are clear and meet community expectations. These changes will take into account the Act's requirements for sustainable development and for buildings that help people stay healthy and comfortable.*[108]

In October 2006, as part of the review of the Building Code, the Building Issues Minister announced a new package of work aimed at improving the energy efficiency of New Zealand homes and commercial buildings through insulation, solar, lighting and other technologies. A public discussion document was released in November with public comment sought by April 2007.[109]

Although the discussion document is focused on improving energy efficiency in buildings, there is some overlap with many of the issues discussed in this report. It would be timely if, as part of the review of the Building Code, some thought were given to the impact of emerging local energy technologies on the code.

Technical standards

Technical standards ensure that microgeneration components of local energy systems are safe, do not adversely affect the security of the electricity system (if they are on-grid), and perform as promised. Some lines companies have already developed standards for those microgeneration technologies that will be connecting to their networks. An example of such a standard is Orion's *Requirements for embedded generation.*[110]

In addition, there are Australian and New Zealand technical standards that cover performance testing and installation of solar hot water heaters, photovoltaics, and heat pumps.

However, many of the technologies identified in this report have not been tested in New Zealand. In these cases, the purchaser and any approving authority will have to rely on the source country's standards for technical information, where they exist. It is possible that such standards may not be recognised, or may be inappropriate for the New Zealand situation.

Issue 7: New Zealand's regulatory framework does not support local energy

New Zealand's current regulatory framework provides some barriers to the adoption of local energy. The range of legislative requirements for the local energy sector could confuse and discourage interested parties and end-users from investing in local energy.

6.2.2 The way forward

Many areas within the regulatory framework require development to facilitate local energy.

The Ministry of Economic Development is currently consulting on the regulatory barriers that prevent lines companies becoming involved in local energy activities. In addition, the Electricity Commission is conducting work on developing model retail contracts for local energy. This work is an important prerequisite to the widespread adoption of on-grid local energy. However, further work is required by local government and the installation industry to devise a framework of authorisation and certification to ensure quality control and resolve liability issues.

All this policy and regulation development will be driven largely by the demand for local energy and the sector's reaction to problems that arise. However, rather than relying on this reactive development approach, some form of proactive strategy – based on discussion among all key stakeholders – could help develop more robust planning and approval procedures, and regulation for the local energy sector. Any strategy needs to link to the issues identified in Chapter 5, and those explored further in Chapter 7.

6.2.3 Initiatives in other countries

There are a number of examples in the UK of regulatory initiatives to overcome the types of barriers identified in this section.

Planning Policy Statement 22: Renewable Energy was published in 2004, and established that local authorities could set targets for on-site renewable energy in residential, commercial or industrial projects.[111] The London Borough of Merton provides an example of this type of initiative in practice (see box).

The UK Office of the Deputy Prime Minister (ODPM) has recently announced a review of permitted development rights enjoyed by householders. The intention is to make it easier to install microgeneration equipment such as micro wind and heat pumps in UK homes. A permitted development right allows owners to make certain types of minor alterations to their homes without the need to apply for planning permission.[112]

Regarding building regulations specifically, the ODPM in the UK announced in March 2006 that it would strengthen the Code for Sustainable Homes alongside tougher building regulations to address climate change. This code sets higher standards for new homes to be rated against, in order to increase environmental sustainability and give homeowners better information about the running costs of their homes.

The code's minimum standards will be raised above the requirements of mandatory building regulations, and each level of the code will set minimum requirements for energy and water efficiency. Code points are part of the scoring system and a minimum number of points are needed for code compliance. New homes that use micro renewable technology such as wind turbines and solar panels will gain extra code points to further promote on-site energy generation.

The proposals for strengthening the Code have been criticised by some environmental organisations for not having tougher standards, not including commercial buildings or refurbishment of existing buildings, and not being mandatory.[113]

In Spain, the Technical Building Code was established in March 2006.[114] This code requires all new buildings and renovations, regardless of their use, to provide 30 to 70 percent of their expected hot water demand by solar energy. This obligation depends on different parameters, including expected volume of water demand, geographical position of the building, and surrounding shade. In addition, large buildings of over 4,000 m^2 floor space will be required to install solar PV systems.[115]

The Merton rule

In October 2003, the London Borough of Merton became the first local authority in the UK to introduce a policy that required new non-residential buildings to generate at least 10 percent of their energy needs from on-site renewable sources. The ruling applies to all non-residential developments larger than 1,000 m^2.

The first development under the policy was a 4,500 m^2 industrial building, on which 10 small wind turbines and 9 kW of photovoltaics were installed. Five further developments have been built or are under construction.

The policy has been dubbed 'the Merton rule' and now almost a quarter of all local authorities in the UK are either implementing or formulating similar policies.

In order to help industry learn more about these requirements, the Merton rule was showcased in seminars at the Interbuild Exhibition in Birmingham in April 2006. The seminars provided an opportunity for designers, architects, surveyors, and builders to share experiences and best practice in working under the Merton rule.[116]

6.3 Summary

In addition to the five issues identified in Chapter 5, this chapter has identified two further issues that are holding back the adoption of local energy systems in New Zealand.

Issue 6: The complex institutional framework of the energy sector is a potential barrier.

Issue 7: New Zealand's regulatory framework does not support local energy.

Possible ways forward that address these issues have been suggested, and examples of initiatives in other countries given. Development of a local energy strategy for New Zealand is particularly crucial. This is discussed in more detail in the next chapter.

