Ministry of Business, Innovation & Employment

National Science Challenges

Potential Challenges for Consideration by Peak Panel

Economic Growth including Energy, Waste Management and Transport

February 2013

CONFIDENTIAL – NOT GOVERNMENT POLICY

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1 Introduction

The potential challenges in this area cover issues related to energy resources and waste management.

Twenty six submissions were received from the science sector in these domains. These submissions have been grouped as shown in Table 1.

Table 1: Summary of proposed challenges by grouping

Entry Id	Challenge
Energy	
40	Due to New Zealand's low density network of dwellings the National Grid and town water supply have high transmission costs for electricity and water supply
279	Keeping New Zealand's electricity networks smart, resilient and secure as the world they power gets more complex and customers' expectations get more sophisticated
282	To develop new solid-state thermoelectric materials or semiconductors with the goal of minimum efficiency of 30%. Doing so will also enable New Zealand clean tech technology Thermagenz to become a world game changer in the energy industry
285	To explore the implications of installing large numbers of a novel design of a domestic hot water heat pump, which incorporates demand side management features and improved consumer controls, which has significant environmental and economic benefits
320	Better Building Performance for Economic Growth
334	A net-zero energy New Zealand at household, community and national levels
349	New Zealand Energy: Secure, Sustainable, and Economical
363	Economic local industrial and transportation fuels
369	New Zealand needs a secure future electricity system to support economic growth and the goal is to develop leading edge technologies to minimise New Zealand's dependence on finite or at risk energy sources
385	The future of (personal) transport, developing a solution that is sustainable
393	Developing energy policy based on using non-fossil primary energy sources
396	The Health & Wellbeing challenge
401	Expanding the opportunities for wise energy systems and use in New Zealand for a future in a changing world
402	An automated, solar-powered, wireless, remote surveillance/data acquisition system. Includes, surveillance, fire- and earthquake-detection and remote access/control. Improves efficiency of managing large remote land areas and optimizes water/energy usage
403	Generating higher revenues, ensuring security of supply, and meeting industry and

Entry Id	Challenge
	societal requirements through increased extraction of our geothermal energy, petroleum, mineral and groundwater resources, whilst minimising impacts on the environment
413	Transforming New Zealand's energy systems for a sustainable future
414	National energy self-sufficiency, defined by a target of net zero fossil-fuel imports into New Zealand
432	Energy Transformed — Fostering An Energy Transition For New Zealand - To make New Zealand energy supply 100% renewable by 2030
447	Energy and the environment
457	Energy Futures: The challenge to New Zealand is to ensure that energy sources are optimally utilised to meet the nation's unique needs for the next 50 years in the context of its resources and environment
471	Energy in New Zealand
477	Energy Self-Sufficiency
Reducing waste	
53	To eliminate the landfills in New Zealand and make New Zealand100% pure
57	To extract value from problematic organic waste streams, specifically farm dairy effluent. Generation of distributed renewable electricity whilst simultaneously and responsibly managing the negative environmental impacts of intensification of agriculture
281	How do we get smart about waste reduction
303	Reduction of waste plastic to landfill. Currently, there is a large component of waste plastic that cannot be recycled as it is poor quality or previously recycled. Technology is available to address this problem using plastic to diesel technology

2 Energy

The submissions in this group are shown with their underpinning themes in the table below. Each submission follows in full.

Table 2: Summary of proposed challenges and themes

Entry Id	Challenge	Themes
40	Due to New Zealand has not a high density network of dwellings the National Grid and town water supply have high cost of electricity and water transmission	1. Understanding of the electricity transmission cost in the New Zealand National Grid due to our country has not a high density network of dwellings 2. Understanding of the town water transmission and distribution cost in New Zealand due to our country has not a high density network of dwellings 3. Understanding the diversity of harvesting of solar and wind energy, and rain water cross New Zealand
279	Keeping New Zealand's electricity networks smart, resilient and secure as the world they power gets more complex and customers' expectations get more sophisticated.	1. Understanding how new customer behaviours are going to impact the power system New Zealand has built 2. Making decisions about how to maintain and improve the New Zealand electricity system as the world it powers changes 3. Using new technologies to manage the future power distribution system in a way that supports our desired lifestyle and economic growth
282	To develop new solid-state thermoelectric materials or semiconductors with the goal of minimum efficiency of 30%. Doing so will also enable New Zealand clean tech technology Thermagenz to become a world game changer in the energy industry.	1. Thermagenz is a solid-sate geothermal power generator developed in New Zealand. We will have a 1kw module installed in Taupo late Feb 2013. We need to show in real terms that Thermagenz can produce grid ready electricity at less than NZD 3million per 1 Megawatt 2. To prototype our commercially viable solid-state thermoelectric generator using current technology 3. To continue the process of developing a whole new thermoelectric material or semiconductor technology. This must solution must be very cost effective when compared to current Thermoelectric solid-state devices 4. To commercialize the Energy efficiency/recovery potential of Thermagenz for Geothermal, Coal, Gas, Solar Thermal and Nuclear powerplant
285	To explore the implications of installing large numbers of a novel design of a domestic hot water heat pump, which incorporates demand side management features and improved consumer controls; with significant environmental and economic benefits.	1. The goal is to design and manufacture 'in high volumes' a more advanced HWHP that overcomes the disadvantages of currently available HWHPs, and be considerably more cost-effective than solar water heating 2. Understanding New Zealand Homeowners Apparent Reluctance to Adopt Housing-Sustainability Innovations

Entry Id	Challenge	Themes
320	Better Building Performance for Economic Growth	1. To investigate and establish how performance improvements at the project and firm level (e.g. profitability, customer satisfaction, decreased waste, increased standardisation) flow through into increased national productivity statistics 2. Identifying barriers and opportunities for productivity improvement - To identify the barriers to innovation and adoption of new smarter practices that will lead to increases in productivity in a sector dominated by small and medium enterprises 3. Realising productivity improvements - Application of the knowledge and tools developed in this programme to realise productivity gains in the two key construction centres of Auckland and Christchurch over the next five years
334	A net-zero energy New Zealand at household, community and national levels	1. Understanding what determines identity, satisfaction and wellbeing provides a basis for policy and investment choices and behaviours that will achieve collective net-zero non-renewable energy demand in our buildings, food, transport and other activities. 2. Understanding the energy costs of food and fibre production, storage, transport, and export and meeting the energy requirements of New Zealand's food and fibre systems from local resources without losing the potential for exports. 3. A demonstration of integrated systems that work with our existing building stock, that would enable that stock of early-mid 20th century houses and other buildings to be net-zero energy, alone and in functional residential communities and business centres 4. Distributed energy production, distribution and storage systems with the potential to increase the robustness of our existing energy production and distribution system, and to integrate alternative energy production into the existing centralised system.
349	New Zealand Energy: Secure, Sustainable, and Economical	1. 100% New Zealand Energy: All of the energy used in New Zealand is produced in New Zealand 2. 100% Renewable: All of the energy used in New Zealand comes from renewable sources 3. 100% New Zealand Green: All of the energy produced in New Zealand is environmentally sustainable 4. 100% New Zealand Involvement: All New Zealand residents use renewable, clean New Zealand energy
363	Economic local industrial and transportation fuels	1. Produce liquid fuels from biomass 2. Purification of liquid fuels

Entry Id	Challenge	Themes
369	New Zealand needs a secure future electricity system to support economic growth and the goal is to develop leading edge technologies to minimise New Zealand's dependence on finite or at risk energy sources.	1. The goal is to develop electricity storage technologies that enable better demand management and reduce generation peaks 2. The goal is to develop energy efficiency and conservation technologies that lower energy demands 3. The goal is to develop technologies that enable vehicles to be operated with alternative fuels
385	The future of (personal) transport, developing a solution that is sustainable	1. Assessment of a sustainable electric car platform 2. Assessment of a sustainable electric bicycle platform
393	Developing energy policy based on using non-fossil primary energy sources	1. Energy efficiency and recovery 2. Safe and secure fossil fuels 3. The renewables revolution 4. Energy sector skills
396	The Health & Wellbeing challenge	1. Achieving sustainable prosperity 2. Process safety leadership 3. The biological engineering opportunity 4. Cutting costs in pharma
401	Expanding the opportunities for wise energy systems and use in New Zealand for a future in a changing world.	1. Smart Technologies - Development of smart technologies to make the best of our renewable energy and respond to variability in supply and demand will help embed the transition to a more sustainable energy landscape 2. Smart Users - The success of a transformed and responsive energy system is dependent on having smart users in the mix. This theme looks at methods for moving New Zealand's energy users towards being informed enough to enable the energy system to operate with maximum effectiveness 3. Robust Energy Systems - As the effects of climate change begin to intensify the energy systems, society, and international pressures are expected to become more erratic. This theme is focused on ensuring New Zealand's energy systems are able to withstand this variability
402	An automated, solar-powered, wireless, remote surveillance/data acquisition system. Includes, surveillance, fire- and earthquake-detection and remote access/control. Improves efficiency of managing large remote land areas and optimizes water/energy usage.	1. Understanding New Zealand's current and future agricultural, land and coastal management requirements, deficiencies and threats to secure and profitable and sustainable operation. This knowledge is essential for establishing appropriate system features 2. The results from research and collation of statistical information and market research would be used to make informed decision with respect to the system features needed. This would ensure that it meets performance, maintainability and cost predictions

Entry Id	Challenge	Themes
403	Generating higher revenues, ensuring security of supply, and meeting industry and societal requirements through increased extraction of our geothermal energy, petroleum, mineral and groundwater resources, whilst minimising impacts on the environment	1. Prospectivity to prosperity - facilitating greater exploration of our extensive Exclusive Economic Zone, so enhancing the discovery of new reserves of petroleum and minerals, leading to significant improvement in the New Zealand economy 2. Security of supply – ensuring New Zealand is resilient to global restrictions on the availability of strategic energy and minerals resources 3. Stewardship – minimising environmental impact whilst realising the full benefits of our natural endowment of geothermal energy, petroleum, mineral and groundwater resources
413	Transforming New Zealand's energy systems for a sustainable future	1. Building energy security and resilience into the whole energy system 2. Transitional technologies and infrastructure 3. Engaging society in the energy transition 4. Demonstrating alternative energy systems in a carbon constrained world
414	National energy self-sufficiency, defined by a target of net zero fossil-fuel imports into New Zealand.	1. Optimising Supply 2. Optimising Use and Distribution 3. Energy-Efficient Machines and Systems 4. Responding to Societal Trends and
432	Energy Transformed — Fostering An Energy Transition For New Zealand - To make New Zealand energy supply 100% renewable by 2030	1. Electricity Supply 2. Transport 3. Energy in Industry 4. Energy in Households 5. Energy Linkages
447	Energy and the environment	1. Renewable Energy – Realise the potential of New Zealand's natural energy systems 2. Develop processing systems with the lowest energy per unit product capacity 3. Distribution and transmission systems that reduces losses and optimises utility and distributed needs
457	Energy Futures: to ensure that energy sources are optimally utilised to meet New Zealand's unique needs for the next 50 years in the context of its resources and environment.	1. Renewable Energy - To build renewable energy capacity 2. Energy Efficiency - To engineer New Zealand's infrastructure for energy efficiency 3. Smart energy technologies - To develop smart products and materials related to energy
471	Energy in New Zealand	1. Investigating tidal, wind, geothermal energy (and associated technologies for implementation) 2. Alternative fuel use 3. Development of electrical grid technologies

Entry Id	Challenge	Themes
		4. Measuring and reducing agricultural emissions
477	Energy Self-Sufficiency	1. Understanding current and future energy needs and supply for domestic consumption and export 2. Evidence-based decision-making to choose the appropriate generation mix for electricity and the extraction pathway for sustainable energy wealth 3. Managing the opportunities and risks from sustainable energy decisions and development to ensure a security of energy supply

Entry ID	40
Due to New Zealand having a low density network of dwellings, the National Grid and town water supply have high transmission costs for electricity and water	
Summary	This challenge proposes to carry out research to identify the current cost of electricity/water transmission, which will help to build measuring tools and predictive models to help improve upon New Zealand's current national grid system. Development/implementation of innovative energy-generating technologies (i.e. solar, wind, tidal) can further aid in making New Zealand's energy generation both sustainable and more affordable.
Theme 1 **Understanding of the electricity transmission cost in the New Zealand National Grid due to our country not having a high density network of dwellings**	
Importance to New Zealand	New Zealand has low population density so that there is no advantage to using the traditional National Grid like other countries with high population densities
Research components	Component 1: Identify the current cost of electricity transmission in New Zealand Component 2: Develop the measuring tools and predictive models to identify the impact of establishment of a sustainable network of dwellings most independently from the National Grid
Theme 2 **Understanding of the town water transmission and distribution cost in New Zealand due to our country not having a high density network of dwellings**	
Importance to New Zealand	New Zealand has low population density so that there is no advantage to using the traditional town water transmission and distribution systems like other countries that have high population densities
Research components	Component 1: Identify the current cost of the town water transmission and distribution cost in New Zealand Component 2: Develop the measuring tools and predictive models to identify the impact of establishment of a sustainable network of dwellings most independently

	from the town water transmission and distribution system
Theme 3 **Understanding the diversity of harvesting of solar and wind energy, and rain water across New Zealand**	
Importance to New Zealand	It is possible to optimize the operation and use of solar and wind energy, and rain water across New Zealand
Research components	Component 1: Identify the current diversity of harvesting solar and wind energy, and rain water across New Zealand Component 2: Develop the measuring tools and predictive models to identify the impact of establishment of integrated system to optimize the operation and use of solar and wind energy, and rain water most independently from the National Grid and town water transmission and distribution systems
Theme 4 **Understanding the diversity of user behaviour of energy and water across New Zealand**	
Importance to New Zealand	It is possible to optimize the operation and use of solar and wind energy, and rain water across New Zealand
Research components	Component 1: Identify the current user behaviour of energy and water across New Zealand Component 2: Develop the measuring tools and predictive models to identify the impact of establishment of integrated systems to meet the user demand of energy and water
Research Gaps and Opportunities	The findings in this research are to enable a development of an energy flow control model in the forms of electricity and hot water upon the user demands in a modular house to optimize the operation and use of solar and wind energy, rain water and natural ventilation in the dwellings. The research and development are also to allow peer to peer sharing of sustainable technologies for power, heating and water supply between dwellings. This novel idea will not only allow sharing of resources for "off the grid" communities independently from the National Grid and town water transmission and distribution system, but also reduce cost per dwelling to install these technologies.
Comments	The academic research outcome is a novel solution to a mathematical model to control the energy flow for the thermal comfort operation (e.g. heating, ventilation, and air conditioning) for sustainable buildings and communities using solar and wind power, rain water collection and natural ventilation. The socio-economic objective is to build renewable-energy efficient and sustainable buildings and communities.