CHAPTER 7

Making the shift to local energy

7.1 The potential for local energy in New Zealand

Local energy systems are in a similar position today as telecommunication and computing technologies were 30 years ago. When the first personal computers and basic internet protocols were developed during the 1970s, most people didn't understand these new technologies or foresee their potential. It wasn't until user-friendly software and lower prices made them more accessible that they began to be widely adopted. The internet and personal computing are now an integral part of most modern societies.

The same potential exists, and could be realised, with local energy systems.

The EHMS study of the uptake of local energy in Chapter 4 found that most growth would occur between 2016 and 2036, when the cost of many of the technologies is expected to decline significantly. By the end of this period the equivalent of 16,000 GWh electricity a year could either be generated on-site, or avoided, by the adoption of local energy technologies. This amount can be compared with New Zealand's net electricity generation of 41,600 GWh in 2004.

In other words, even without additional government intervention, 39 percent of New Zealand's current electricity use could be displaced by local energy systems in 30 years' time. Considerably more is possible with government leadership and support.

7.2 The time is right

New Zealand is particularly well suited to local energy systems because of its abundant renewable energy sources (i.e. sun, wind, and water). Although wind and hydro energy sources can be (and are already being) used in large electricity generating plants, such plants have significant drawbacks compared with using these energy sources in local energy systems (as discussed in Chapter 3). In the case of hydro power, many of the sites suitable for large-scale development have already been used. Most of the remaining sites are in areas with significant environmental or other values, where public acceptance of large-scale development plans would be difficult to gain.

Local energy systems that can displace electricity generated from large, centralised plants, especially those that use fossil fuels, have the potential to deliver many public benefits. These have been discussed in Chapter 3 under four headings: national energy system benefits, environmental benefits, economic benefits, and social and cultural benefits (see Section 3.1).

Now is an appropriate time for New Zealanders to seriously consider how to realise these benefits, and how to introduce local energy systems into the marketplace. Overseas experience clearly indicates that, with government's support, local energy systems could become an integral part of New Zealand's future energy sector.

7.3 The way forward

The potential benefits of local energy will not be realised on any significant scale unless there is government leadership. In addition, this report has identified seven issues affecting the adoption of local energy systems (see Chapters 5 and 6).

Further work is needed to address these issues. Recommended actions are summarised in the following sections.

7.3.1 Increasing awareness and understanding of local energy systems (Issue 1)

Awareness of local energy is growing, but among the general public there remains a lack of understanding about:

- what local energy comprises – that it's not just about generating electricity, and that successful systems need an integrated range of energy sources, control technologies, energy storage technologies (or access to the wider grid), and demand management systems
- the potential contribution of local energy systems to energy services in homes and workplaces
- the relative costs of local energy technologies, particularly those that generate electricity.

The focus of the electricity industry is primarily on larger-scale distributed generation rather than local energy. However, some lines companies, such as Orion and MainPower, are aware that local energy systems, particularly those that allow for the microgeneration of electricity, present both opportunities and risks to their businesses. The attitudes of the 'gentailers' are more difficult to determine, but at this stage they seem to have more of a 'wait and see' attitude.

The Government can take a lead in building local energy awareness and knowledge by endorsing its future role, and developing programmes to address the barriers identified in this report. The current work on developing a National Energy Strategy provides an opportunity to bring local energy into the mainstream of energy policy.

The Government can also take a lead in its own activities by looking for local energy opportunities within government. The Govt^3 programme is an ideal means of implementing local energy initiatives into mainstream government activities.[117] The programme works with agencies to implement the Government's sustainability policies (including the National Energy Efficiency and Conservation Strategy, the Climate Change Programme, and the New Zealand Waste Strategy).

Recommendation 1

a) That the Minister of Energy, as part of the New Zealand Energy Strategy, develops a specific local energy work programme for New Zealand that:

- endorses the concept of local energy
- identifies the contribution that local energy systems can make to New Zealand's future energy services provision
- sets targets for the short, medium, and long term uptake of local energy
- sets out the roles and responsibilities of government agencies in achieving the targets
- provides a framework that coordinates the work programmes to implement Recommendations 2 and 3.

b) That the Minister for the Environment supports local energy initiatives through the Govt^3 programme.

7.3.2 Getting the costs and benefits right (Issue 2)

Some local energy technologies identified in this report already make financial sense (e.g. solar water heating). However, many are still more expensive to install and operate than using reticulated electricity and gas. Current costs and projections make it clear that these technologies will not be a significant component of New Zealand's energy future in the next few years unless there is government intervention (as demonstrated in Chapter 4).

Nevertheless, New Zealand has a history of government intervention in the energy sector for the public good. Our large hydroelectric projects were funded and built by the Government. The Government underwrote the development of the Maui gas field through the Maui take-or-pay gas contract. More recently, the Government intervened in the electricity market through the Whirinaki power plant and the Huntly e3p gas contract. The net result of these interventions is that New Zealand has had some of the lowest priced energy in the world.

In the same way, adoption of local energy systems could be supported through a range of economic instruments as outlined in Section 5.2.2. Such intervention could be justified by the fact that these systems provide private and public benefits that are not taken into account by the market. For this reason, work is required to assess the value of the private and public benefits of local energy.

Work is also needed to develop economic instruments that value the costs and benefits of local energy, and promote its uptake. Some of the instruments used in other countries should be investigated including standard offer contracts, net metering and net billing, rebates, capital grants, tax relief, and mandatory requirements targeted at small-scale applications.

Recommendation 2

That the Ministers of Finance and Energy:

- undertake work that identifies the value of the private and public benefits (social, economic, and environmental) arising from local energy systems
- develop economic instruments that recognise the value of these benefits and promote the uptake of local energy, possibly by including:
  - net metering and net billing
  - standard contract offer/feed-in tariffs
  - rebates
  - capital grants
  - tax relief
  - mandatory requirements (similar to the renewable portfolio standard but targeted at small-scale applications).

7.3.3 Local energy technology research (Issues 3 and 5)

Many local energy technologies have been developed to the point where they are ready for uptake in the marketplace. However, there remain a number of areas requiring further knowledge development. Future research should give priority to:

- demonstration projects showing the feasibility of local energy to potential end-users
- improving the performance and lowering the costs of selected energy generation and transformation technologies, in particular energy storage systems and local energy system control technologies
- developing tools to assess the impact of future local energy on existing electricity networks
- development of assessment methods for designing site-specific local energy systems, which help system providers work with communities and individuals.

Recommendation 3

That the Foundation for Research Science and Technology develops specific guidelines for funding local energy research.

7.3.4 Building capability to design, install and maintain local energy systems (Issue 4)

A challenge common to all countries encouraging the uptake of local energy technologies is the shortage of suitably qualified people to design, install, and maintain local energy systems. This investigation has identified a number of essential professions and trade groups for this work: engineers, architects, developers and property managers, builders, plumbers, electricians, and accreditors and inspectors (the officials that issue approvals).

A comprehensive training strategy is required to deliver integrated management training and certification schemes for these people. These schemes should be developed bearing in mind that local energy requires customised application for each situation.

Recommendation 4

That the Minister of Tertiary Education and Associate Minister of Tertiary Education direct the Ministry of Education, NZQA, and the Tertiary Education Commission to work with tertiary institutions and Industry Training Organisations to develop training programmes and qualification standards for skills in:

- designing site-specific local energy systems (engineers, architects, developers and property managers)
- installing, maintaining, and servicing local energy systems (tradespeople)
- approving local energy systems (accreditors and inspectors).

7.3.5 A place in the market for local energy (Issue 6)

The energy sector and its associated regulatory agencies have for 80 years been focusing on large-scale, centralised energy projects. Consequently, the current institutional framework does not provide the best conditions for encouraging local energy. Work is needed specifically to assess the barriers this institutional framework creates, and how these can be lifted.

Recommendation 5

That the Ministers of Energy and Commerce identify barriers in the electricity market that are preventing the uptake of local energy, and develop policies to:

- ensure that there are no market barriers preventing the sale of surplus electricity produced by local energy systems
- create pricing conditions that reflect the true value of local energy
- guarantee access to the wider grid for end-users with on-grid local energy systems, subject to safety and quality standards
- address the effect of line and connection charges on the financial viability of on-grid local energy systems
- address the barriers facing lines companies wanting to be involved in local energy (which is different from lines companies being involved in larger-scale distributed generation)

- develop measures that encourage the uptake of smart/advanced meters that support local energy systems (i.e. meters that record and display imported and exported electricity, and the amount of gross generation).

7.3.6 Getting the regulatory framework right (Issue 7)

This investigation has identified a number of regulatory issues that present barriers to the uptake of local energy (Section 6.2.1). The key ones are:

- the lack of information and precedents for approving local energy systems under the RMA 1991 and the Building Act 2004
- the need to improve the thermal and light performance of new and existing buildings (commercial and residential) in the Building Code
- the lack of 'acceptable solutions' for local energy technologies in the Building Code
- the lack of New Zealand-specific technical standards for local energy technologies that ensure quality and performance for consumers (Sections 5.4.1 and 6.2.1).

Guidance documents are needed to help local authorities understand the approval process for local energy systems in relation to the RMA and planning regulations. The Ministry for the Environment could lead this initiative, with input from the Electricity Commission, EECA, and the Department of Building and Housing.

The current Building Code review needs to support the uptake of local energy in commercial and residential buildings by aiming for the world best practice for thermal performance and natural light use in residential and commercial buildings. The code also needs to account for the requirements of local energy systems when buildings are designed and built (e.g. planning their orientation to the sun for energy efficiency), and possibly including some 'acceptable solutions' for local energy systems.

Standards New Zealand, with the Electricity Commission, EECA, and Department of Building and Housing, needs to identify local energy technologies appropriate for New Zealand, and develop appropriate technical compliance standards.

Recommendation 6

The PCE recommends that:

- the Ministry for the Environment, with the Electricity Commission, EECA, and the Department of Building and Housing, develop guidance documents to help local authorities understand the implications of local energy technologies for the RMA and planning process
- the Minister of Building Issues ensures that the review of the Building Code sets standards that will achieve world best practice in thermal performance and use of natural light for residential and commercial buildings

- the Minister of Building Issues ensures that the review of the Building Code takes account of the structural requirements on commercial and residential buildings for installation of local energy systems
- Standards New Zealand, with support from the Electricity Commission and Department of Building and Housing, initiates a programme to identify local energy technologies currently and potentially applicable in New Zealand, and develop technical compliance standards for these technologies.