Entry ID	**279**

Keeping New Zealand's electricity networks smart, resilient and secure as the world they power gets more complex and customers' expectations get more sophisticated	
Summary	The goal of this proposal is to improve the resilience and reliability of the way we use and consume power. The proposed research has the following themes: (1) Understanding how new customer behaviours are going to impact the power system New Zealand has built (2) Making decisions about how to maintain and improve the New Zealand electricity system as the world it powers changes (3) Using new technologies to manage the future power distribution system in a way that supports our desired lifestyle and economic growth
Theme 1 **Understanding how new customer behaviours are going to impact the power system New Zealand has built**	
Importance to New Zealand	Improving the resilience and reliability of the way we use and consumer power, recognising that the things people want to do with electricity are getting more unpredictable and diverse. The New Zealand power system is the most complex machine in the country and it's crucial to every form of economic and lifestyle activity but it has evolved over the last century. It was never designed as a complete entity and is as unique as our landscape and people. We're only going to be able to meet the electric power needs of the next generation with some very smart science and engineering, specific to: the conditions (including potentially very serious security challenges) that we face, the legacy we have inherited and the things we're going to want to do in the future.
Research components	1. Identify how changing consumer behaviour will impact on New Zealand's power system. We are already seeing how heat pumps are changing the characteristics of demand on local electricity lines. If neighbouring electric vehicle owners all charge their vehicles at the same time, local transformers will be dramatically overloaded. Behavioural scientists are modelling consumer behaviour for new and digital technology adoption. Scenarios for this behaviour will model the impact on electricity demand and its clustering in particular locations across the national power system. 2. Understanding the limitations of the power system and the environment it operates in, and identifying ways to overcome those limitations. Electricity distribution systems are products of their time. The specific designs and technical components of each local network vary across the country. To manage the impact of the changing use of power on the networks, research will need to be made into the New Zealand specific characteristics of the legacy power systems and the impacts of changing use and creation of power across them. 3. Predicting where we're going to see problems as consumers start using the power system differently. Clustering of new technologies and consumer behaviour will impact power systems dramatically. In parallel security challenges and data protection issues are emerging. Formal data scientific techniques to

	evaluating data sources and modelling the actual impact of these changes on New Zealand's networks will prioritise how we apply scientific research to mitigate the technical issues with power quality, reliability and system resilience that will arise.
Theme 2 **Making decisions about how to maintain and improve the New Zealand electricity system as the world it powers changes**	
Importance to New Zealand	The consumerisation of the power industry - where individual customers will increasingly make their own decisions about the reliability of the power supply they want, how and when they use it and the environmental impacts they want to create - will require a completely different way of running the system. In the old days, the industry was centrally-planned and consumers were simply prevented from doing things which would affect the reliability of supply for others. 21st Century customers are already expecting far more from the power supply system, creating new requirements for affordable, quality supply and increasing consumer empowerment. While there are new technologies emerging rapidly that will allow this to happen, focussing effort now on coordinating research, targeting impediments and promoting consumer benefits will help New Zealand step up into the world of smart networks quickly and efficiently.
Research components	1. Understanding how much a greener, more reliable and resilient power supply is worth to customers. Centrally-planned electricity networks with centralised delivery mechanisms don't allow customer-specific service levels. With new technologies, it will be possible to tailor electrical supply to individual customers' needs – whether in terms of quality, reliability or sustainability. Price will be a key input to the discovery of efficient means of delivering services to meet customers' needs and promoting technologies, and the scientific research to develop them, that reconciles these needs with the value that customers place on their being met. 2. Modelling what types of interventions will most cost effectively maintain secure, reliable and environmentally sustainable supply. The new technologies that are already available to support future power supply needs are in various stages of maturity – from Soft Open Point power electronics, Power electronics for synthetic inertia of generation & DC links, Solid State transformers to Inductive EV charging. Pockets of research exist in New Zealand universities and CRIs but this initiative provides a framework in which research could be resourced against national power system needs, complementary to the pure science agendas that currently exist.
Theme 3 **Using new technologies to manage the future power distribution system in a way that supports our desired lifestyle and economic growth**	
Importance to New Zealand	New Zealand's power distribution system has been smart from the start and we've made good use of our unique resources: hydropower, geothermal and wind, as well as pioneering demand-management technologies. We've researched and developed ways of doing this from scratch, for example through techniques such

	as ripple control which have been copied and exported to the rest of the world. If New Zealanders are to be able to rely on an environmentally-sustainable, resilient and reliable power supply without having to limit the way in which they use, store and create electricity in the future, the country needs to take on the challenge of understanding the problems we'll face, identifying the technologies that we can use to solve them and then integrating those technologies into our unique environment. New Zealand's electricity industry has a proud and successful history of pioneering new technologies in the power industry and then exporting them and our expertise in them to the rest of the world – from ripple control, to the first undersea "HVDC" cable and of course our sustained innovation in exploiting geothermal, hydro and wind to generate safe and reliable power. This programme will be no different – bringing forward areas of scientific research and development to commercial operation in areas where we lead the world. We will gain locally from strong research and rational deployment programmes, and also export products and know-how to other countries, just as we will become fast following adopters for complementary innovations from overseas.
Research components	1. Ensuring that the best current and future technologies are used in a timely and efficient and secure manner. Many technologies exist - the key is to identify target technical solutions for New Zealand's power system and the scientific research that is necessary to commission these solutions locally from the smorgasbord of theoretical l options available. 2. Creating room for developments such as electricity storage technologies to reconcile intermittent supply from new types of generation with customer demands Electricity has the unusual property that it cannot be stored directly but must be converted into another form of energy. The critical role of energy storage in managing the intermittency of certain new and renewable energy makes it a particular priority for the future of electricity networks, yet few commercial solutions exist – relying on scientific research in context to bring them to market. 3. Designing and developing new technologies to allow each individual customer's demand to better respond to price so that they can allocate power resources in the way that best meets their needs. Smart power systems are only an input to the delivery of benefits to consumers, which rely on a user interface that allows customers to respond to price and control demand, or generate power from their own resources. Behavioural and statistical scientific research will be important tools in the effective harnessing of this potential flexibility in the power system if it is to benefit all New Zealanders.
Research Gaps and Opportunities	1 Social science research at the Universities of Otago, Auckland & Lincoln: has never been coordinated and focused on electricity consumers. 2 Engineering research at Canterbury + behavioural science analysis at a national: understanding where and how the local power networks in New Zealand will be affected by 21st century electricity use. 3 Operations Research at Auckland + Power Systems Modelling work at Canterbury and IRL: understand the nationwide impacts of these changes in a consistent and rigorous fashion.

	4 Waikato 'smart homes' + Victoria incentive effects of regulation: how to use prices to maximise this impact in the operation of the future power system. 5 Canterbury Distributed Generation: intelligent switching logic and adaptive protection and control solutions for New Zealand power systems. Auckland inductive power transfer, motor control, electric vehicles: likely types of EV adoption in New Zealand. IRL's continued research into Superconductivity could be focused on fault current limiter applications specific to the New Zealand environment. 6 NERI is currently researching all smart grid activity in New Zealand: prioritisation and selection of key scientific research necessary to resolve the technical issues 7 Distributed energy generation and storage research at IRL: seed research in universities around the country 8 Waikato: demand-side measures to manage intermittency: how current and future appliances could support this type of power stabilisation.
Comments	Electricity is unlike any other commodity. It is a factor input to production – enabling the transformation of raw materials into finished products through heat, light and automated manipulation. Unlike other industrial inputs, electricity powers information technology and the tools of the knowledge economy and its related service industries. Without affordable and reliable power, New Zealand will not maintain growth in productivity and welfare rates as this depends so much on doing what we do smarter not at greater volumes. More importantly still, electricity is a catalyst for the lifestyles New Zealanders expect to enjoy in a knowledge economy – allowing our citizens to work where they want, how they want to, and so it accelerates both economic growth, welfare and lifestyle improvements. The current power system was never designed with the knowledge economy in mind, and it is now the right time to use the tools of the knowledge economy to ensure that it can support it! The future net economic benefit to New Zealand from successful smart network deployment has been estimated at $10.7b in the recently released Green Growth: Opportunities for New Zealand, report prepared for the New Zealand Green Growth Research Trust by Vivid Economics and the Energy Centre at the University of Auckland Business School. Keeping New Zealand's power networks smart means optimising the large economic gains to New Zealand achievable through developing an efficient smart electricity network and consumer interface to it.

Entry ID	**282**
To develop new solid-state thermoelectric materials or semiconductors with the goal of minimum efficiency of 30%. Doing so will also enable New Zealand clean tech technology Thermagenz to become a world game changer in the energy industry	
Theme 1	

Thermagenz is a solid-sate geothermal power generator developed in New Zealand. We will have a 1kw module installed in Taupo late Feb 2013. We need to show in real terms that Thermagenz can produce grid ready electricity at less than NZ$3 million per 1 Megawatt	
Importance to New Zealand	New Zealand is seen as a leader in geothermal power and in fact we deployed the world's first geothermal power plant back in 1958. Geothermal power is internationally recognised as the cleanest and least environmentally impacting of all the large infrastructure power systems. Geothermal is thus the perfect 'brand' to further enhance our clean green image. However to date we have not developed any technology that converts the heat to electricity ourselves. All of the generation plants that we have developed to date both locally and abroad use foreign turbines sourced from either Israel or Japan. Currently geothermal power generation costs about NZ$4 million per megawatt however that figure is only achievable on a 20 megawatt power plant or larger. The reason for this is that the cost of drilling and finding the permeable rock (aquifer) is a significant cost of the project. So if the geothermal resource is only predicted to be able to produce say 10 Megawatts the cost of the final plant per megawatt goes up significantly and is usually not viable. If New Zealand could show that a non-aquifer based solid-state thermoelectric generation system (e.g. Thermagenz) offered a more cost effective and reliable option, then New Zealand would (or could?) stand to gain more export contracts from all over the globe and for wider outputs from hundreds of kilowatts to hundreds of megawatts. New Zealand would leapfrog ahead of competing countries by 20 years. Also this technology could be seen as a viable option in other energy sectors.
Research components	We need to define the relationship of the key technologies required for a 50-100kw Thermagenz installed module through the establishment of an undertaking of a real-world trial thus allowing for further new thermal & geothermal knowledge to be gained. Thermagenz currently uses 3 key technologies; custom designed peltier devices, custom thermal designs and thermal super conductors. The thermal super conductors incorporate revolutionary technology, the nano-coated rods that we have are 30,000 times more conductive of heat than silver. This means that over a 1.6km length of rod the loss of energy is only 1/1000th. These rods enable two things; •That the heat (up to 27MW per metre) from deep within the ground can be extracted without the use of drilling into aquifers and the extraction of heat on the 'cold' side of the semiconductor and •That this can be done with greater efficiency and potentially done with no use of water. We have reached a point where we now need to define the working relationship of these key technologies through the conducting of a 50-100kw installed module real-world trial. Such a trial will allow for further new thermal & geothermal knowledge to be gained. Currently at this stage of our development in Thermagenz technology we have reached a point where it is 6-7% efficient. Current turbine technology is about 15% efficient. Note: findings to date are showing that conservatively we can expect an installed cost per 1 megawatt of well under NZ$3 million which is already extremely competitive.
Theme 2 **To prototype our commercially viable solid-state thermoelectric generator using current**	

technology	
Importance to New Zealand	The export market potential is extremely large. Of the more than $9 trillion projected to be invested in new power plants between 2011 and 2035, almost $6 trillion will go toward renewables – approximately twice the investment amount projected for more traditional coal, gas, and oil plants. (US State Department 05/03/12) Whether electricity is generated by geothermal, gas, coal, nuclear, or thermal-solar all produce heat which is then converted to electricity. The average efficiency of these turbine based systems is less than 20%. All use turbines and water and require maintenance, however Thermagenz is solid state so has many advantages over existing technology which is attracting international interest already: Pertamina in Indonesia – they are extremely interesting in using 1-5MW Thermagenz systems in 6 sites in remote Indonesia – quotes have already been given for a few sites. General Atomics in San Diego USA. If they can incorporate our current Thermagenz solution on the waste heat side of the reactor then they have their 55% efficiency target reached. National Nuclear Laboratories UK, they are exploring using our heat-pipes to transfer waste heat from their nuclear waste to above the surface then using this heat to power a small facility above the site. The Large Hadron Collider at CERN and Steenkampskraal Thorium Limited in South Africa While Thermagenz technology can be further developed and could be fully manufactured in New Zealand there will be a requirement for the development of significant systems of supply and support worldwide.
Research components	The requirements to accomplish this theme are more in the product development, market research and commercialization logistics rather than pure research. However a smart, experienced and well-resourced team will be required.
Theme 3 **To continue the process of developing a whole new thermoelectric material or semiconductor technology. This must solution must be very cost effective when compared to current Thermoelectric solid-state devices**	
Importance to New Zealand	We need to show that working as a focussed team across industry and institution can be beneficial for all involved. New Zealand's place as the leader of Geothermal power generation is becoming a distant memory as Iceland is forging ahead with projects and geothermal powered Data Centres. We have even imported Icelandic engineers to work on our own projects IN New Zealand! New Zealand currently has tremendous materials expertise and engineering innovation. However in my 30 years of business I have seen repeatedly that we rarely focus our broad resources on a big opportunity. We tend to work in silos. In the past 12 months I have met amazing people/minds from universities, companies and research facilities while developing Thermagenz and was amazed that we are doing development sometimes three times over and the knowledge is not being shared! We need to show ourselves that a system/process of working together can work well, however this will only be fruitful when you have a clearly defined objective with strong leadership driving. We are almost irrelevant globally in terms of our population, yet New Zealand has become known for various significant accomplishments over the years – nearly all of these have become real because we have worked as a team. Americas Cup & Lord of the Rings are our

	most noted – all done with focus teams. I feel we should now prove this process in the sciences. The clean energy sector is one area that could benefit the New Zealand 'PURE' branding
Research components	1. a complete re-think of the relationship of heat and electricity with a focus on a clean, viable energy sector solution. 2. Development of a new thermoelectric material or semiconductor We discuss/list all known features of heat and electricity plus also discussing the relationships/symmetries etc. We also add this information into a computer model that enables us to transfer this data into two systems to enable alternative data processing. 1. A Gaming scenario (As recently used with success in the Biotech area) 2. A big data system like Quid and Lucidworks. Currently worldwide over 50 institutions are working on thermoelectric yet none have succeeded in developing a solution that is more efficient than 15%. I re-think is required. I strongly believe that a commercially viable high efficiency solution exists – we just need to find it, by looking in new ways. I have already started this process and in September formed the New Zealand Extreme Materials Initiative. Currently NZEMI includes expertise from GNS Science, Auckland and Waikato University, TiDA and three companies. I have also developed strong links with Huddersfield University and the Chinese Academy of Sciences as I was in Shanghai in November to present a paper on Thermoelectric devices at a Nuclear power conference.
Research Gaps and Opportunities	To commercialize the Energy efficiency/recovery potential of Thermagenz for Geothermal, Coal, Gas, Solar Thermal and Nuclear powerplants.
Comments	By developing Thermagenz to be a viable ' output efficiency increasing' solution for use in and with the existing and already installed' various power plant systems means that New Zealand will get the broadest international exposure and will also have this export market not dependant on any one country, commodity or technology. It is also probable that we may open up opportunities for partnership with international companies and institutions in other fields. So often New Zealand has a great export success but the market changes beyond our control and the opportunity is gone. The energy industry is fundamentally conservative. Absolute reliability is required equal cost. Thermagenz builds on principals that are over 100 years old and have even powered keys science projects like Voyager and the Mars Curiosity. If New Zealand can establish a pragmatic science vision of coupling unique solid-state thermoelectric solutions to the varied energy needs of the world then this success will allow us to explore other industry solutions.