Glossary

Active networks	A possible evolution of the current passive distribution networks. Proposed as a means of technically and economically facilitating distributed generation. The model is based on increased interconnection as opposed to the current mostly linear/radial connections, and requires active management of congestion unlike conventional passive systems.
Biomass energy source	Any organic matter that is available on a renewable or recurring basis, including dedicated energy crops and trees, agricultural food and feed crop residues, wood and wood wastes, animal wastes, and other waste materials.
Cascade failure	Cascade failure can occur when a system composed of interdependent elements is loaded to or near capacity. The cascade occurs when one of the elements fails and the load shifts to other elements in the system. Those elements, already at capacity, also fail, shifting their load onto other elements. The term is frequently used in reference to large power grids but cascade failure can also occur with other systems such as roads.
Cogeneration	The simultaneous generation of electricity and heat.
Combined cycle power plant	A power-producing engine or plant that employs more than one thermodynamic cycle. A cogeneration plant is a combined cycle power plant.
Demand-side management	Management that influences the amount or timing of users' energy demand in order to use scarce energy resources most efficiently. This includes reducing the peak demand by spreading the customer load more evenly over the entire daily or weekly period.
Distributed energy resources (DER)	The microgeneration of electricity or electricity and heat (combined heat and power).
Distributed generation	The use of power generation technologies located close to the end-user, but still connected to the grid.
Electrical resistance	A measure of the degree to which an object opposes the passage of an electric current.
Energy demand	Energy use measured in blocks of power flow (usually in half hour periods).
Energy efficiency	Increasing the energy services provided for a given amount of energy input.

Energy services	Services that people value and that require energy, such as lighting, heating, cooling, mobility, communication, and information technologies.
Energy sources	The forces or materials that provide energy when accessed or converted by technologies; for example, solar heat and light, wind, gravity (falling water), geothermal, wind, biomass, and fossil fuels.
Fuel cell	An electrochemical energy conversion device that is designed for continuous replenishment of the reactants consumed. They produce electricity from an external supply of fuel (usually hydrogen) and oxygen.
Fuel switching	Using a different fuel to provide the same energy services (for example, using wood pellets instead of electricity for heating a home).
Gigawatt hour (GWh)	1,000,0000,0000 watt hours. New Zealand uses around 41,000 GWh of electrical energy per year. See Watt hour.
Grid constraint	When the capacity of the transmission or distribution system is insufficient to transport enough electricity to meet demand (usually at peak times).
Hydrological cycle	The continuous circulation of water between the atmosphere, land, surface water, and groundwater; driven by solar radiation.
Kilowatt (kW)	1,000 watts. See Watt.
Kilowatt hour (kWh)	1,000 watt hours. See Watt hour.
Lines companies	The companies that manage the local networks. There are 33 lines companies; many are owned or co-owned by community trusts.
Local network	The electricity network excluding the transmission grid operated by Transpower.
Megawatt (MW)	1,000,000 watts. See Watt.
Megawatt hour (MWh)	1,000,000 watt hours. See Watt hour.
Micro grids	Small electrical distribution systems that connect many customers to many distributed sources of generation and storage.
Mirror trusts	Section 38 of the Electricity Industry Reform Act 1998 allows energy trusts to establish mirror images (mirror trusts) of themselves to conduct the business they had to relinquish as a result of the lines/energy split.

National grid	The high voltage power cables that transmit electricity from where it is generated to local lines networks or directly to industrial users; operated by Transpower.
Natural monopoly	These occur where the technological advantages of large-scale production preclude efficient competition among smaller companies. The necessary conditions for a natural monopoly are high fixed costs of entering which cause long run average costs to decline as output expands. Network companies such as electricity and telecommunications are often cited as classic natural monopolies. However, technological developments can quickly alter this situation.
Peak load/Peak demand	The times when demand for electricity is at its maximum, requiring generation to operate at or near its full capacity.
Power factor	New Zealand's electricity system is based on Alternating Current (AC). The current and the voltage change polarity (phase) 50 times a second. Only voltage in phase with current provides useful energy. Poor power factor occurs when inductive loads (the loads caused by the magnetic fields in electric motors, solenoids) cause the current and voltage to not change polarity at the same time. Power factor can be corrected through the installation of certain equipment, and the owners of large loads are required to keep their power factor within specific limits.
Renewable energy	Energy from sources such as the sun, wind, waves, tides, ocean currents, the hydrological cycle, and biomass, that are sustainable and naturally replaced within a short time period.
Reserve generation	A generation plant specifically built and operated to be used only in times of exceptional peak demand, or in an emergency when other generation is not available.
Reticulated electricity	Electricity supplied through the electricity network (transmission and distribution networks).
Smart grids	A similar concept to active grids but with a greater emphasis on integrating microgeneration into the system and managing demand (including the control of domestic loads).
Solar photovoltaics	A technology that converts solar energy directly into electricity.

Spot price	The price set in the wholesale market for electricity in a specified half hour period at a specific point where it leaves the transmission grid.
Stirling engine	A type of combustion piston engine that incorporates a heat-exchange process that allows for the near-ideal efficiency in conversion of heat into mechanical movement.
Terawatt hours (TWh)	1,000,000,000,000 watt hours. See Watt hour.
Thermodynamic cycle	There are two primary classes of thermodynamic cycles. *Power cycles* are cycles that convert a heat input into a work output. *Refrigeration cycles* transfer heat from low to high temperatures using work input.
Transmission	The transmission of electricity through high voltage current. Usually used to describe the grid operated by Transpower and not the local distribution networks.
Vertically integrated monopoly	A monopoly created through vertical integration. These companies are united through a hierarchy and share a common owner. Each part of the hierarchy produces a different product or service that combine to satisfy a common need. In New Zealand prior to reforms the local electricity power boards could generate, distribute, and sell electricity.
Watt (W)	Measure of power equal to one joule per second. See Kilowatt and Megawatt.
Watt hour (Wh)	A measure of energy equivalent to one watt of power used for one hour, or 3,600 joules. See Kilowatt hour, Megawatt hour, and Gigawatt hour.

Acronyms

CHP	Combined heat and power
DBH	Department of Building and Housing
DOC	Department of Conservation
CRI	Crown Research Institute
DG	Distributed generation
DTI	Department of Trade and Industry (United Kingdom)
e3p	Genesis Energy's planned Energy Efficiency Enhancement Project at Huntly. It will generate 385MW.
EECA	Energy Efficiency and Conservation Authority
EEE	Energy export equivalence
EHMS	East Harbour Management Services
FRST	Foundation for Research Science and Technology
HERS	Home energy rating scheme
IRL	Industrial Research Limited (a CRI)
LPG	Liquid petroleum gas
MED	Ministry of Economic Development
MRST	Ministry of Research, Science and Technology
NEECS	National Energy Efficiency and Conservation Strategy
NZPVA	New Zealand Photovoltaic Association, now called the Sustainable Electricity Association New Zealand (SEANZ).
PV	Photovoltaics
ROC	Renewable obligation certificate
SIA	Solar Industries Association
SMEs	Small to medium-sized enterprises
SWH	Solar water heater

Endnotes

[1] Dobbyn and Thomas, 2005.

[2] *ibid*., 2005: 3.

[3] PCE, 2006b.

[4] DTI, 2003: 16.

[5] Energy services are defined as the services (e.g. lighting, heating, cooling, and power to drive machinery) that can be derived from various forms of energy. See www.pce.govt.nz/reports/allreports/1_877274_55_0.pdf [Accessed 6 November, 2006].

[6] For a more in depth definition of microgeneration see www.dti.gov.uk/files/file27576.pdf [Accessed 2 November 2006].

[7] Ministry for Economic Development (MED), 2006a.

[8] MED, 2003.

[9] MED, 2006a.

[10] Waterways with significant conservation values (and Water Conservation Orders) are identified on the Ministry for the Environment website. See www.mfe.govt.nz/issues/water/freshwater/water-conservation/ [Accessed 21 August 2006].

[11] MED, 2006a.

[12] PCE, 2005.

[13] The PCE's assessment role for the electricity sector is explained more fully on the PCE website. See www.pce.govt.nz/reports/allreports/1177_0066.pdf [Accessed 6 November 2006].

[14] PCE, 2004: 9-11.

[15] See section 172N of the Electricity Act 1992 and the Government's Policy Statement for electricity. See www.med.govt.nz/templates/StandardSummary____395.aspx [Accessed 1 September 2006].

[16] The PCE has not investigated Transpower's proposed upgrades to the national grid. For example, Transpower plans to build a new 400 kV transmission line between the central North Island and Auckland. The Electricity Commission is investigating Transpower's proposal (see www.electricitycommission.govt.nz/).

[17] For more information about the Electricity, Energy and the Environment work of the PCE see www.pce.govt.nz/reports/allreports/1_877274_14_3.shtml and www.pce.govt.nz/reports/allreports/1177_0066_2006.shtml [Accessed 6 November 2006].

[18] The Economist, 2004: 17.

[19] DTI, 2006a: 32.

[20] Energywatch, 2005.

[21] Donn & Thomas, 2001.

[22] Other variables, such as the surrounding landscape and vegetation, may also influence the thermal performance of buildings. For example, a nearby hill or tree may provide shading to a building and influence its heating and cooling requirements.

[23] Benefits and costs in this context include monetary and non-monetary benefits and costs, and also benefits and costs that affect the direct users of the energy, the broader community, and the environment. For further explanation of the PCE definition of energy efficiency, see www.pce.govt.nz/reports/allreports/0_908804_90_3.pdf [Accessed 6 November 2006].

[24] Dobbyn & Thomas, 2005.

[25] DTI, 2005.

[26] Greenpeace UK, 2005.

[27] *ibid*., 2005: 72.

[28] Lasseter *et al.*, 2003.

[29] For example, the Gridwise Alliance is a joint private and government initiative to develop smart grid systems. See www.gridwise.org/index.htm [Accessed 29 August 2006].

[30] Penny, 2005.

[31] For further information on the Auckland outage see www.med.govt.nz/templates/ContentTopicSummary____20837.aspx [Accessed 28 August 2006].

[32] See subs.nzherald.co.nz/location/story.cfm?l_id=145&objectid=10386656 and subs.nzherald.co.nz/topic/story.cfm?c_id=187&objectid=10388160 [Accessed 28 August 2006].

[33] Failure can be a result of accidents, climatic events, or a collapse of the transmission and distribution lines.

[34] U.S.–Canada Power System Outage Task Force, 2004.

[35] MED, 2006b.

[36] Lovins *et al.*, 2002.

[37] WADE, 2004.

[38] See www.bmu.de/english/renewable_energy/press_statements_speeches/doc/36601.php [Accessed 26 July 2006] and www.globalchange.umd.edu/?energytrends&page=germany.6 [Accessed 26 July 2006].

[39] Lovins *et al.*, 2002: 297.

[40] Dobbyn & Thomas, 2005: 4.

[41] *ibid.*, 2005.

[42] *ibid.*, 2005: 10.

[43] Rifkin, 2002.

[44] Rankine, 2005.

[45] Howden-Chapman *et al.*, 2005. See also www.wnmeds.ac.nz/academic/dph/research/housing/insulation.html [Accessed 28 August 2006].

[46] A ballast is a device to stabilise current in a circuit, and is a component of a fluorescent light.

[47] McChesney, 2006. See www.scoop.co.nz/stories/PO0607/S00164.htm [Accessed 20 July 2006].

[48] Oxford English Dictionary (OED) Online, 2006. See www.oed.com/ [Accessed 27 April 2006].

[49] DETR, 1999.

[50] See www.greypower.co.nz/bulletin.pdf [Accessed 26 July 2006].

[51] DTI, 2006a.