Entry ID	**285**
To explore the implications of installing large numbers of a novel design of a domestic hot water heat pump, which incorporates demand side management	

features and improved consumer controls, which has significant environmental and economic benefits	
Theme 1 **The goal is to design and manufacture 'in high volumes' a more advanced HWHP that overcomes the disadvantages of currently available HWHPs, and be considerably more cost-effective than solar water heating**	
Importance to New Zealand	Social benefits for the environment. To substantially reduce the 'upfront cost' to the homeowner.
Research components	•Develop an understanding of the extent of the resource that preheat roof space air has in improving the coefficient of performance of a HWHP. Identify the parameters when it would be undesirable to remove heated air from the roof space that could cool the habitable living space below. •Utilises BRANZ's extensive energy and environment expertise, specifically their knowledge gained from The Household Energy End-Use Project. • Investigate the role for smart metering to flatten the high peaks in electricity demand, when used in conjunction with large number of HWHPs.
Theme 2 **Understanding New Zealand Homeowners Apparent Reluctance to Adopt Housing-Sustainability Innovations**	
Importance to New Zealand	Understanding the homeowner's attitude –behaviour gap.
Research components	•What are the barriers to the homeowners' widespread adoption of HWHP. •Investigate the potential Influences on homeowners behaviour (I'm sticking with what I know: it's not worth it: I can't think that far ahead) •Homeowners' real or perceived risks (financial risk, functional risk and social risk).
Research Gaps and Opportunities	This project suffered from the principal-agent problem, in that manufacturers are not compensated for (nor willing to pay for research) producing more energy efficient models that have additional social benefits for the environment. Extracts from the Treasury published Electricity Demand-Side Management October 2005, in terms of appliances, consumers can be largely in the hands of manufacturers – who may be unwilling to produce energy efficient models (which may be more expensive relative to competing models). The costs of investing in such production could outweigh the benefits if energy efficiency features benefits are a minor concern in purchase decisions. More efficient use of electricity has environmental benefits. Some of these benefits (such as reduced emissions) accrue beyond the investor, to society at large i.e. social benefits exceed private benefits. The investor is not compensated for these aspects, and is therefore unlikely to factor them in to their decision-making – the so-called principal-agent problem. Another pricing problem occurs when electricity prices are based on

	average rather than marginal costs. This can distort decision-making, as it inhibits users' price-responsiveness and provides inadequate incentives to invest in energy efficiency. The structuring of tariffs (fixed rather than variable pricing) acts in a similar way. The remaining potential for direct peak trimming in the residential sector would therefore lie with improving cost information via smart metering. Enforced rolling cuts are unlikely to be acceptable to consumers.
Comments	Currently the market in New Zealand for HWHPs is unarticulated. This challenge is to create a large-scale market (on a national scale) for HWHPs, and then there is the opportunity to unitise high volume production to substantially reduce the 'upfront cost' to the homeowner and provide significant benefits to the environment. [Extract Tech-Net Consultancy Report (Ian Bywater)] The upfront cost is consistently the key parameter for the uptake rate for new energy efficiency technologies (the simple 'pay-back economic barrier) regardless of the energy efficiency gain. However, increasing electricity prices in the future will lower the 'pay-back period and therefore encourage technologies with higher energy efficiency. Nevertheless, the upfront cost remains the key factor'* {My emphasis added} The following work has already been carried out on this project: •Tech–Net report Industrial Research Ltd: A Gardiner •Tech-Net Consultancy Report: Ian Bywater •EECA 1.28 Investigation the combined attributes of convective and radiant air to water heat pumps •Finalist in the Wellington's inaugural Bright ideas challenge. •James & Wells Intellectual Property has provided an opinion that the novel HWHP has 'freedom to operate'. Based on the information at hand, we believe you can commercialise your invention in at least the USA without infringing any current patents.

Entry ID	320
Better Building Performance for Economic Growth	
Summary	The goal is to identify how performance in the construction sector can be improved for national economic growth. The following research themes are proposed: (1) investigate and establish how performance improvements at the project and firm level flow through into increased national productivity (e.g. profitability, customer satisfaction, decreased waste, increased standardisation) (2) Identify barriers and opportunities for productivity improvement - To identify the barriers to innovation and adoption of new smarter practices that will lead to increases in productivity in a sector dominated by small and medium enterprises (3) Realise productivity improvements - Application of the knowledge and tools developed in this programme to realise productivity gains in the two key construction centres of Auckland and Christchurch over the next five years -
Theme 1 **To investigate and establish how performance improvements at the project and firm level**	

<table>
<tr><td colspan="2">(e.g. profitability, customer satisfaction, decreased waste, increased standardisation) flow through into increased national productivity statistics</td></tr>
<tr><td>Importance to New Zealand</td><td>The construction sector employs 8% of the workforce and in the last 10 years 14% of all new employment has been in the building and construction sector. It contributes 4% to GDP almost the same amount as agriculture but this figure is low compared to overseas economies. OECD figures also show that productivity in the New Zealand construction sector is lower than the average. National figures also show that construction productivity is declining and lags behind most other sectors of the New Zealand economy. Previous research has indicated that a 10% increase in construction productivity leads to a 1% increase in the national GDP. Every dollar spent on construction translates into three dollars of economic activity.</td></tr>
<tr><td>Research components</td><td>Component 1 What does productivity mean at the project, firm and sector level, what is the current productivity of the industry by sub-sector and how do we compare with other economies? Component 2 How is quality of the output accounted for in measures of productivity? Component 3 What is the impact of skill levels from the client though the whole supply chain? Component 4 Value stream and process mapping to identify the critical leverage points where the biggest productivity gains can be made.</td></tr>
<tr><td colspan="2">Theme 2

Identifying barriers and opportunities for productivity improvement - To identify the barriers to innovation and adoption of new smarter practices that will lead to increases in productivity in a sector dominated by small and medium enterprises</td></tr>
<tr><td>Importance to New Zealand</td><td>Understanding and quantifying current construction sector productivity at the macro and micro scale is the first step toward improving productivity. However, the construction sector is fragmented and complex and we need to understand how it operates, where the inefficiencies and barriers to innovation and productivity are, and what impact culture and lifestyle choices have on productivity in order to ensure any activities, interventions, education to improve productivity are properly targeted.</td></tr>
<tr><td>Research components</td><td>Component 1 What are barriers to innovation and adoption of best practice? Component 2 How does a sector of predominantly SMEs improve productivity? Component 3 How can smarter use of technology improve information flows and productivity? Component 4 What can be learnt from other manufacturing processes?</td></tr>
<tr><td colspan="2">Theme 3

Realising productivity improvements - Application of the knowledge and tools developed in this programme to realise productivity gains in the two key construction centres of Auckland and Christchurch over the next five years</td></tr>
<tr><td>Importance to New Zealand</td><td>The cost of rebuilding Canterbury is estimated at $20 billion. Auckland Council estimates demand for new housing in Auckland will rise from 3800 pa in 2011 to 10,000 pa by 2020. With an aging population, these challenges cannot be met without significant gains in productivity from the construction sector.</td></tr>
</table>

Research components	Component 1 Use of better production systems to improve productivity and affordability and support the growth of Auckland. Component 2 Application of relevant KPIs and benchmarking (both local and overseas) to allow self-improvement by firms. Component 3 To realise productivity gains in the Canterbury rebuild through enhanced procurement, better health and safety and project management.
Research Gaps and Opportunities	To date, there has been little research directly relating to construction sector productivity in New Zealand. Research has concentrated on understanding factors that contribute to low productivity and summarising overseas initiatives to improve productivity. It has not been directed at development of tools, products and processes to raise productivity. The productivity partnership has developed a “Research Action Plan’ through a process or workshops and sector consultation. This plan identifies the most important knowledge gaps and the key science questions that need to be addressed. Many of these are economic in nature. The plan can be found at: http://www.buildingvalue.co.nz/sites/default/files/rap.pdf Funding to date for the Partnership has been limited and this has restricted the amount of research that has been commissioned far.
Comments	The New Zealand construction sector is much less productive that it must be if it is to play its part in growing the economic wealth of New Zealand. It is characterise by a large number of firms and growing their productivity is a difficult challenge. The Productivity Partnership is an initiative from industry and government leaders committed to a goal of a 20% improvement in productivity by 2020. It was set up in response to a taskforce report completed in 2009 which identified that declining construction sector productivity was a result of low levels of innovation, impacts of regulation, procurement practices, low skill levels and job churn in the sector. The Partnership has a goal of leading a sector lift in measured productivity by 20% by the year 2020. Achieving this alone will add 2% to the country’s GDP – around $3 billion each year. The Productivity Commission in its report on housing affordability considers that the Partnership is the appropriate organisation to develop practical initiatives to improve industry productivity.

Entry ID	**334**
A net-zero energy New Zealand at household, community and national levels	
Summary	The goal of this proposal is achieving net zero energy consumption in New Zealand at the level of the individual, household, business, local community and nation. Themes suggested appear to include: (1) understand what determines identity, satisfaction and wellbeing provides a basis for policy and investment choices and behaviours that will achieve collective net-zero non-renewable energy demand in our buildings, food, transport and other activities (2) understand the energy costs of food and fibre production, storage, transport, and export and meeting the energy requirements of New Zealand’s food and fibre systems from local resources without losing the potential for exports, (3) demonstrate integrated

	systems that work with our existing building stock, that would enable that stock of early-mid 20th century houses and other buildings to be net-zero energy, etc.
Theme 1 **Understanding what determines identity, satisfaction and wellbeing provides a basis for policy and investment choices and behaviours that will achieve collective net-zero non-renewable energy demand in our buildings, food, transport and other activities.**	
Importance to New Zealand	We are the problem. Our changing lifestyle choices, behaviours and investments currently result in an ever-increasing energy consumption in all aspects of our lives – in our homes, commercial buildings, transport, food consumption and other activities. Changes in lifestyle choices and behaviours, coupled with technologies, are essential if we are to achieve net zero energy in New Zealand at the level of the individual, household, business, local community and nation.
Research components	We know already that individual, collective and business policy and investment choices and behaviours can make greater contributions towards net zero energy than can technical solutions. What we do not yet know is how to encourage these choices and behaviours and make them the norm. Research is needed first into appropriate choices and behaviours and then into effective ways to promote those choices and behaviours at all levels in society.
Theme 2 **Understanding the energy costs of food and fibre production, storage, transport, and export and meeting the energy requirements of New Zealand's food and fibre systems from local resources without losing the potential for exports.**	
Importance to New Zealand	Understanding the energy costs of food and fibre production, storage, transport, and export is essential if alternatives are to be identified. We know that the production of sufficient food from the available land area, to meet the needs of both the population and exports, requires major imported energy inputs. We also know that replacing imported energy with grown energy crops may not be an option because of the excessive land requirement. A way is needed to meet the energy requirements of New Zealand's food and fibre systems from local resources without losing the potential for exports. Much of the energy input required for production, storage, transport, and export is based on imported petroleum fuels. Becoming self-sufficient in energy while still maintaining food production capability for local supply and for export means massive reductions in imported fuel energy, but it must be achieved without losing the land that grows the crops that provide the country's export earnings.
Research components	Establishing the net energy demand and energy flows between production, transport and export of a wide range of food and fibre groups. This will provide a sense of where to apply the research efforts. Investigating new options for production, storage, transport and export. These options will need to involve both technology solutions and changes in methods and practices at all levels.

Theme 3 **A demonstration of integrated systems that work with our existing building stock, that would enable that stock of early-mid 20th century houses and other buildings to be net-zero energy, alone and in functional residential communities and business centres**	
Importance to New Zealand	The built environment is a major consumer of energy and one where control of the energy demand is within the control of the owner/occupier, and where improvements can be made in an incremental manner. Buildings where energy is well managed are generally healthy buildings, a factor that has multiple spin-offs for society in terms of wider health and welfare costs. The rate of new construction is small as a percentage of total building stock, making replacement very slow. What is required is a demonstration of integrated systems that work with New Zealand's existing building stock.
Research components	A demonstration that the various separate technologies that are required to produce, store and control energy at the domestic, commercial, and community level can be integrated in a reliable manner. A study of the linkages and energy interactions between individual buildings, urban planning and transport energy in the built environment. There is also the need to link this integrated modelling with a study of ecological footprint (as a measure of the energy and non-energy resources that go into the built environment) and recently developed morphogenetic modelling of resilience to create a model of the urban environment as a complex system. This will allow the assessment of any proposed energy system changes against what these do to both existing resilience and existing ecological footprint.
Theme 4 **Distributed energy production, distribution and storage systems with the potential to increase the robustness of our existing energy production and distribution system, and to integrate alternative energy production into the existing centralised system.**	
Importance to New Zealand	Developing a capability to deliver turn-key, medium sized systems, including new energy-lopping systems for Auckland, provides New Zealand with alternatives to installing large, central infrastructure and so provides a long-term insurance policy against externally controlled energy supplies and prices. An increasingly important part of the New Zealand economy will be around exportable skills, capability and know-how in energy installation, automation, control and transformation, as global demand for such expertise builds up this capability could support an export component.
Research components	Modelling of the existing energy production and distribution system as increasing levels of distributed production and storage are incorporated into the community, including management of interactions from a range of energy supply sources at different times of year and demand levels.
Research Gaps and Opportunities	Gaps and opportunities exist in the integration of technologies for small-medium scale systems and in long-term data on energy performance related to different lifestyle choices and behaviours. Research is needed into alternatives to battery storage for the storage of significant amounts of energy at, for example, the

	community scale, and intelligent control of demand to reduce power use. Electrical energy is required in isolated and small towns and communities in often remote sites, such as on the East coast, Chatham Islands, Waiheke and Rakiura and across the Conservation estate. These locations could offer ideal places in which to trial proposals for wider adoption.
Comments	Victoria University of Wellington will draw researchers into these four themes from across its schools of psychology, media, government, policy and economics, geography and environmental studies, architecture and design, engineering, chemical and physical sciences. We will also work with: •Businesses and the community at all levels from international corporate to national power supply companies (Meridian, Genesis, Vector et al.) to small renewable energy installers to households to community organisations and local councils. Many of these have been, and are still, involved with Victoria University's net-zero energy First Light house development. •Education sector including pre-school, primary, secondary and tertiary organisations. As significant consumers of energy, and (at least in Victoria University's case) having a commitment to the environment and to conservation, universities and research institutes can be ideal test beds for new developments •Other research organisations, including BRANZ, with its capability in energy use in domestic and commercial buildings. •Member organisations of the National Energy Research Institute (NERI). We have had extensive discussions with NERI and contributed to their submission, and would see them playing an important role in determining the direction of future energy research.

Entry ID	349
New Zealand Energy: Secure, Sustainable, and Economical	
Summary	This challenge proposes to make New Zealand100% energy independent through the exploration and development of improved sources of energy across a range of platforms (petroleum, tidal, geothermal etc.). Pre-emptive research into renewable energy sources will provide a major boon when carbon-based fuels are eventually exhausted. This will help to re-enforce New Zealand's 'clean, green' image, which will have both local and international benefits.
Theme1 **100% New Zealand Energy: All of the energy used in New Zealand is produced in New Zealand**	
Importance to New Zealand	New Zealand is well situated become 100% energy independent because of our extensive carbon (gas, oil) and renewable resources. The two major benefits to New Zealand of energy independence are: (1) energy security and (2) a positive economic boost. Energy security: Currently New Zealand is quite sensitive to global fluctuations in the availability (and price) of energy. As the source of

	carbon-based energy (oil, gas) dwindles, being able to secure a steady, reliable source of energy over which we have control will become increasingly important. Being able to supply 100% of our own energy will mitigate the risk to our economy and way of life. Positive economic boost: Energy produced here will be sold here and perhaps even abroad. The economic security from a reliable, stable source of energy will benefit not just the energy industries, but also every endeavour in New Zealand that requires energy to succeed - from dairy to metal smelting to growing high-tech manufacturing industries. Theme 1 is the most immediate of the four Themes in this challenge. Achieving energy independence (100% New Zealand Energy) rapidly will only be possible if we maximize our resources, including carbon-based, non-renewable ones. Other options are unlikely to be economically viable.
Research components	A. Improved sources of energy. 1. Carbon-based energy extraction: (oil, gas, fracking, biomass/biofuels (algae, forestry, crop residues), etc.). Improving efficiency; reducing cost; reducing environmental impact. 2. Renewable energy extraction: (wind, solar, geothermal, tide/marine, hydro, biomass, etc.). Improving efficiency; reducing cost; reducing environmental impact. 3. New ways for distributed energy production: Energy produced on the site of use reduces the load on the electrical grid and other energy systems that require transportation. Many small sources can add up to a significant amount of New Zealand-based energy production. Solar (photovoltaic, thermal), wind, geothermal, gas and water energy can all be generated locally. Research into making these technologies more robust, cost-effective, and user-friendly would spur widespread use. B. Improved use of energy: 4. Research into a "smart" interface/balance between the centralized energy system(s) and these distributed ones would be needed. In particular, tuning the economic incentives (who pays the cost, who reaps the economic reward) will be critical to success. 5. Improved efficiency of energy use by major industries, through practices and technological advances. 6. Improved efficiency of energy use by households, through practices and technological advances. 7. Energy equity research. Scientific research into the equity issues associated with energy availability and cost will be required to ensure that subsets of the population are not disadvantaged. For example, rural users should enjoy the same benefits as urban ones (and vice versa). High-tech advances must be usable by relatively unsophisticated user, as well as the more sophisticated (like cell phone technology).
Theme 2	

100% Renewable: All of the energy used in New Zealand comes from renewable sources	
Importance to New Zealand	New Zealand is particularly well situated to lead the world in moving to a 100% renewable energy system over a relatively short time. Our natural resources of hydro, wind, solar, marine, geothermal and biomass (sustainable) are sufficient to power the country into the future. The two major benefits to transforming 100% of New Zealand energy to renewable sources are: (1) long term energy security, and (2) economic benefits from exporting technology and innovation. Long term energy security: These benefits are very similar to those in Theme 1. Additionally, as New Zealand carbon-based reserves are tapped out, an investment now in developing renewable sources will pay off in a seamless (or minimally disruptive) transition. Economic benefit: The development of technology to efficiently and economically harvest renewable energy will generate new technology, companies, and intellectual property. As the rest of the world runs out of gas and oil, they will need our innovations. We can become a net exporter of renewable energy technology. In the long-term, as oil and gas resources are played out, renewables will become a more important part of the energy economy. By prioritizing their development in New Zealand- a land with fertile renewable sources - we can achieve a global advantage.
Research components	A. Improved sources of energy: 1. Renewable energy extraction. (overlap with Theme 1) 2. New ways for distributed (on site of use) energy production. (overlap with Theme 1) B. Improved Energy Storage 3. New methods of storing energy in large energy use situations. Major users of energy usually require a relatively balanced load. Research into batteries, liquid fuel, pumped water and other methods of storing energy is needed. 4. Energy storage down to the household level. With distributed (on site of use) energy production comes the need for distributed energy storage that is safe and affordable. Energy storage needs and mechanisms will be different across the diverse landscape (and people-scape) of New Zealand, and these diverse situations offer the opportunity for tailored innovation. 5. Energy for transportation. New research into fuels suitable for transportation within New Zealand and from New Zealand to the rest of the world is absolutely required. The solutions are likely to be very different for short, moderate and international scales of travel. C. Improved use of energy. 6. Improved efficiency of energy use by major industries (overlap with Theme 1). 7. Improved efficiency of energy use by households (overlap with Theme 1).