[52] EHMS, 2006.

[53] See www.pce.govt.nz/reports/pce_reports.shtml

[54] Prices stated in real terms are adjusted to take out the effects of inflation.

[55] DTI, 2006a.

[56] MED, 2006b.

[57] PCE, 2005.

[58] Energy Saving Trust *et al.*, 2005.

[59] DTI, 2006a.

[60] The lines companies are: Alpine Energy Ltd, Aurora Energy Ltd, Buller Electricity, Centralines Ltd, Counties Power Ltd, Delta Utility Services Ltd (manages Aurora), Eastland Network Ltd, Electra Ltd, Electricity Ashburton Ltd, Electricity Invercargill Ltd, ElectroNet Ltd (manages Westpower), Horizon Energy Distribution Ltd, MainPower NZ Ltd, Marlborough Lines Ltd, Nelson Electricity (Network Tasman & Marlborough Lines JV), Network Tasman Ltd, Network Waitaki Ltd, Networks South Ltd (manages Alpine Energy and Network Waitaki), Northpower Ltd, Orion New Zealand Ltd, OtagoNet Joint Venture Ltd, Powerco Ltd, PowerNet Ltd (manages Electricity Invercargill, The Power Co, and Otago Power), Scanpower Ltd, The Lines Company Ltd, The Power Company Ltd, Top Energy Ltd, Unison Networks Ltd (manages Centralines), UnitedNetworks Ltd (see Vector), Vector Ltd, Waipa Networks Ltd, WEL Ltd, Westpower Ltd.

[61] MainPower have recently built a new office block with solar passive design features, and solar photovoltaic panels. They were also involved in a joint project with the Department of Conservation (DOC) and the Energy Efficiency and Conservation Authority, to install a micro hydro generator on a remote DOC hut in the South Island. See www.localgeneration.co.nz/home/ [Accessed 23 August 2006].

[62] See www.med.govt.nz/templates/ContentTopicSummary____4145.aspx [Accessed 27 April 2006].

[63] See www.photovoltaics.org.nz/news.html [Accessed 27 April 2006].

[64] Apart from solar water heating reducing the effectiveness of ripple control, there was no apparent concern about the impact of other forms of microgeneration on gentailers' business.

[65] See www.caenz.com/caeindex.html [Accessed 26 April 2006].

[66] See www.clear-skies.org [Accessed 28 August 2006].

[67] OECD & IEA, 2004.

[68] DTI, 2005.

[69] Jäger-Waldau, 2005.

[70] AGO, 2006.

[71] See www.greenhouse.gov.au/renewable/pv/index.html [Accessed 28 August 2006].

[72] REACT, 2004.

[73] REN21, 2005.

[74] *ibid.*, 2005.

[75] PCE, 2006a.

[76] The effects of intermittency can be reduced to some extent by having a diversity of energy sources (e.g. wind and solar, or solar and hydro).

[77] Murray, 2005. See also www.caenz.com/DistGen/DGdownloads/Totora_Valley.pdf [Accessed 14 March 2006].

[78] Dobbyn and Thomas, 2005.

[79] See www.arcinnovations.co.nz/why-amm.html [Accessed 7 August 2006].

[80] DTI, 2005.

[81] See www.greenhouse.gov.au/solarcities/ [Accessed June 2006].

[82] Mazza, undated.

[83] Mazza, undated; Bush, 2004.

[84] DTI, 2006a: 37.

[85] See www.energyinst.org.uk/content/files/Smale%20scall%20renewables%20and%20microgeneration.pdf [Accessed 2 May 2006].

[86] A zero net energy house is a building with a net energy consumption of zero over a typical year.

[87] Charron, 2005.

[88] DTI, 2006a.

[89] See www.beehive.govt.nz/ViewDocument.aspx?DocumentID=25823 [Accessed 20 May 2006].

[90] DTI, 2006a: 36.

[91] See www.hm-treasury.gov.uk/budget/budget_06/bud_bud06_speech.cfm [Accessed 2 July 2006].

[92] Brandon, 2004.

[93] Section 172N(2) of the Electricity Act 1992.

[94] DTI, 2006a.

[95] *ibid*., 2006a: 3.

[96] See www.micropower.co.uk/news/newsrelease39.html [Accessed 10 April 2006].

[97] Commerce Commission, 2006.

[98] MED, 2006c.

[99] MED, 2003.

[100] See www.energy3.co.nz/generation.htm [Accessed 29 August 2006].

[101] MED, 2003: 8.

[102] For example, a large farm with a 30 kW to 300 kW micro hydro plant or wind turbines would fit within the category over 10 kW 'connected behind load'.

[103] MED, 2006d.

[104] See www.electricitycommission.govt.nz/pdfs/opdev/retail/model/MRC-app-A2-marked.pdf [Accessed 6 November 2006].

[105] Section 3 Building Act.

[106] Section 400 Building Act.

[107] Section 4(2)(m) Building Act.

[108] See www.dbh.govt.nz/ba-further-changes [Accessed 31 August 2006].

[109] See www.beehive.govt.nz/ViewDocument.aspx?DocumentID=27293 [Accessed 5 October 2006].

[110] See www.oriongroup.co.nz/Default.htm?/Page%20path%20here%20(minus%20.asp [Accessed 31 August 2006].

[111] ODPM, 2004.

[112] See www.communities.gov.uk/index.asp [Accessed 31 August 2006].

[113] See www.foe.co.uk/resource/press_releases/sustainable_building_code_07032006.html [Accessed 24 October 2006].

[114] ESTIF, 2006.