<table>
<tr><td></td><td>8. Energy equity research (overlap with Theme 1)</td></tr>
<tr><td colspan="2">Theme 3
100% New Zealand Green: All of the energy produced in New Zealand is environmentally sustainable</td></tr>
<tr><td>Importance to New Zealand</td><td>The New Zealand global brand is "100% Pure," and this Theme extends that aspiration to our energy production, storage and use. The two major benefits to New Zealand are (1) stewardship of our unique and valuable natural resources and (2) economic benefits from exporting technology and innovation.</td></tr>
<tr><td>Research components</td><td>A. Improved sources of energy
1. Producing renewable energy with minimal environmental footprint. This requires research in engineering, physics and chemistry as well as environmental science, biology, and the social sciences.
B. Improved use of energy.
2. Optimizing the efficient use of energy in industry, business, and the home. (overlap with previous themes)
3. Minimizing the waste generated by energy production and use. Research into capturing emissions, extracting maximal energy from sources, and converting waste into useful materials.
C. Reduced environmental impact of energy extraction and use.
4. Developing technology to mitigate the impact of energy extraction and use on New Zealand flora, fauna and people.</td></tr>
<tr><td colspan="2">Theme 4
100% New Zealand Involvement: All New Zealand residents use renewable, clean New Zealand energy</td></tr>
<tr><td>Importance to New Zealand</td><td>Theme 4 is most easily accomplished if Themes 1 - 3 are very successful. New Zealand is a small country with a many different communities. 100% uptake of the 100% New Zealand, 100% Renewable and 100% Green energy technologies across this diverse population will ensure that the improved outcomes and economic benefits are provided to all New Zealanders, and that the science and technology developed will be widely applicable on the export market.
The two major benefits of Theme 4 are:
1. enhanced health and well-being to all New Zealanders, and
2. economic benefits through high adoption within New Zealandand high exports globally.</td></tr>
<tr><td>Research components</td><td>The main research components needed achieve the objectives in this theme are more in the psychology and social science fields. Questions to be answered include:
1. What are the barriers to adoption of new technology?
2. What resources can be used to overcome those barriers?</td></tr>
</table>

	3. How can we maintain equity in access to clean, renewable energy? 4. What are the less-tangible benefits to New Zealand of going to a 100% New Zealand, 100% Renewable, 100% Green energy system?
Research Gaps and Opportunities	New Zealand is one of the few countries in the world who could achieve this challenge, because of its unique location, abundant renewable resources and strong national ethos of "100% pure." Importantly, New Zealand already has significant strength in many of the research areas needed to succeed in meeting this grand science challenge. World leading research into energy production and storage is going on at Auckland, Victoria, the MacDiarmid Institute, and other research locations within New Zealand (e.g. inductive power transfer, NERI, polymer-based solar energy harvesting, and many more). Leveraging international research can spur technological innovation here in New Zealand as well. Research into the environmental, psychological and social science issues is also already quite robust in New Zealand as well. The key will be to link these various science and technology strengths together in a way that leads to meaningful, directed research that balances esoteric scientific discovery with palpable economic outcomes.
Comments	I volunteered to be part of a discussion at an MBIE/MSI workshop that developed the Energy theme and came up with the "100% New Zealand, 100% Renewable, 100% Green and 100% Uptake" idea. I have incorporated some of the discussion in this submission. The four themes here are progressive: Theme 1 is the most short-term, and Theme 4 is likely to take the longest to accomplish. For example, the development of New Zealand's oil and gas resources in Theme 1 is seen as absolutely necessary economically, but also as transitional for long term energy security - that will come when we are 100% New Zealand and 100% Renewable. It was also felt that having energy produced at the site of use (i.e. in homes, small businesses) is critical to our becoming energy independent.

Entry ID	**363**
	Economic local industrial and transportation fuels
Summary	The goal of this proposal is to manufacture liquid fuels from biomass within New Zealand. The proposed research programme includes the following themes: (1) Produce liquid fuels from biomass - small scale experiments using novel catalysts and chemical and thermal degradation controlled by on-line monitoring of products using gas and liquid chromatography. A diverse range of biomass sources would be quickly investigated (2) Purification of liquid fuels - a "fast fail" evaluation of process conditions necessary to separate liquid fuels from water, and also separate undesirable contaminants from liquid fuels. A wide range of fuels from different feedstocks

	would be investigated (3) Improved combustion properties of fuels - Fuels from different biomass sources would be subjected to small Otto engine evaluations to ascertain necessary modifications to produce optimal power. The use of enhancers would be investigated (4) Examine emissions and total energy balance of fuel production - Analyse emissions and wastes from preferred systems to ensure novel process that do not produce toxins or unwanted chemicals when used with different biomass systems
Theme 1 **Produce liquid fuels from biomass**	
Importance to New Zealand	Fossil fuels continue to provide the major liquid fuels for internal combustion engines. Whilst personal transport will have increased efficiency as Japan reduces vehicle mass and improves engine efficiency, internal combustion will provide motive power for hybrids and even some electricity. This project will provide viable liquid fuels.
Research components	Small scale experiments using novel catalysts and chemical and thermal degradation controlled by on-line monitoring of products using gas and liquid chromatography. A diverse range of biomass sources would be quickly investigated. The product will be a liquid fuel suitable for use in Otto cycle engines. The process would start with small particles of the biomass, both dried and as received. The initial main process would be for continuous catalytic flash pyrolysis producing a liquid fuel. The major innovation would be use of novel ceramic-based catalysts.
Theme 2 **Purification of liquid fuels**	
Importance to New Zealand	Flash pyrolysis of biomass produces a liquid fuel containing acids and organics along with carbon (akachar) and water. This process would look to increase the quantity and quality of liquid fuel using novel catalysts on a range of differing biomass feedstocks, typically wood or dried foliage. New Zealand has been exploring flash pyrolysis for nearly three decades with no commercial success. This programme would be to investigate conditions necessary to minimise the energy cost of reactions and water removal from the fuel. Such a regional fuel could be used for either electricity generation or transportation via the improving otto cycle engine technology and efficiency.
Research components	This programme would be a "fast fail" evaluation of process conditions necessary to separate liquid fuels from water, and also separate undesirable contaminants from liquid fuels. A wide range of fuels from different feedstocks would be investigated. The major techniques would be purification systems (other than distillation) monitored by gas and liquid chromatography combined with spectrometry. The major innovation would be the recycling of char to purify the fuel, combined with heat recovery to sustain impurity destruction and capture.
Theme 3	

Improved combustion properties of fuels	
Importance to New Zealand	Would facilitate use of biomass as a fuel replacing imported fossil fuels. The fuels could be used at production source in engines or to generate electricity.
Research components	Fuels from different biomass sources would be subjected to small Otto engine evaluations to ascertain necessary modifications to produce optimal power. The most likely use would be in small engines in locations where biomass pyrolysis was viable. It's unlikely the fuels would be sufficiently pure for external combustion turbine use, but that option would be explored. The use of enhancers would be investigated. All of the programme would be subjected to "fail fast" reviews from project initiation.
Theme 4 **Examine emissions and total energy balance of fuel production**	
Importance to New Zealand	Novel fuels should provide improved emissions and minimal transition costs over existing fossil fuel systems. These systems would be small with low capital cost, so changes to conditions can be matched to feedstock properties.
Research components	Analyse emissions and wastes from preferred systems to ensure novel process do not produce toxins or unwanted chemicals when used with different biomass systems. Emissions would be compared to current and proposed fuel production systems. Most testing would be performed at existing vehicle emissions testing facilities, but some toxin testing would be conducted in research facilities at Universities and CRIs.
Research Gaps and Opportunities	Main issue is cost of biomass collection and movement of liquid fuels, so the whole process would be self-contained to obtain optimal cost-effectiveness. Consequently, low energy consuming means of comminution and drying would improve economics.
Comments	The whole programme would be subjected to a "fast fail" strategy via regular reviews to ensure only processes that are feasible are continued.

Entry ID	369
New Zealand needs a secure future electricity system to support economic growth and the goal is to develop leading edge technologies to minimise New Zealand's dependence on finite or at risk energy sources	
Summary	This challenge proposes to develop leading edge technologies to minimise our dependence on finite or at risk energy sources. Development of advanced energy-storage and energy management technologies will result in long-term energy security. Research is also needed to develop socially acceptable, and widely-implementable energy-saving actions/behaviours that are embraced by the public. Developing technologies that allow vehicles to be run on advanced biofuels is both an environmentally sustainable action, and will help to lessen New Zealand's

	reliance on imported fossil fuels.
Theme 1 **The goal is to develop electricity storage technologies that enable better demand management and reduce generation peaks**	
Importance to New Zealand	Storage technologies result in more efficient management of New Zealand's generation capacity, better management of the national grid, and lower electricity prices. With the increasing penetration of renewable electricity generation in the generation mix and its variability (wind, hydro), grid connected storage and a grid that can react to this variability will be important developments for security.
Research components	The particular research need in New Zealand is the need to research the use of dedicated storage technologies and smart control to manage the load to suit the particular characteristics of our national electricity system and its variability over time. While there is attention internationally to producing very large electricity storage devices to help with grid stability and increased renewables, research is required into storage and reactive control technologies tailored for our circumstances.
Theme 2 **The goal is to develop energy efficiency and conservation technologies that lower energy demands**	
Importance to New Zealand	Behaviour change is an essential part of developing a country of smart energy users who are able to engage with the energy systems in a constructive way and be able to understand the impacts of their energy decisions on the energy infrastructure. Developing an understanding of these behaviours and the incentives and pressure points to motivate behavioural change are important steps in the path towards more efficient energy systems. Research would help understand the effects of people's decisions on the energy systems and allow development of techniques and technologies to either help change the behaviour of consumers or alleviate the negative impacts of uninformed users.
Theme 3 **The goal is to develop technologies that enable vehicles to be operated with alternative fuels**	
Importance to New Zealand	Advanced biofuels are very important for reducing New Zealand's dependence on imported fossil fuels.
Research components	Research on bio-fuels is a major focus internationally and New Zealand needs to develop niche technologies, and making use of local feed-stocks. What makes the advanced bio-fuels production processes economically viable are the co-products. More research into the co-products is required for developing innovative technologies for low carbon transport fuels that are economically viable. Examples include biochar, torrified wood, and biocrude.

Entry ID	385
The future of (personal) transport, developing a solution that is sustainable	
Summary	The goal of the challenge is the assessment of an electric transport platform for New Zealand. The themes proposed include: (1) assessment of a sustainable electric car platform - - Assessing state of the art. - Setting up a pilot network of charging points and battery service points. - Simulating power and battery needs for optimal power distribution and service levels and (2) assessment of a sustainable electric bicycle platform - inventory of the state of the art - Setting up a network of electric bikes (for rent - e.g. the network of bikes that can be rented in big cities like Paris) - Simulating the use of the network and optimizing it
Theme 1 **Assessment of a sustainable electric car platform**	
Importance to New Zealand	New Zealand could be the pioneer in developing a total solution. What the solution needs is a network that allows cars to charge easily and everywhere. New Zealand could develop a standard that could be applied globally. The solution could either be network of charging points or a system for replacing and servicing batteries (currently tested in Israel)
Research components	Assessing state of the art. - Setting up a pilot network of charging points and battery service points. - Simulating power and battery needs for optimal power distribution and service levels
Theme 2 **Assessment of a sustainable electric bicycle platform**	
Importance to New Zealand	Electric bicycles are an excellent add-on to car transportation. They could complement cars in urban environments. In order to make them widely accessible they need to be easily available. Again New Zealand could set the standard in this domain.
Research components	Inventory of the state of the art - Setting up a network of electric bikes (for rent - e.g. the network of bikes that can be rented in big cities like Paris) - Simulating the use of the network and optimizing it
Research Gaps and Opportunities	Current technologies for electric transport lake a holistic view. You need to provide a system where the user is not hampered by the use of an electric vehicle. Providing a network for this is crucial and this can only be done by simulating it on a small scale and expanding it to a bigger scale.
Comments	New Zealand is ideally placed for this as it no cars leave the country. This is a perfect testing ground for this type of concept.

Entry ID	393
Developing energy policy based on using non-fossil primary energy sources	
Summary	The goal of this proposal is the development of energy policy based on using non-

	fossil primary energy sources. The proposal proposes a research programme with the following themes (1) Energy efficiency and recovery - further improvements in power generation efficiency, a systematic approach to the construction of smart grids and demand side management etc. (2) Safe and secure fossil fuels - improving the efficiency of conversion, supply and use of energy and the speedy demonstration and deployment of carbon capture, transportation and sequestration to limit the environmental impact of the continuing use of these fuels (3) The renewables revolution - development of substitutes for scarce materials (4) Energy Sector Skills - Skilled chemical and process engineers
Theme 1 **Energy efficiency and recovery**	
Importance to New Zealand	In the short term, fossil fuels will remain the major source of primary energy for the world's population. There are concerns around price, demand, availability and the impact of carbon dioxide emissions on our climate. Technologies to reduce CO_2 emissions, including CCS, must be developed and implemented globally. At the same time, chemical engineers must support the transition to a decarbonised energy economy and a step change in energy efficiency. In the longer term, global energy strategy should be based on nuclear power and renewables. At present, renewables (solar, wind, wave, tidal) make a very small contribution to energy production world-wide. Solar energy sees limited applications. Shortages of refined silicon are hampering growth but manufacturing costs are falling. Wind power is popular with governments but suffers from high cost and intermittency issues. Wave power is still largely experimental. R&D into alternative materials and production cost reduction is needed, as well as research into bulk electricity storage. Many countries have legislated to stimulate biofuels and biodiesel production. However, a variety of challenges are apparent, including the availability of water, food crop displacement and the impact on biodiversity. A better understanding of the available options is required via life cycle analysis and reliable carbon foot printing. Fischer-Tropsch processes offer an attractive route to renewable transport fuels but further research is needed.
Research components	Improving energy efficiency is the most effective way of reducing energy demand, but insufficient progress is being made in this key area. A step change is needed to increase efficiency throughout the electricity supply chain. A megawatt saved is better than a megawatt made. Further improvements in power generation efficiency are needed along with a systematic approach to the construction of smart grids and demand side management to reduce both demand peaks and demand itself. Advanced energy efficiency and demand response management are very much in the domain of the chemical engineer and there are huge opportunities in the global power generation sector, which is undergoing rapid change. Process integration, with the aim of optimising the design and operation of all energy intensive processes along with energy recovery from side and waste streams must be pursued with renewed vigour in all parts of process industry.