[115] See www.estif.org/index.php?id=46&backPID=2&pS=1&tt_news=71 [Accessed 2 May 2006].

[116] See www.interbuild.com & www.themertonrule.org [Accessed 31 August 2006].

[117] Govt^3 is a government programme aimed at improving government agency sustainability within their activities. Energy efficiency is a key part of this programme. See www.mfe.govt.nz/issues/sustainable-industry/govt3/ [Accessed 31 August 2006].

[118] See www.caenz.com/info/programmes/programmes.html [Accessed 2 May 2006].

[119] See www.irl.cri.nz/newsandevents/innovate/Innovate-57/Energy-at-the-cross-roads.aspx [Accessed 29 April 2006].

[120] See www.landcareresearch.co.nz/about/tamaki/index.asp [Accessed 2 May 2006].

[121] See ite.massey.ac.nz/researchandconsultancy/EnergyResearchWebsite/contents.htm [Accessed 2 May 2006].

[122] See www.niwascience.co.nz/maori/energy [Accessed 2 May 2006].

[123] See www.scionresearch.com/bioenergy.aspx [Accessed 2 May 2006].

[124] See www.ontario-sea.org/pdf/PoweringOntarioCommunities.pdf#search=%22Sufficient%20Contract%20Length%2C%20Reliability%20and%20Stability%22 [Accessed 31 August 2006].

[125] See www.frst.govt.nz/database/abstracts/index.cfm [Accessed 31 August 2006].

[126] See www.frst.govt.nz/Business/fund_GPSRD.cfm [Accessed 31 August 2006].

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Appendix A: Summary of tables from EHMS study

Table A1 Energy from microgeneration in the residential sector (GWh/year)

Technology	Short term (0-5 years) GWh	Medium term (0-10 years) GWh	Long term (0-30 years) GWh
Electricity			
Solar PV	0.1	5.1	42
Combined heat and power	0.3	0.8	23
Micro hydro	0.2	0.7	14
Wind turbine (adjacent to house)	3	10	64
Wind turbine (on rooftop)	0.2	7	29
Total – electricity generation	**3.6**	**23.2**	**172**
Heat			
Pellet burner	27	143	401
Wood burner	61	179	366
Heat pump	182	440	1,304
Heat pump water heaters	3	112	603
Solar water heaters	115	927	1,893
Total – heat generation	**387**	**1,800**	**4,568**
Building performance			
Ceiling insulation	120	177	243
Water heating efficiency	11	33	152
Passive solar design (retrofit)	54	107	321
Passive solar design (new)	116	231	693
Double glazing (retrofit)	11	21	64
Double glazing (new)	71	282	679
Total – building performance	**382**	**852**	**2,152**
TOTAL	***772***	***2,675***	***6,891***

N.B. Some columns do not add up due to rounding
Source: EHMS, 2006

Table A2 Energy from microgeneration in the SME (industrial/commercial) sector (GWh/year)

Technology	Short term (0-5 years) GWh	Medium term (0-10 years) GWh	Long term (0-30 years) GWh
Electricity			
Solar PV	0.3	15.4	127
Combined heat and power	0.5	1.6	68
Micro hydro	0.5	1.4	27
Wind turbine (adjacent to house)	6	20	127
Wind turbine (on rooftop)	0.4	13	58
Total – electricity generation	**7.7**	**51.4**	**408**
Heat			
Pellet burner	2	5	13
Industrial combustors	4	4	25
Heat pump	380	950	2,836
Direct geothermal heating	N/E	N/E	N/E
Heat pump water heaters	2	15	51
Solar water heaters	123	290	508
Organic Rankin cycle	0	6	18
Anaerobic digesters	0	1	2
Total – heat generation	**510**	**1,270**	**3,453**
Motive power			
Wind pumping	2	7	21
Hydro pumping	N/E	N/E	N/E
Total – motive power	**2**	**7**	**21**
Building performance			
Energy management and equipment efficiency	719	2,388	5,603
Total – building performance	**719**	**2,388**	**5,603**
TOTAL	***1,237***	***3,712***	***9,485***

N.B. Some columns do not add up due to rounding
N/E = Not estimated
Source: EHMS, 2006

Appendix B: Some key researchers and their projects

Some of the key researchers and their projects on local energy in New Zealand are listed below. This list is by no means comprehensive, but indicates the depth and breadth of local energy research in New Zealand.

- The Centre for Advanced Engineering has a broad ‘energy’ research portfolio, and a specific research focus on Distributed Generation (DG).[118]
- Industrial Research Limited (IRL) is involved in research on energy system projects for remote communities in the Totara Valley near Woodville, and Te Puia Springs, Gisborne.[119] IRL is also involved in the development of microgeneration systems, including stationary fuel cells.
- Landcare has a portfolio of urban design research, and their new Auckland office development uses local energy technology and energy focused design.[120]
- Massey University’s Centre for Energy Research is involved in a number of projects of relevance to local energy (including involvement in the Totara Valley project with IRL).[121]
- National Institute of Water and Atmospheric Research (NIWA) has local energy projects in two Maori communities in Waihi, near Lake Taupo and Waipoua, Northland (described in the box in Section 2.4).[122]
- Scion is researching the use of biomass to produce bioenergy, and has put together an energy proposal to make the energy supply of the City of Rotorua totally renewable.[123]

Appendix C: Net metering, net billing, and standard offer contracts

Net metering and net billing

Net metering is a way of refunding people with microgeneration capacity for at least a portion of the electricity they export into the wider network. The electricity meter spins backwards when power is being exported rather than used, and the microgenerator will either pay or receive a refund, depending on the net flow of electricity, calculated using the retail tariff.