Theme 2 **Safe and secure fossil fuels**	
Research components	In the short term at least, fossil fuels will continue to play a major role in the world's primary energy mix. However, the wisdom of simply 'burning' diminishing hydrocarbon resources is becoming increasingly open to question and many commentators argue that their use as feedstocks for added value products should now take priority. Issues of security of supply, global warming, process safety, fuel poverty and political instability continue to make energy policy a challenge for governments. The chemical and process engineering activity in this core area is directed towards improving the efficiency of conversion, supply and use of energy and the speedy demonstration and deployment of carbon capture, transportation and sequestration to limit the environmental impact of the continuing use of these fuels.
Theme 3 **The renewables revolution**	
Importance to New Zealand	Despite the recession, total global investment in renewable energy broke new records in 2010. Investment in renewable power and fuels reached $211 billion up 32% on 2009. Worldwide, jobs in renewable energy industries exceeded 3.5 million in 2010, with China, Brazil and India accounting for a large share of global total employment. Job opportunities will grow rapidly as markets expand and pressures for the automation of manufacturing and economies of scale will create new opportunities for chemical engineers.
Research components	Biological routes to fuels and platform Favourable regulation has stimulated activity in Europe and the USA and liquid biofuels provided almost 3% of global road transport fuel in 2010, though much of this shows a negative impact on carbon dioxide emissions if land use change is taken into account. The economic viability of bio refineries at scale remains unproven. Nonetheless, the production of biofuels from cellulosic residues and non-food crops presents the opportunity for a major advance that may address concerns over carbon balances, water abstraction and the competition with food crops and poor energy efficiency. Other options include algae-derived biodiesel. 'Clean energy' technologies, including solar PV, wind turbines and electric vehicles now account for around one fifth of the global consumption of critical materials including rare earths and other key elements. Price rises of 300-700% have been reported. Chemical engineers will contribute to the development of substitutes for scarce materials and deploy their skills in order to achieve a step change in reducing material and energy flows and environmental impact and increasing the recycle and reuse of end of life materials. Renewables will only contribute on a massive scale when cost parity on the grid is achieved, either by pricing in the cost of carbon abatement to the alternatives, or a step change in supply chain efficiency, which drives down cost. Government intervention may deliver this goal in the medium term but the problem of intermittency and the lack of reliable energy storage remains.
Theme 4	

Energy sector skills	
Research components	Skilled chemical and process engineers with a strong background in systems thinking and a firm grasp of sustainable development will be required to secure progress in all parts of the energy economy. However, in the developed economies past peaks in recruitment have resulted in a skewed workforce age profile and retirements will take an increasing toll through to 2020. The skills challenge may become particularly pressing in Australia where approaching 100 major projects in the energy and resources sector are reported to be at an advanced stage with a further 300 at an earlier stage of planning. A series of growth scenarios predict employment peaks between 40,000 and 70,000 around 2014. Around 20% will be employed in managerial and professional roles and the chemical engineering skill set will clearly be in high demand.
Research Gaps and Opportunities	Capturing carbon Tight gas, including shale gas and coal bed methane, has attracted considerable attention over the last decade and these new resources offer improved energy security, with a lower carbon footprint and new potential routes to petrochemicals. Nonetheless, reserves are finite and the carbon challenge remains. CCS is a three stage technology, where CO_2 is captured from large point emission sources, transported by a network of pipelines, before injection and storage in geological formations and depleted oil fields. The process offers the potential to remove 90% of CO_2 from fossil fuel electricity generation and industrial processes including steel making and cement production. IChemE has consistently supported CCS and has recognised that there are several routes available, including post combustion flue gas scrubbing; integrated gasification combined cycle, oxyfuel combustion as well as more novel technologies such as accelerated carbonation, catalytic uses in polyol production and algal growth. Safety and environmental issues are a concern, but the Institution remains confident that CCS offers the potential to limit the environmental impact of fossil fuels as the world transitions to a truly low carbon economy and chemical engineers will play a central role.
Comments	Biofuels Conventionally, biofuels can be divided into three categories: first generation derived from edible sugars and starches, second generation made from cellulosic plant materials and third generation sourced from marine algae and other microbial material. First generation biofuels have relied heavily on chemical process technology that is well understood but there are significant concerns over food crop displacement, deforestation, the greenhouse gas implications of fertilizer production and the distorting effect of subsidies. IChemE has argued that much first generation biofuels production does not pass the sustainability test. Advanced biofuels look more promising and could help the world meet some of its energy needs. Chemical engineers are involved in further work on the scalability, sustainability and cost of biofuel production. In addition to the process engineering challenge, there is also demand for chemical engineers to embrace new areas of opportunity including synthetic biology and the development and production of bacteria and enzymes with the potential to revolutionize energy production. Harnessing the sun Enough energy arrives on earth in the form of incident radiation from the sun in one hour to meet the needs

	of every human being on earth for a year. However, sustainable biomass provides less than 1.5% of humanity's energy needs and despite rapid growth, solar panels contribute just 0.1% of energy production. Chemically engineered smart materials are needed to deliver step change improvements in solar photovoltaic materials, fuel cells and batteries. The chemistry community is pushing hard to develop new photo active substances that will enable the mass production of flexible and transparent solar arrays.

Entry ID	396
The Health & Wellbeing challenge	
Summary	This challenge proposes to conduct research which investigates key issues related to the involvement of chemical engineering in wealth creation (with the overlying goal of doing so to achieve sustainable prosperity). Chemical engineering is vital in establishing efficient energy generation; however efforts need to be made to ensure that advances incorporate a vision of environmental sustainability (i.e. adherence to principles of 'green energy'). Other issues this challenge proposes to address are; establishing positive safety culture throughout the process industries, and investigating the industrial potential of biological/biotechnological engineering.
Theme 1 **Achieving sustainable prosperity**	
Importance to New Zealand	The 1992 Rio Earth Summit made an historic commitment to sustainable development. Twenty years on, and several summits later some commentators argue that human civilization has never been closer to ecological collapse. A third of humanity lives in poverty and another two billion people are projected to join the human race over the next 40 years. Chemical engineering is central to the wealth creation but a balance must be struck with the need to protect the environment and build social capital. A step change in energy efficiency is needed alongside the adoption of 'closed loop' business models that will conserve scare resources via a cradle to grave approach to product design. Greater emphasis should be placed on prioritizing fossil energy sources for feedstocks rather than fuels and this suggests the adoption of manufacturing strategies based on adding value closer to source, as suggested in Australia and the USA.
Research components	The human right to a 'satisfactory environment' is enshrined in the legislative frameworks of many nations in the developed and developing worlds. Environmental protection is a key component of the sustainable development concept; however some commentators argue that the role of chemical engineers in safeguarding the environment has become side-lined in the sustainability debate. Environmental wellbeing can be secured through adherence to the principles of 'Green Engineering' and chemical engineers should redouble their efforts to apply these principles at the earliest stages in the design and development of a process or product.

Theme 2 Process safety leadership	
Importance to New Zealand	Process safety is a critical component of 'wellbeing', not just for the workers employed in high hazard chemical process operations and those who live in the immediate vicinity, but also for the reputation of the process industries and the chemical engineers they employ. The Macondo blowout in the Gulf of Mexico in April 2011 killed 11 men and resulted in the release of more than 4 million barrels of crude oil. Deepwater Horizon has taken its place alongside Texas City, Piper Alpha, Seveso and Flixborough in the lexicon of process safety disasters. Clear and positive process safety leadership is at the core of managing a major hazard and it is vital that risks are managed effectively. In the developed economies the challenge is compounded by cost pressures and aging assets. Meanwhile in Asia and the Middle East, rapid growth presents a different challenge, but also an opportunity to learn from the incidents that have come to define process safety. Chemical engineers must work with all stakeholders to reinforce the principles of process safety leadership and secure effective management of risk throughout the process industries.
Research components	Process safety education and technology transfer: IChemE will continue to work to build positive safety cultures throughout the process industries, learn from past successes and failures by encouraging open dialogue and further develop links with regulators to ensure that professional chemical engineers are positioned at the heart of the process safety debate. We will prioritize our efforts to ensure that process safety accountability is defined and championed at board level in the companies where our members are employed.
Theme 3 The biological engineering opportunity	
Importance to New Zealand	Biological engineering offers great potential to chemistry using industries worldwide; however many chemical engineers have yet to recognise the exciting possibilities that exist in the bio domain. Growth in this promising area requires new thinking to bridge the gap between biology and process engineering. Systems thinking can solve biological problems on an industrial scale. IChemE will actively promote the development of biological engineering as a professional discipline in its entirety and facilitate interaction between all scientists and engineers involved in this diverse field.
Research components	Biotechnology food processing; enzyme technology; metabolic engineering; synthetic biology
Theme 4 Cutting costs in pharma	
Importance to New Zealand	Complexity in the manufacture of active pharmaceutical ingredients (APIs) adds to the cost base in an industry that faces mounting financial pressure. Chemical engineering expertise will help reduce the complexity of API manufacturing processes and make them easier to scale up and control. Core unit operations,

	including mixing, downstream separation and crystallization, can improve the control of product characteristics. The pharmaceutical industry is in a state of flux and chemical engineers can improve cost effectiveness in a whole range of areas from vaccine manufacture and oral dosage formulation to validation and the determination of overall equipment effectiveness.
Research components	The application of chemical engineering from first principles will bring new insight to many health related challenges. Process system engineering can be used to model organs and cells in a similar manner to that which has been applied to chemical plants for almost a century. Fundamental chemical engineering science, such as fluid mechanics, can be used to model blood flow and other bodily functions. Chemical engineering can improve drug delivery and other treatments via the application of process control principles. Biosensors can be used to monitor vital signs and, when coupled with an implanted microchip controlling drug delivery, automated treatment with no patient interaction is possible.
Research Gaps and Opportunities	The application of science to public debate The macroeconomic and political context Chemical engineers do not have a monopoly on wisdom and it is essential that the community and the institution engages across boundaries with other disciplines in pursuit of sustainable solutions to the water challenge facing our planet. But we need to think beyond the technical dimensions of these challenges and contribute to the political process, both as informed citizens and by using the platform that IChemE provides to interact with policy makers and opinion formers and the general public. Whilst acknowledging the role played by the market to varying degrees in the different parts of the world where IChemE members practice, the role of legislation cannot be ignored. Evidence based policy making requires active engagement from scientists and engineers. IChemE will speak out on a wide range of policy topics that impact on the health & wellbeing of people and the planet that we inhabit
Comments	see http://www.icheme.org/media_centre/technical_strategy.aspx

Entry ID	**401**
Expanding the opportunities for wise energy systems and use in New Zealand for a future in a changing world	
Summary	This challenge proposes to improve the sustainability of our energy generation through the development of novel, renewable energy technologies. Targets for such research include biofuel production, wind turbines, tidal energy etc. To maximise the benefit from these technologies, they must be implemented at large, inter-connected scales. In order to ensure such wide-spread use, the public must be well-informed and accepting of their benefits. Public engagement is also needed to ensure smarter, more efficient everyday choices are made.
Theme 1 **Smart Technologies - Development of smart technologies to make the best of our renewable energy and respond to variability in supply and demand will help embed the transition to a**	

more sustainable energy landscape.	
Importance to New Zealand	It is expected that climate change and international influences will make for a future marked by instability. To ensure New Zealand continues to function successfully it will be essential to develop technologies that allow the energy infrastructure to continue operating.
Research components	Generation Technologies • This will include developing New Zealand's Primary industry to deliver bio-energy feedstocks efficiently for processing into high value bio-co-products and bio-energy products. • Development and demonstration of efficient generation of transport fuels from biomass using advanced technologies and processes. • Investigating and enhancing co-activities with renewable energy generation. Ie forestry and wind turbines, marine farms and wave energy devices. Distributed Generation • Developing and demonstrating community scale generation and models for ownership and funding such developments. • Developing and implementing technologies to enable connectivity of micro and community scale renewable generation. Storage Technologies and Techniques Storage and speed of response to changes are the solutions to high levels of resilience and renewable energy in energy systems. It is a challenging topic that is gaining a lot of attention world wide. Effective developments in this area will have many benefits for New Zealand not only in terms of greater resilience of our energy infrastructure but also in terms of wealth generation through the development of exportable expertise and technology. There is a need for storage solutions to be at the large grid-connected size and small household size. Electric cars may play a part in this. The other method for greater resilience is to have an energy system that can respond to changes quickly. This will require development of high-tech devices that can sense the need for change and respond appropriately. It is expected that technologies developed in this space will may have the effect of creating paradigm shift in the way energy is generated, transmitted and used. For this reason it is important to not restrict development to trying to pick winners. End Use Technologies Develop end-use technologies that will be able to interact with the energy infrastructure and allow it (the infrastructure) to respond to shock changes. It is expected that some disruptive technologies may be present here and so it is important to keep a wide portfolio of projects in this area. The potential benefits for wealth creation from these developments are high but not as high as developments in storage technologies.

	Alternative methods Transport is our largest energy consumer and one that can be alleviated with alternatives to travel such as use of telecommunications, telepresence, and digital fabrication. Developments and demonstration of technologies and solutions is this area will help socialise the technologies that are already present, increase uptake, and spawn further developments. It is possible that disruptive technologies may be developed in this area.
Theme 2 **Smart Users - The success of a transformed and responsive energy system is dependent on having smart users in the mix. This theme looks at methods for moving New Zealand's energy users towards being informed enough to enable the energy system to operate with maximum effectiveness**	
Importance to New Zealand	It is expected that climate change and international influences will make for a future marked by instability. To ensure New Zealand continues to function successfully it will be essential to develop technologies that allow the energy infrastructure to continue operating.
Research components	Personal Transport • Develop and demonstrate new ways of working to substitute for transport. How would society be better arranges to reduce the need for travel. This can touch on urban design and availability of reliable and effective telecommunications infrastructure to enable more non-transport choices. • Making the choice to not travel easy. Develop and demonstrate ways in which the choice to substitute other activities for travel are an easy and effective solution. • Investigating and demonstrating how an informed user can benefit from smart interactions with the energy infrastructures. Business Transport • Developing and demonstrating ways in which people and good can be moved from one place to another (or not moved) through the use of smart high tech solutions such as telecommunication, telepresence, and digital fabrication. Process Heat Process heat is not a high tech topic area, but methods for enhanced ability to shift loads, store process heat, and use substitute fuels/heat sources will make a large difference to New Zealand's energy infrastructure's resilience. Developing and demonstrating techniques and technologies to enable transitions to these sorts of systems will be valuable to New Zealand and also have the potential to become exportable expertise and products
Theme 3 **Robust Energy Systems - As the effects of climate change begin to intensify the energy systems, society, and international pressures are expected to become more erratic. This theme is focused on ensuring New Zealand's energy systems are able to withstand this**	

variability	
Importance to New Zealand	Without a robust energy system that can withstand the fluctuations and extreme events expected in the future, many of New Zealand's economic activities are at risk, as is the smooth functioning of Society. This work stream will seek to mitigate these risks.
Research components	Smart grids for resilience In the past New Zealand developed some world leading skills in telecommunications. These skills can be re-enlivened to develop world leading technologies in control and connectivity that enhances and accelerates the implementation and effectiveness of smart grids. This is an opportunity to grow exportable skills, expertise, and products. Diversified Energy Portfolio to Protect Against Supply Side Threats This works stream is to look at the best balance of energy sources (and demand side measures) that will work best for New Zealand in a carbon constrained future that is subjected to the extreme events brought about by climate change. It will also look at techniques and technologies to ensure the energy infrastructure remains effective with a high level of renewable energy sources supplying to it. It will also consider the balance of technologies, and fuels, and infrastructure for transport. The Role of Storage in Energy Systems Resilience What technology, where, and how much are three questions that this stream of research will be able to address when looking at how to best stabilise the energy infrastructure. This will also consider the reserves of transport fuel (or other methods) for ensuring New Zealand continues to function despite variations in supply and international effects on fossil fuel imports.

Entry ID	402
An automated, solar-powered, wireless, remote surveillance/data acquisition system. Includes, surveillance, fire- and earthquake-detection and remote access/control. Improves efficiency of managing large remote land areas and optimizes water/energy usage	
Theme 1 **Understanding New Zealand's current and future agricultural, land and coastal management requirements, deficiencies and threats to secure and profitable and sustainable operation. This knowledge is essential for establishing appropriate system features**	
Importance to New Zealand	New Zealand's national security is paramount to the safety of its citizens and assets. Maintaining competitive, environmentally responsible and energy efficient operation of agriculture, is of fundamental importance in feeding the population and represents a significant component of export budget.

<table>
<tr><td>Research components</td><td>Statistical and market research would be necessary for the collation of presently available bodies of knowledge for coastal surveillance, agricultural and land management operating methods, technologies and costs as well as short- and long-term predictions of local and global economic, environmental and technological change, would be necessary in order to determine the required features and potential return on investment for the development of suitable technologies and to understand the implications of not doing so.</td></tr>
<tr><td colspan="2">Theme 2

The results from research and collation of statistical information and market research, would be used to make informed decision with respect to the system features needed. This would ensure that it meets performance, maintainability and cost predictions</td></tr>
<tr><td>Importance to New Zealand</td><td>In order that any effective and economically viable product or system can be developed, an internally consistent and mutually supported marketing plan must be developed, ensuring that it is socially acceptable, technologically achievable, competitive, readily implementable and economically viable. Without embarking on quite significant preliminary research, it would be very difficult to quantify some of the aspects, implications and benefits which this system would encompass.

> For example, what is the value attached to national security?

> What is the value of protecting the lives of the citizens of the country?

> What is value of preserving and maintaining the natural environment?

> How would costs be distributed for insurance payouts and premiums be affected with respect to damages resulting from natural disasters?

> What would be the potential losses in revenue applicable to not maintaining agricultural technological competitiveness?

It is clearly evident by considering these points, that the value and benefit to the country is huge.</td></tr>
<tr><td>Research components</td><td>It is envisaged that owing to the considerable economic and technological investment already being applied to agriculture that this area would occupy centre-stage and would initially necessitate the most extensive research. Sub-divisions in this category would also be necessary, such as size and type of operation, which would include diary, sheep, cropping, wineries, orchards, and others, each with their own unique sets of requirements.

Since the management of national parks and DoC land would not have such predominantly economic interest, this area of research would most probably be focussed on inter-operation with essential services, social acceptability and environmental responsibility.

Coastal surveillance would encompass entirely different areas of focus. Some of these would include border security, search and rescue and fisheries.

Certain aspects of the proposed system would continue to evolve to meet progressive technological developments, additional feature requirements and</td></tr>
</table>

	changing operating methods. It would be appropriate to segment the research into three broad categories, being agriculture, land-management and coastal surveillance. This information could then be collated and used to properly assess an overall development strategy.

Entry ID	**403**
Generating higher revenues, ensuring security of supply, and meeting industry and societal requirements through increased extraction of our geothermal energy, petroleum, mineral and groundwater resources, whilst minimising impacts on the environment	
Summary	This challenge proposes to ensure that our future energy needs are sustainably taken care of. This will require sediment basins within the EEZ to be extensively prospected and quantified, and then developing means to sustainably use the petroleum and mineral resources that they may provide. Other avenues include harnessing geothermal flow to produce energy, and investigating unconventional petroleum sources (coal seam gas etc.). Methods must be developed to use these resources in a way that is environmentally friendly.
Theme 1 **Prospectivity to prosperity - facilitating greater exploration of our extensive Exclusive Economic Zone, so enhancing the discovery of new reserves of petroleum and minerals, leading to significant improvement in the New Zealand economy**	
Importance to New Zealand	Petroleum and minerals are currently among the country's highest export earners. Exploration injects around $1.5 billion a year into the economy and the Government receives over $2 billion a year in royalties, levies and corporate taxes from oil, gas and mining operations. While significant, the income could be much higher. New Zealand has jurisdiction over the fourth largest EEZ and ECS in the world, an area of 5.6 million km^2. This vast area has potential to provide wealth from petroleum and mineral extraction for many generations to come. Exploration activity and success in such frontier areas depends on the availability of good technical information. The main barrier to realising our full geo-resource potential is the lack of detailed knowledge of the structure and characteristics of the 17 frontier sedimentary basins that surround New Zealand, and the value of seabed minerals found along the volcanic arcs to the north and in the deep sea to the northwest and southeast. As there has been only limited mineral exploration onshore, significant potential remains for extraction of precious and base metals. Increased provision of high-quality data and improved understanding of our potential geo-resource endowment through scientific research will help the Government to promote New Zealand as a desirable destination for exploration investment, and to optimise value from licensing and industry activity. Increased activity will lead to discoveries, bringing new revenue flows and a host of spin-off economic benefits nationally and locally.

Research components	1. Frontier offshore basins, and associated petroleum system analysis: The petroleum systems of our frontier basins need to be studied in more detail, both to quantify the resource potential and to attract investment and activity by petroleum exploration companies. The fundamentals of basin structure and evolution need to be complemented by an understanding of the distribution and characteristics of source and reservoir rocks and a semi-quantitative evaluation of petroleum generation, migration and trapping, in order to delineate the most prospective areas for exploration. 2. EEZ minerals: Enhanced knowledge of the origins and extent of alluvial minerals, seafloor massive sulphides, ferromanganese nodules and crusts, and gas hydrates is needed to spur interest by offshore mineral exploration companies, especially in currently unexplored regions such as the Havre Trough and Colville Ridge to the north of New Zealand. 3. Onshore minerals: Enhanced prospectivity of on-land precious metals, particularly gold, silver and platinum group is needed to expand and broaden mining activities and increase the current revenue stream for the government.
Theme 2 **Security of supply – ensuring New Zealand is resilient to global restrictions on the availability of strategic energy and minerals resources**	
Importance to New Zealand	New Zealand is a small country, distant from all hubs of global activity. We are vulnerable to erratic supply or price fluctuations of essential commodities, particularly petroleum and strategic metals. The best way to buffer against this is to establish an indigenous supply of strategic resources, both in terms of volume and variety. Currently, our utilisation of geothermal energy, particularly in terms of the deep and shallow resource is less than optimal, and we have yet to fully explore the potential of unconventional petroleum resources such as coal-seam gas, shale gas and gas hydrates. Realising the full potential of industrial minerals such as clays, zeolites, building stone etc. will have benefits both in terms of import substitution (reducing overseas debt) and developing local industries. Both geothermal and industrial mineral development are of particular interest to Māori, who have governance over many of the richest resources. Supply of strategic metals such as copper and nickel is becoming more critical globally as the demands from 'green energy' technologies (wind turbines, batteries, solar panels etc.) outstrip production and recycling. An indigenous supply of such metals will buffer the country against shortages and price hikes that will inevitably become commonplace in the future. Availability of aggregates for construction is another key reliance issue that has received scant attention to date. Secure supplies of groundwater are also vital to underpin our biological and manufacturing industries, and will be even more so in the future as surface supplies become increasingly in demand for domestic use
Research components	1. Enhancing geothermal use: The extremely high heat flow in central North Island has provided New Zealand with a rare endowment of geothermal energy, which is currently under-utilised. By tapping deeper sources, and better utilising low-temperature resources, a doubling of current electricity generation is considered

	possible. Further research is critical to exploring both these possibilities. 2. Investigating unconventional petroleum sources: Enhanced research into the potential of coal-seam gas, shale gas and methane gas hydrates is needed to establish their future viability. 3. Realising mineral technology opportunities: Processing of New Zealand's diverse and abundant supplies of industrial minerals (clays, zeolites etc.) is required to fully develop their potential as import substitutes, and as the basis for new or enhanced local industries. 4. Ensuring the availability of aggregate supplies: Significant issues around the future availability of aggregate for infrastructure construction (i.e., closure of inner-city and riverine sources) need to be urgently addressed. 5. Determining the availability of strategic metals: New Zealand has some potential for strategic metals, including rare earth elements, which has yet to be fully investigated. 6. Maximising groundwater availability: Although the locations of our major groundwater aquifers are known, there is still a great deal to learn about their detailed plumbing systems.
Theme 3 **Stewardship – minimising environmental impact whilst realising the full benefits of our natural endowment of geothermal energy, petroleum, mineral and groundwater resources**	
Importance to New Zealand	In a competitive world it is in New Zealand's best interest to take advantage of our natural resources with which our nation is well endowed. However, a compromise is required to allow us to use our inventory of geo-resources while preserving the integrity of our other natural assets. New Zealanders have great respect for their natural environment, and the ecosystems that exist within it. In realising the benefits that will arise from increased geo-energy, mineral and groundwater extraction, it is imperative that the impacts on the natural environment are minimised (recognising that there will always be some impacts from such activities). In permitting extraction activities the Government, guided by expert advice, must weigh up the positive impacts (export revenue, jobs, and security) against the negative impacts (impacts on biodiversity, ecosystems, landscapes and the atmosphere). It is vital to understand the true magnitude of the impacts and find ways to mitigate them. Such information is critical if the Government is to develop sound, evidence-based policies and regulations around mining activity, and the industry is to be equipped with appropriate knowledge and tools to deal with regulations, and any issues that may arise. This theme addresses specific side effects of developing key resources, and utilises similar research capability and specialist expertise to that required to delineate the resources
Research components	1. Responsible petroleum development: Investigating ways to mitigate the risks associated with hydraulic fracturing, deep sea drilling, and seismic surveys 2. Responsible mineral development: Investigating ways to mitigate the risks associated with acid mine drainage, marine sediment plumes, and disturbance of

	marine ecosystems 3. Sustainable geothermal development: Investigating ways to mitigate the risks associated with geothermal development, including ground subsidence, reduction of thermal features, reduced biodiversity, and pollution of waterways 4. Balancing the carbon budget: Developing options for carbon sequestration, particularly for enabling the use of giant gas fields with >10% natural CO_2 5. Improving groundwater quality: Investigating the cause and effect of groundwater contamination, and developing appropriate mitigation strategies
Research Gaps and Opportunities	The following initiatives would significantly boost all three goals of this challenge – increasing New Zealand's prosperity, enhancing security of supply, and improving responsible management and public acceptability of extraction operations. 1. More ship-time to explore frontiers and for ecological baseline research: This is a 'big ticket' item, requiring several $M additional each year due to the high cost of research vessels [withheld due to commercial confidentiality]. Our vast EEZ will take many decades to fully explore, but an intensive, targeted effort in the near-term would pay substantial dividends. 2. Enhanced data management: This is a key component for the Government to promote exploration activity. 3. Regional geochemical and geophysical mapping: This is critical for prospectivity assessment on land and near-shore, and has spin-off benefits in agriculture, forestry and regional health. 4. Re-establishment of mineral processing research capability: This is necessary for the development of new mineral technologies. 5. Establishment of a virtual centre (hub) for geo-resources research: This would help to coordinate research activities, which are currently carried out by several different agencies. It would also enhance interaction with consultancies and industry. 6. Research into carbon sequestration: Technically similar to petroleum research, this currently receives little funding, inhibiting development of future gas fields and associated regional industry. 7. Research into unconventional petroleum, aggregates and mineral technology opportunities: These all represent opportunities that are largely un-researched at present. 8. Development of advanced technologies: This is necessary to effectively explore our territory and assess our resources.
Comments	Much of New Zealand's past wealth has been generated from physical resources that lie on or beneath the land's surface or seabed – so-called geo-resources. There is vast potential for even more such wealth generation. For instance, extrapolation of geological understanding of Taranaki Basin, now a significant oil and gas producer, to other basins around New Zealand suggests that, in time, commercial petroleum discoveries there are highly likely. With increased revenues

	from geo-resources, the Government could ease current fiscal constraints and invest more on social programmes (health, welfare, policing, retirement) and in future-proofing the nation via R&D and education, thus enhancing the well-being of all New Zealanders. This challenge is deliberately focused on geological resources to ensure that the research community can address key strategic issues in a coherent way, without being diverted by other essentially disconnected (though important) concerns. If other ‘natural resources’ such as soils, fisheries, and forests were included, established research interconnections, which are well suited to addressing the stated goal may be weakened. The over-arching tenet is to optimise the use of our geo-resources endowment in a systematic, planned way, gathering as much salient technical data as possible, to make well-informed decisions on optimising the exploration and development process. A parallel tenet is that geo-resources can be developed without undue environmental harm. Potential research collaborators include universities (Victoria, Auckland, Otago, Waikato, Canterbury, Massey, Lincoln), NIWA, ESR, Landcare and CRL. The general thrust of the challenge is supported by mineral industry associations Straterra and NZMIA.

Entry ID	**413**
Transforming New Zealand’s energy systems for a sustainable future	
Summary	This challenge proposes to change New Zealand's energy management systems to allow us to better adapt to instances of uncertainty/variability. This will be achieved by increasing our energy-independence and reducing our reliance on foreign fuel imports. This will require the development of 'transitional' technologies and infrastructure, as well as co-opting existing technology/infrastructure for more efficient use. In order for this to be achieved on a national scale, society must be engaged in this 'energy transition'.
Theme 1 **Building energy security and resilience into the whole energy system**	
Importance to New Zealand	The Christchurch earthquakes served to illustrate the inadequacies of New Zealand’s preparedness to respond to a shock change when, for example, compared to the decisive actions of other governments in similar situations (eg the recent natural disasters in Japan and New York). New techniques will be needed to ensure New Zealand can respond more quickly to changes brought about by natural disaster, climate change and external economic and supply perturbations. Not only must processes change to meet to the expectations of society around responses to shock changes/events, but also ensure our energy technologies would be able to handle the increased level of variability expected – physical and economic. One aspect of this is energy security through reduced import of fuels (fossil and

	biofuels), and the growth of domestic production of bio-based transport fuels.
Research components	• Developing a whole-system view of New Zealand's current energy system and changes required for future energy security including: Supply and demand across all forms of energy Sources of energy and carbon intensity Risks associated with specific energy sources, demand changes and potential scenarios • Analysis and prioritisation of energy needs and energy options for crisis management • Identifying opportunities to mitigate key areas of risk Adaptability of technology – what can we do to ensure technology introduced now is going to be resilient or help our resilience? Technical future proofing Reducing our consumption of imported liquid fossil fuels Energy self-sufficiency for New Zealand – economic modelling (ie what does it look like?) and what is the value? What is the risk of New Zealand being outbid for fuel supply? What can we do to mitigate this risk? Is there a social value in having a broader range of transport options? Dealing with rapid response requirements in emergency situations to meet society's expectations Capturing effects of changes through ongoing monitoring
Theme 2 Transitional technologies and infrastructure	
Importance to New Zealand	It is recognised that in order to transition to a more resilient, efficient and sustainable infrastructure for energy supply, energy transmission/transport and energy use, New Zealand needs to build up its capacity in areas that have been eroded or have not been required in the past. It is also recognised that some of the supply chains in New Zealand are constraining our ability to make the transition. There is a need to clearly identify and characterise these internal constraints and come up with solutions and systems that will alleviate them. New Zealand's 'soft' infrastructure of regulations, standards and governance also needs to be appropriate to support transitions in the energy system. This stream also recognises that the electricity grid and other fuel infrastructure can be made more robust while also making it more efficient by reshaping it to include an improved ability to control the channels, route around problems, and include more storage capacity in various forms (including larger transport fuel reserves).
Research components	Drawing on the findings in Theme 1: • an analysis of existing hard and soft infrastructure, its strengths and weaknesses • an analysis of technologies available worldwide and relevant to the New Zealand

	circumstances • identifying areas where existing technology and hard infrastructure already in the system can be put to better use • Identifying areas where alternative technology and new hard and soft infrastructure should be introduced Building up capability to respond to extreme events and perturbations and external pressures How are New Zealand suppliers/supply chains constraining transition? Forming new energy architectures
Theme 3 **Engaging society in the energy transition**	
Importance to New Zealand	At present, energy supply is taken for granted by most of society, and there is little understanding of the trade-offs involved in choices around supply and demand. . At the same time there is widespread concern about fuel and electricity price rises, opposition to new energy developments such as wind farms, and slow uptake of energy efficient technologies and practices. An improved level of societal understanding can help support good decision-making about transforming New Zealand's energy infrastructure to become more resilient and robust. The uptake of household-level supply (e.g. PV) and demand (e.g. electric vehicles) and demand-side management (e.g. home energy management systems) will also require a more informed public and well-trained trades people and retailers. To occur smoothly, the energy transition will involve a better informed public and a cultural change in energy behaviour across much of the New Zealand population.
Research components	• Improve knowledge about current public perceptions, social norms and aspirations relating to energy systems transitions in homes, businesses and transport • Develop communication tools to better engage the public in understanding and having input into the trade-offs relating to future energy choices • Review suitability of trade training to support future energy systems, and develop new training where necessary • Develop community-specific and socially appropriate messaging to support uptake of new energy technologies and practices and lift awareness so that people can see the link between the energy they use, where it comes from, and what the true costs are. • Develop an integrated cross-stakeholder 'energy pathways calculator' for New Zealand which allows different energy supply and demand scenarios to be tested against a range of criteria. • Provide policy-makers and other key agents of change with the necessary (evidence-based) information to stimulate and inform decision-making. Understanding the mechanisms for implementing behaviour change Shifting society's understanding of energy and its scarcity/value (this is using the above 'understanding' research).