Net billing requires two meters: one each for the incoming and outgoing electricity. There will also be two tariffs: one for electricity bought and the other for electricity sold (usually at lower than the retail price). Net billing is more attractive to the electricity retailer than net metering, as it can resell the electricity with some margin of profit, but net billing is more complex to administer.

Standard offer contracts

This is the most common method that regulators have used to promote the microgeneration of electricity from renewable energy sources. These contracts are also known as renewable energy tariffs, renewable energy feed-in tariffs (REFITs), feed laws, and minimum price standards. They are intended to stimulate the adoption of renewable energy – often in the form of local energy generation – by offering owners a fixed price for any electricity they export back to the grid. The designated price is intended to better reflect the full benefits provided by renewable energy sources.

The box describes the principles of standard offer contracts.[124]

Principles of standard offer contracts

Sufficient contract length, reliability, and stability: Contracts need to be long enough to provide certainty for investors, so that they earn a reasonable rate of return and expectation of profit.

Stable prices: In order to minimise risk, the price offered must be stable, predictable and high enough to attract investment. Potential investors, such as householders, community groups, and small businesses, will be less likely to afford the risk of variable and uncertain pricing.

Sufficient pricing levels: The price offered can vary regionally, according to the strength of local resources. A tailored system provides an opportunity to attract investors in areas of low resource availability as well. Variable rates can also be applied to different technologies.

Simple, streamlined contracts: The process of applying for and awarding contracts needs to be straightforward and hassle free.

Appendix D: Germany's combined incentive scheme

Germany's 100,000 Roofs Programme was integrated within the Renewable Energy Law in April 2000. The law provided for surplus power from renewables to be sold to the grid at a price that reflects the cost of installation. This policy is a feed-in tariff and owners of PV units could sell their surplus electricity for the attractive rate of 50.4 Euro cents/kWh. From 2005 the rate became 59.53 Euro cents/kWh for solar electricity from small façade systems.

The Renewable Energy Law applies to all forms of renewable energy – not just on a local energy scale. Table D1 shows that the level of adoption has been astonishing.

Table D1 German renewable energy installations and production in 2005

Installations	Energy from renewables	Economic effects
200,000 PV installations 2,000 biomass plants 550MW of farm biogas 6,000 hydro plants 18,000 wind turbines	About 10% of total supply (55 TWh/yr)	45,000 direct and indirect jobs in wind energy 30,000 jobs in the PV industry

Source: Gipe, 2006

Altogether 226,000 new renewable installations are operating in Germany and 150,000 new jobs have been created.

Appendix E: Funding for local energy research in New Zealand

In New Zealand, funding for research comes from public and private sources. The Ministry of Research, Science and Technology (MRST) and the Foundation for Research, Science and Technology (FRST) are the key government agencies involved in research policy and funding, respectively.

The Government's main funding of energy research is through FRST's 'Optimising Physical Resource Use and Infrastructure Services (ORI)' portfolio. In 2005/06 the total for this portfolio was around $19.6 million.[125] Of this, about $13.5 million was directed to energy-related research. Analysis of research proposals on the FRST website indicates that about $8 million worth of funding is directed at research that could be interpreted as promoting local energy in New Zealand.

FRST also manages the TechNZ for Business programme, which includes the Grants for Private Sector R&D (GPSRD) fund. This fund assists private sector companies where:

- a new production process needs development funding
- an existing product or process needs new features to be adapted for a new market
- an existing product or process needs to be upgraded to provide new functions or to meet new customer demands.

The eligibility criteria state:

> *Your business must be making a new investment in R&D that extends your capability to undertake R&D beyond current capacity. A new investment means an investment in an area of technological development or technological expertise that is new to the firm, that is relatively new to New Zealand, and that makes sense to be invested in locally from a global perspective.*
>
> *The primary qualifying tests for R&D are identifying the technological or technical risk or uncertainty and planning the methodical resolution of the uncertainty. The fund is not available to support R&D that, in the context of the applicant firm, can be seen as 'business as usual'.*[126]

Funding, however, is limited to up to 33.3 percent of the eligible project costs, to a maximum of $100,000, and the minimum grant value is $10,000 including GST. Businesses seeking the grant must have a good track record. Given the current state of the local energy business sector, few businesses would have the capital to make up the 67.7 percent of the project costs, or the track record required.

Funding is also available from New Zealand Trade and Enterprise but this organisation is focused on assisting the development of existing small companies, not specific technologies.

About the Parliamentary Commissioner for the Environment
Te Kaitiaki Taiao a Te Whare Pāremata

Independent scrutiny, advocacy and advice for a better environment

The Parliamentary Commissioner for the Environment (PCE) is an independent officer of Parliament with wide-ranging powers to investigate environmental concerns. The office was set up under the Environment Act 1986, and the Commissioner is appointed for a five-year term. In 2002, Commissioner Dr Morgan Williams was appointed to a second five-year term. The primary objective of the office is to contribute to maintaining and improving the quality of the environment in New Zealand.

The PCE has five key roles:

- **Environmental systems guardian** – checking on the ability of management regimes to ensure that the quality of the environment is maintained or improved
- **Environmental watchdog** – responding to the general public's enquiries and concerns, and encouraging preventative measures and remedial actions to protect the environment.
- **Information provider, facilitator and catalyst -** providing information about the environment to a wide range of groups and individuals
- **Environmental management auditor** – evaluating the performance of public agencies to ensure they are meeting their environmental responsibilities
- **Advisor to Parliamentary Select Committees** – responding to requests from Select Committees to provide assistance and advice.

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