	Decision-making skills upgrade for transforming New Zealand infrastructure Crowd sourcing and revolving funds approaches to funding energy initiatives – how would this work?
Theme 4 **Demonstrating alternative energy systems in a carbon constrained world**	
Importance to New Zealand	It is important to demonstrate that comfortable/high-tech solutions that reduce our energy consumption and use/generate energy sustainably do not mean reduced energy services and thus desired qualities of life. It is also about being smart and making better use of technologies (that we have at present) in smart ways to significantly reduce energy for travel or the transport of goods. This stream focuses on demonstration. It is recognised that many of the technologies needed are already present, but they just need to be used in more innovative ways. By prioritising retrofit solutions, using current and emerging technologies, innovative solutions can be rolled out much sooner and more widely than possible if new technologies and solutions are sought.
Research components	• Determining the real energy use of the different elements of New Zealand living • Establishing examples of alternative energy systems that could be applied incrementally and which would work on either a small or large scale • Establishing indices of quality of life, and relating these to energy consumption • Establishing large-scale demonstrations of sustainable energy solutions incorporating household, business, transport and community initiatives A picture of a decarbonised world to demonstrate that a genuinely acceptable standard of living can be maintained. Trial/pilot systems of embedded generation/storage - retrofit a priority
Research Gaps and Opportunities	New Zealand is facing significant current and challenges in the supply and use of energy. These challenges include the economic impacts of fuel prices for national and international transport; greenhouse gas emissions related to electricity generation and energy use, particularly in the transport sector; technical and social challenges of moving to 90% renewable electricity generation; the reliance of New Zealand's transport systems on imported oil; the impact of increasing distributed generation on current distribution networks; the extremely poor thermal comfort of much of New Zealand's housing stock and associated health issues; technical, environmental and safety issues relating to offshore resource exploitation; Treaty issues relating to water and energy resources; and significant challenges in achieving energy efficiency changes in businesses and households. Changes in the global market such as high steel prices, decreasing costs of PV, low coal prices, and high/fluctuating oil prices and carbon pricing are also impacting on the energy sector. Climate change responses and impacts are also likely to exacerbate these challenges. The International Energy Agency has coined the phrase 'energy environmental revolution' to describe the scale of change that it considers is required globally to respond to the combination of climate change and changing availability of energy resources.

	While New Zealand is fortunate in its high proportion of electricity generated from renewable sources, it is likely to face increasing pressure to change from the dominance of fossil fuels as an energy source in sectors such as transport, dairy processing and steel manufacture, or at the very least significantly improve efficiencies. This will bring both predictable and unanticipated challenges for energy markets, government policy and energy consumers. Two existing documents already point to much of the research effort needed. The MoRST Energy Research Roadmap (2006) provides useful and, largely, still relevant pointers to research needs on the supply side. The FRST Demand-Side Research Strategy: A system-wide approach (December 2010) outlines research challenges and needs in the area of energy consumption. The existence of both documents however points to one of the greatest research gaps - an understanding of the entire energy system, both what already is in place and what technologies and capabilities New Zealand will need to bring to bear on energy challenges. For New Zealand to navigate this energy transition successfully, it will need to adopt a coherent, whole-system approach, with multi-disciplinary research contributing to the challenges of transitioning to clean, affordable energy supplies, efficient energy use, and low-carbon transport systems. While much is known in specific technical areas, the key shortfall is in working on a whole (energy) system basis. This National Science Challenge takes this as its starting point. The research required is a sophisticated gap analysis, projects to plug the knowledge gaps identified, and then the development of frameworks encompassing the whole energy system to afford an integrated application of the knowledge.

Entry ID	414
National energy self-sufficiency, defined by a target of net zero fossil-fuel imports into New Zealand	
Summary	The goal of this proposal is to establish national energy self-sufficiency as defined by a target of net zero fossil-fuel imports into New Zealand. The themes include: 1. Optimising Supply - stocktake / projections for indigenous fossil fuel supplies, review strategy to determine best mix of future pathways, consider specific opportunities etc. 2. Optimising Use and Distribution - supply/demand load balancing in electricity sector, explore new more efficient forms of electricity distribution etc. 3. Energy-Efficient Machines and Systems - improving efficiency of high consumption industries, power applications of High Temperature Superconductors 4. Responding to societal trends and preferences - sociological survey of energy use in New Zealand providing better information and informing a strategy for easier and more user-friendly ways to harvest untapped energy efficiency

	improvements and usage, options to reduce transport needs, understand city versus rural requirements etc.
Theme 1 **Optimising Supply**	
Importance to New Zealand	• Maximising the economic value of all New Zealand's natural sources of energy supply • Within this, optimising New Zealand's use of clean renewable sources of energy • Lowering New Zealand's dependence on offshore supply of fossil fuels and the uncertainty and associated risks • Reducing Greenhouse gas emissions in line with Kyoto commitments • Increasing flexibility to serve New Zealand's dispersed population and geography with distributed energy production • Being a global leader and exporter in energy supply technologies • Spill-over benefits in jobs and New Zealand reputation for 100% Pure
Research components	• Stocktake / projections for indigenous fossil fuel supplies, including fuel supplies in the bio and geothermal areas • Review strategy especially access and extension for renewable supplies (hydro, geothermal, wind, wave, tidal, solar, biofuel) to determine best mix of future pathways. • Consider specific opportunities for lignocellulosic biomass, specifically from waste bark from the Forestry industry, and third- and fourth-generation liquid biofuels from algae • Review and develop new and more efficient ways of transport, harvesting New Zealand specific advantages e.g. wind for transport , high urbanisation) • Technologies for clean use of New Zealand's own fossil fuel resources (coal, gas, lignite)
Theme 2 **Optimising Use and Distribution**	
Importance to New Zealand	• Increasing efficiency of existing energy supply, distribution and use • Reducing risk to consumers and businesses of both short and long-term short-term demand and supply variability • Reducing dependence on fossil fuels for transport • Increasing flexibility to serve New Zealand's dispersed population and geography with distributed energy production • Being a global leader and exporter in energy distribution technologies
Research components	• Supply/demand load balancing in electricity sector • Explore new more efficient forms of electricity distribution • Novel energy storage (liquid gaseous, solids) e.g. hydrogen as an energy storage and distribution tool • Electrification of transport and energy storage needs for this • Improved local energy generation and distribution

Theme 3 Energy-Efficient Machines and Systems	
Importance to New Zealand	• Increasing efficiency of our major energy-intensive activities and industries • Reducing the cost of access to advanced technologies and opening up new technologies • Income from major export and supply chain opportunities • Reduced Greenhouse Gas emissions in line with Kyoto commitments
Research components	• Improving efficiency of high consumption industries • Power applications of High Temperature Superconductors • New building design enabling better usage of residential energy use • More efficient agriculture & dairy infrastructure • Reduction of greenhouse gas emissions in industrial, residential and dairy energy use • Appropriate incentives to encourage change
Theme 4 Responding to societal trends and preferences	
Importance to New Zealand	• Understanding the shifting global context within which the previous themes sit and in particular, the impact on New Zealand • Understanding the opportunities of, and how to use, new global technologies that support the previous themes • Understanding New Zealand's own demographic drivers
Research components	• Sociological survey of energy use in New Zealand providing better information and informing a strategy for easier and more user friendly ways to harvest untapped energy efficiency improvements and usage • Exploration of Tele-working technology, cloud data sharing to reduce transport needs • Understand city versus rural requirements and how to target both groups with specific strategies (public transport, local energy generation and use) • Survey of impact of an aging and growing population of energy use patterns and improvement opportunities
Research Gaps and Opportunities	Numerous – investment in energy research is a very small proportion of government supported research investment and has generally declined during a long period of low global oil prices in the past 20 years. Other countries such as Brazil invest much more.
Comments	In order to achieve this objective the general population must be educated about the advantages and acceptance of new technologies e.g. biofuels. This will require a media campaign by the government and education in schools and the general public to raise awareness. Outreach activities from scientists working in this area should be encouraged to achieve this. Only when the public are educated will they support government to invest more into these new technologies.

Entry ID	432
Energy Transformed — Fostering an Energy Transition for New Zealand - To make New Zealand energy supply 100% renewable by 2030	
Summary	This challenge proposes to achieve 100% energy self-sufficiency. Avenues for research include renewable energy sources such as wind/solar/tidal/geothermal etc., developing biofuels for transport, improving energy-use throughout industry, and improving energy use throughout the household. This will require existing technology to be co-opted, and new technologies to be developed.
Theme 1 **Electricity Supply**	
Importance to New Zealand	The New Zealand electricity supply currently (2011) gets 76.7% of its supply in GWh from renewable generation. In the past it has been up to 91.4% from renewable generation (1980). Getting close to 100% should not be a large problem but there will be issues coordinating storage and transmission especially with regards to incorporating large amounts of intermittent sources such as wind and solar. Critical research components will include investigating and optimising the use of: wind energy; solar energy; tidal flows and other marine energy; geothermal energy; and biomass. There will also be a need for significant grid integration and modelling studies
Theme 2 **Transport**	
Importance to New Zealand	The use and integration of electric vehicles, biofuels and public transportation needs to be considered in a full systems context.
Theme 3 **Energy in Industry**	
Importance to New Zealand	Energy efficiency in industry, and seeking alternatives for coal in steel & concrete making would be among the foremost priorities.
Theme 4 - Energy in Households **Theme 5 - Energy Linkages**	
Research components	Theme 4 — Energy in Households This Theme encompasses a suite of inter-related components including: Passive solar house design; urban design; Healthy indoor environment; Insulation and energy efficient appliances; and PV for rooftops as retrofits and as building integrated Theme 5 — Energy Linkages This Theme would look to maximise the connections of the activity in the above Themes with other Challenges such as in Climate Change, Sustainably Profitable Primary Industries and High Value Manufacturing. It would also involve national

	energy modelling and linkages internationally.
Comments	The University of Otago has worked with the National Energy Research Institute (NERI) in developing its submission and support the framework they have provided.

Entry ID	**447**
Energy and the Environment	
Summary	This challenge proposes research into energy and environmental issues, leading to low emission industrial processes, new forms of energy generation, with improved energy security and improved natural resource utilisation and management. Research themes will focus on developing systems which best utilise New Zealand's renewable energy stocks (i.e. wind, tidal, biological), exploring novel options for energy production (such as the use of gas hydrates), developing waste-to-energy systems that maximise production efficiency, and developing transmission/distribution systems which maximise overall energy efficiency (with both industrial/domestic application). Long term strategic pathways will need to be devised to ensure that New Zealand migrates to these new energy systems with the least risk
Importance to New Zealand	If New Zealand is to achieve its ambitions to build a stronger manufacturing base, we will require a reduced reliance on imported energy both in direct products (e.g. oil) and indirect energy forms (such as plastics for secondary processing). In addition, the attraction of international investment into New Zealand will require presentation of a special value proposition to those investors. A reliable, secure, low cost (relatively) and green energy situation in New Zealand is a major catalyst to securing such investment and enabling New Zealand manufacturing industries to grow and be internationally competitive. Successful outcomes will lead to: • Increased growth in New Zealand's manufacturing base. • New investment realised to support the above. • Greater productivity within our manufacturing industries. • New industries based on energy and industrial products and related ICT and similar systems – including new energy crops that do not compete with food. • Enhanced environment. • Spill-over benefits notable in new, sustainable transport options.
Theme 1 **Renewable Energy – Realise the potential of New Zealand's natural energy systems**	
Importance	Exposure to world-wide energy resource depletion and unmanaged exploitation of

to New Zealand	New Zealand renewable energy resources mitigates against growth of manufacturing capability in New Zealand and its need for lowest cost and reliable energy without compromising the environment. Should we address this then we could expect to achieve the following benefits: • An internationally competitive manufacturing industry in New Zealand. • Attraction of green investment to New Zealand to support growth of our industrial base. • Expansion of new products and export value creation.
Research components	• Develop systems that permit better exploitation of New Zealand's renewable energy stocks and overcome barriers to uptake (e.g. distributed biological resources). • Explore options to utilise not yet commercial opportunities for energy production, such as use of hydrates. Wind, tidal, geothermal, biological, other energy system (e.g. hydrates).
Theme 2 **Develop processing systems with the lowest energy per unit product capacity**	
Research components	• Develop waste-to-energy options to maximise production efficiency and lower embedded energy component in manufactured products. • Develop new symbiotic energy systems to reduce energy and environmental impact, e.g. geothermal – wood waste combinations, production of low grade energy on site to reduce diesel in stationary energy systems. Waste-to-energy processing systems; Closed cycle processing; Multi energy (symbiotic) systems
Theme 3 **Distribution and transmission systems that reduces losses and optimises utility and distributed needs**	
Research components	Develop expert systems that maximise utilisation, reduce losses, and meet New Zealand's distributed use needs. • Develop transmission and distribution systems to minimise losses and maximise overall energy efficiency - over industrial and domestic applications. • Develop long-term strategic pathways for New Zealand to migrate to new energy systems with least risk. Resource management; Transmission; Distributed energy systems

Entry ID	457
Energy Futures: The challenge to New Zealand is to ensure that energy sources are optimally utilised to meet the nation's unique needs for the next 50 years in the context of its resources and environment	
Summary	This challenge proposes to develop energy management strategies/methods to ensure that energy sources are optimally utilised heading into the future. Renewable energy capacity can be generated by developing enhanced methods of energy storage, and by using building materials to function as energy sources (i.e. constructing roofs with solar energy capacity). New Zealand's infrastructure can also be engineered to maximise efficiency, i.e. by integrating renewable energy systems into the national-grid, using better material for housing insulation. New, smart-technologies must be developed that replace our reliance on imported fossil fuels.
Theme 1 **Renewable Energy - To build renewable energy capacity**	
Importance to New Zealand	New Zealand has a stated goal of supplying 90% of its energy needs with renewables by 2025 [Renewable Energy Policy Network for the 21st Century, www.ren21.net]. Although New Zealand has a good head start in that 60% of its energy needs are currently renewable, achieving 90% is a lofty goal that can only be achieved by sound science and innovative engineering. No country in the world has come close to this level, despite huge investment in some cases.
Research components	(1) Development of methods of energy storage, e.g. projects recently undertaken by IRL. (2) Using building materials to function as energy source. Constructing roofing systems with photovoltaic material is now technically feasible, viz. EnaSolar, Christchurch (http://www.enasolar.net)
Theme 2 **Energy Efficiency - To engineer New Zealand's infrastructure for energy efficiency**	
Importance to New Zealand	Electric power generation from renewable sources will remain the cornerstone of New Zealand's economy and living standard. New Zealand must lead the world in optimal utilization of this resource with distributed generation, low-loss transmission systems, efficient converters, etc. New Zealand's largest source of export income is primary produce. Generating and distributing these products requires considerable energy input (in addition to the inherent input of solar energy into the growing process). New ways must be found to reduce the energy budget by substituting fossil fuels with renewable sources of energy, by seeking less energy-intensive methods and by developing crops and products which require less energy to produce.
Research components	(1) Integration of renewable energy into the national energy supply network, e.g. Green Grid project, University of Canterbury. (2) Development of low-loss transmission systems and efficient converters.

	(3) Energy auditing of transport in all sectors including behaviour patterns and freight logistics.
Theme 3 **Smart energy technologies - To develop smart products and materials related to energy**	
Importance to New Zealand	Smart products can play a role throughout the 'energy landscape'. For example, the smart application of water can conserve energy (ground water sensors, better local climate forecasting, and close monitoring of growth). Well-designed buildings can maximise the use of natural light and solar energy, with smart electronics and low energy actuators employed to control the lighting and ventilation of living and working spaces. The challenge here is to make the new smart products in these areas affordable, reliable and desirable. It is inevitable that digital technology will play an ever increasing role in these developments, yet the overhead in electric power for the electronics and bandwidth for the communications device-to-device must be tiny to justify their use. Thus the development of new materials, new devices and new clever processing methods all play a part in lowering the overall energy budget.
Research components	(1) Use of organic material (e.g. use of nano particles to capture and improve system of solar cells). (2) Use of better insulating material (to save energy). (3) Developing lower power electronics, so that the smart devices controlling energy usage are themselves very power efficient.
Comments	UC believes energy is a major challenge for New Zealand, and UC has significant research strengths in the area, notably the Electrical Power Engineering Centre (EPECentre), geothermal research, and relevant materials, social and economic research. Our experts were already too committed to prepare a detailed submission, but we have made some contribution to the submission by the National Energy Research Institute (NERI), and UC supports their submission. Theme 1 - We have lots in common with our Pacific neighbours, not least in sharing a substantial population of people from Pacifica. The tiny economies of some Pacific states make them extremely vulnerable to international changes in the cost of fuels to run their homes, transport and businesses. New Zealand is well equipped to assist these states in achieving a much reduced reliance on expensive imported fuel. Theme 2 - There is a real opportunity for New Zealand to become a world leader in this area, but only for a very short time. One limitation with energy infrastructure projects is that nobody wants them ‘in their backyard’; care must be taken to integrate infrastructure in ways that minimizes environmental impact. Theme 3 - The use of smart products is relatively easy to introduce to New Zealanders, who are world leaders in adopting new technology.

Entry ID	471
Energy in New Zealand	
Summary	This challenge proposes to develop a wide array of innovative, manufactured and exportable technologies which combat/offset the negative impacts of continuing global increases in energy consumption. These technologies will be designed with the goal of achieving a renewable energy target of 95%, and a 15% improvement in energy efficiency. Areas of research include: Investigating tidal, wind, geothermal energy (and associated technologies for implementation), alternative fuel use, development of electrical grid technologies, and measurement and reduction of agricultural emissions.

Entry ID	477
Energy Self-Sufficiency **New Zealand to be 100% self- sufficient in energy**	
Summary	This challenge proposes to ensure that our future energy needs are sustainably taken care of. This will require sediment basins within the EEZ to be extensively prospected and quantified, and then developing means to sustainably use the petroleum and mineral resources that they may provide. Renewable forms of electricity generation should be concurrently developed, and integrated with existing forms over-time. Eventually, wholly renewable electricity generation should predominate (and replace) energy generated from extractable resources (i.e. petroleum based).
Theme 1 **Understanding current and future energy needs and supply for domestic consumption and export**	
Importance to New Zealand	Baseline and projections for energy use established over 100 year timeframe and updates every 10 years to measure progress against
Research components	5.1.1 Identifying ways of achieving 100% renewable electricity by ensuring energy conservation, and security and affordability of supply, and leveraging Smart Grid technologies towards efficiency and export potential. 5.1.2 Developing decision and response frameworks for sustainable extraction of onshore and offshore energy sources.
Theme 2 **Evidence-based decision-making to choose the appropriate generation mix for electricity and the extraction pathway for sustainable energy wealth**	
Importance to New Zealand	Ratio of energy supplied from extractable and renewable resources trends towards renewable over time

Research components	5.2.1 Identifying ways of achieving 100% renewable electricity by ensuring energy conservation, and security and affordability of supply, and leveraging Smart Grid technologies towards efficiency and export potential. 5.2.2 Developing decision and response frameworks for sustainable extraction of onshore and offshore energy sources.
Theme 3 **Managing the opportunities and risks from sustainable energy decisions and development to ensure a security of energy supply**	
Importance to New Zealand	New Zealand becomes a net exporter of energy by 2050 (or similar)
Research components	5.3.1 Developing innovative technologies to improve energy generation and extraction 5.3.2 Developing a regulatory and risk management environment to facilitate market participation by a range of producers, and manage energy production, storage and transmission in ways that are environmentally and socially sound. 5.3.3 Designing tools to ensure the transition of electrification of transport energy and the development of the 100% renewable electricity supply
Research Gaps and Opportunities	This will ensure compliance with the 100% green brand for New Zealand domestic electricity usage, ensure our economic security by removing dependence of energy imports and pave the way for New Zealand to generate wealth by becoming an energy exporting nation.

3 Reducing Waste

The submissions in this group are shown with their underpinning themes in the table below. Each submission follows in full.

Table 3: Summary of proposed challenges and themes

Entry Id	Challenge	Themes
53	To eliminate the landfills in New Zealand and make New Zealand 100% pure.	1. Reduction of the non-recyclables into the land fills
57	To extract value from problematic organic waste streams, specifically farm dairy effluent. Generation of distributed renewable electricity whilst simultaneously and responsibly managing the negative environmental impacts of intensification of agriculture.	1. Optimisation and commercialisation of core technology. Understanding the technical application of the core technology (anaerobic digestion) in specific New Zealandapplications. Making the core technology practically and economically viable 2. Application and integration of widespread distributed renewable energy generation across regional New Zealand 3. Understanding the secondary environmental impacts of anaerobic digestion technology 4. Understanding of the wider implications of the application of anaerobic digestion technology on New Zealand's international trade and citizenship
281	How do we get smart about waste reduction	1. Direct Waste Re-use 2. Indirect Waste Re-use 3. Gathering Waste 4. Mining landfills for the future
303	Reduction of waste plastic to landfill. Currently, there is a large component of waste plastic that cannot be recycled as it is poor quality or previously recycled. Technology is available to address this problem using plastic to diesel technology.	1. Waste reduction 2. Waste to diesel energy

Entry ID	53
To eliminate the landfills in New Zealand and make New Zealand100% pure	
Summary	Reduction of non-recyclables into landfills. Landfills are old technology and New Zealand landfills receive 1.6 million tonnes/year. Proposes to research (and

	introduce) the best current technologies for land fills
Theme 1 **Reduction of the non-recyclables into the land fills**	
Importance to New Zealand	Clean, Green Environment. As we know landfill is a very old technology to dispose of the waste of many kinds. At the moment New Zealand landfills 1.6 million tonnes per year. The figure is huge compared to the population in New Zealand. The theme 1 is important for New Zealand because in 20 years' time we will be living on the rubbish dump. Think again.
Research components	To research and introduce the best available current technologies and implement them.
Research Gaps and Opportunities	There is no clear understanding of the new technologies in New Zealand in respect to cleaning the landfills. The total awareness and research will contribute to the physical work to clean New Zealand from rubbish dumps and landfills. New Zealand is limited with its land and it is very important to stop and look around, before it's too late. New Zealand needs to spend more time on implementation not research. It is a gap in research when new technologies are arising - the resistance is politically driven, therefore any research in that matter would be stalled on purpose.
Comments	Please be aware that sooner or later we will come back to that topic, but we afraid it will be too late to change. We are an environmental alliance and possess the best technologies available and ready to stand next to the Council and develop a feasible, comprehensive, environmentally friendly system to clean existing and new landfills from pollution of soil, fresh water, and air.

Entry ID	**57**
To extract value from problematic organic waste streams, specifically farm dairy effluent. Generation of distributed renewable electricity whilst simultaneously and responsibly managing the negative environmental impacts of intensification of agriculture	
Summary	This challenge proposes to develop anaerobic-digestion technology, which will require the identification of microbial species that are key to the anaerobic-digestion process, and then designing a practical device to efficiently employ these microbes in real-world applications. Whilst such technology will help to treat problematic organic wastes, it may also have significant secondary benefits (nutrient re-cycling for agriculture, reducing greenhouse gas emissions). The net benefit of such technology is the re-enforcement of New Zealand's 'clean, green' image, which provides further opportunity for capitalisation.

Theme 1 **Optimisation and commercialisation of core technology. Understanding the technical application of the core technology (anaerobic digestion) in specific New Zealand applications. Making the core technology practically and economically viable**	
Importance to New Zealand	It is critical that the core technology of anaerobic digestion be comprehensively researched and understood such that it can be applied to specific New Zealand systems e.g. Dairy or municipal waste. Much understanding of the technology exists abroad and it is important that New Zealand finds a way of applying it to our unique situations.
Research components	1. Comprehension of the variation of component nature of organic waste streams both across and within specific industries. 2. Comprehension leading to exploitation of the micro biological environments and species (population and diversity) that are core to the function of anaerobic digestion systems. 3. Understanding of the physical design requirements to enable practical real world application of anaerobic digestion technology to specific New Zealand application e.g. dairy farming. 4. Understanding of the commercial barriers for investment in anaerobic digestion technology such that the barriers can be addressed as appropriate to enable industry uptake of said technology.
Theme 2 **Application and integration of widespread distributed renewable energy generation across regional New Zealand**	
Importance to New Zealand	Widespread renewable energy generation from nationally distributed sources of organic waste would significantly alter the dynamics and improve the efficiency of the national electricity grid, contributing to lower energy prices and greater security of supply of energy nationwide. It will also reduce the demand on capital for centralised power generation schemes and align with current policy for 90% renewable energy by 2020.
Research components	1. Researching how widespread integration of distributed generation will affect the structural integrity (capital requirements and security of supply) of the national electricity grid. 2. Researching how widespread integration of distributed generation will affect electricity prices.
Theme 3 **Understanding the secondary environmental impacts of anaerobic digestion technology**	
Importance to New Zealand	There are many, and significant, secondary environmental impacts of anaerobic digestion technology i.e. efficient recycling of nutrients in agriculture, reduction in contamination of waterways specifically Nitrogen, reduction in greenhouse gas emissions (both as a direct result of the application of the technology and the offset of renewable energy generation). These impacts are critical in maintaining

	New Zealand's pristine environment and 100% pure clean green image.
Research components	1. Assessment of greenhouse gas emissions reductions 2. Assessment of efficacy of nutrient recycling and subsequent improvement in agricultural efficiency 3. Assessment of reduction of pollution of waterways
Theme 4 **Understanding of the wider implications of the application of anaerobic digestion technology on New Zealand's international trade and citizenship**	
Importance to New Zealand	New Zealand is perceived internationally to be a clean green country with high environmental standards and high quality primary industry exports; indeed this is what a large portion of our economy is built on. It is therefore critical that New Zealand (as the farm of the world) continues to be world leaders in quality food production whilst maintaining our pristine environment such that international markets will continue to pay premium prices for our high value produce.
Research components	1. Methods of maintaining and capitalising on the international market perception of New Zealand's clean green image, specifically with regards to our dairy sector, i.e. showing the world that we are evolving and producing food responsibly. 2. Changing the perception of New Zealand farmers from intensive polluters to highly valued export earners who protect the environment and generate e.g. 33% of the nation’s energy requirements.
Research Gaps and Opportunities	1. Comprehensive understanding of how the core technology (which is widespread throughout Europe) can be applied to the New Zealand agricultural sector. Specifically understanding the key differences in farming practices and how they impact application the technology. 2. An understanding of the economic value for an individual farmer of mitigating pollution of waterways as a national problem. 3. An understanding of the economic value of the reduction of greenhouse gas emissions in the agriculture sector 4. An understanding of the economic effects widespread distributed electricity generation 5. An understanding of the wider social and market effects of applying environmentally responsible agricultural practices to New Zealand primary industries
Comments	The New Zealand dairy industry (and wider agriculture) require a solution to the omnipresent problem of effluent disposal from an ever intensifying sector. Anaerobic digestion not only provides the solution to mitigate the environmental impacts but also an opportunity to extract significant value in the form of distributed renewable electricity. Development and application of this technology is a necessity for the future survival of agriculture of New Zealand and hence the survival of our most important economic sector.

Entry ID	281
How do we get smart about waste reduction	
Summary	Direct waste re-use. Develop technologies to efficiently and cheaply clean waste (esp. glass) for reuse. Indirect waste re-use: Many of the waste materials New Zealand exports can be turned into raw materials for other processes. Identify techniques and technologies to collect waste materials and transfer them to appropriate point where they can be reused. Preparing for mining landfills in the future:
Theme 1 **Direct waste re-use**	
Importance to New Zealand	New Zealand exports large amounts of its waste, which could otherwise be easily reused in this country. Doing this would reduce greenhouse gases, and also be a more responsible way of acting.
Research components	Developing technologies to efficiently and cheaply clean waste materials (esp. glass) for reuse. Understand the behaviours and their source that suggests people do not want to re-use materials. Develop methods for changing this behaviour. Demonstration pilots.
Theme 2 **Indirect waste re-use**	
Importance to New Zealand	Many of the waste materials New Zealand exports can be used turned into new raw materials for other processes thereby reducing the embodied energy and emissions associated with the new product produced.
Research components	What are the barriers to re-using materials as a raw feedstock? Technological, societal, etc. Develop techniques for overcoming these barriers. Develop new products and technologies to re-use waste materials as a feed stock. Demonstrations.
Theme 3 **Gathering waste**	
Importance to New Zealand	One of the major barriers cited by industry is the cost of collecting waste materials. The waste material was distributed as a new product and so it cannot be that hard to gather it back up in a similar method. This theme looks at techniques and technologies to collect waste materials and transfer them to the appropriate point where it can be reused, etc.
Research components	Understanding the psychology of disposal and how it can be changed to ensure disposal is carried out in a way that is efficient for enabling reuse of the water materials. Developing techniques and technologies for collecting waste materials. Developing techniques and technologies for returning waste materials to where they can be re-used appropriately.

Theme 4 Mining landfills for the future	
Importance to New Zealand	For those materials that simply cannot be re-used today there may be an opportunity for reuse in the future when technologies have changed. There is an opportunity now to make sure that those things that are being disposed are disposed of in such a way that does not make it hard for future generations to make use of them.
Research components	Developing strategies for landfilling with future mining in mind. Understanding the risks and mitigation measures associated with storing concentrated collections of whatever chemicals, components, or materials may be required in future in one place for potential future reuse. Demonstrations

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Reduction of waste plastic to landfill. Currently, there is a large component of waste plastic that cannot be recycled as it is poor quality or previously recycled. Technology is available to address this problem using plastic to diesel technology	
Summary	Waste reduction: This challenge proposes the investigation of the potential for conversion of plastics (and other waste materials) to diesel at a scale that is economically viable by developing high and low quality diesel products.
Theme 1 Waste reduction	
Importance to New Zealand	The theme is important to New Zealand as we have a huge reliance on landfill disposal for waste. New Zealand has a finite land area, landfills are a waste of a production resource. Plastic waste is a problem in New Zealand and there is a large portion of plastic waste that cannot be recycled. This is due to the quality of the plastic or that the plastic has previously been recycled. The theme would reduce waste to landfill and also contribute to the New Zealand's energy budget by providing diesel energy from the waste plastic.
Research components	Engineering to complete the technology. Plastic to diesel technology is widely known, but the technology has not yet been proven at a scale that is economically feasible. Neither is the quality of the diesel known and therefore the usage of product. By investing in the technology to make the plastic to diesel conversion economically feasible there are two options, make the technology available to all recycling centres to use the plastic to diesel technology on site. The second option is to make the technology feasible so that plastic can be imported from other centres and processed into a high quality diesel product. The end quality of the product affects feasibility of the project as the end use of the product would affect the value. If the process results in a high quality product, then potentially the project is higher value. If the product is lower quality then it

	will be less valuable and uses of the product may require more investigation.
Theme 2 **Waste to diesel energy**	
Importance to New Zealand	Waste to energy is a good use of resources. Residual waste in New Zealand is disposed of to landfill. This is a waste of two resources, firstly the land resource that is tied up in the landfill, the second is the waste of the resource that is being disposed of
Research components	Waste to diesel energy would be a huge boost to the country's energy budget as well as a use of wasted resource.
Research Gaps and Opportunities	Research gaps include feasibility of the plastic to diesel conversion technology. Quality of the end product of the diesel. Uses of the end product and feasibility of a large scale conversion plant.