# New Zealand's EnergyScape™

2000 2005 2030 2050

## Research Prioritisation Tool Development

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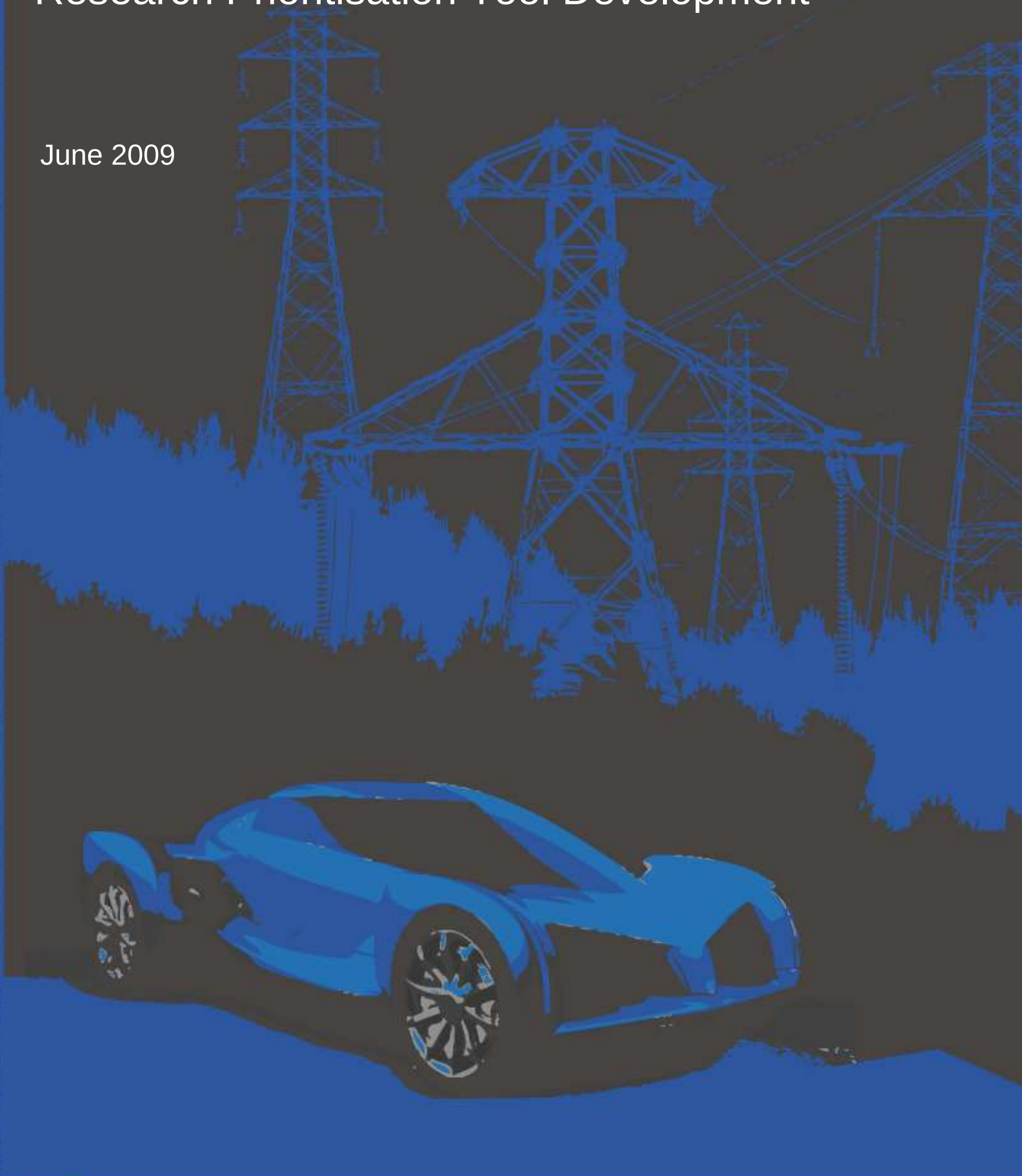



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# Research Prioritisation Tool Development

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# TABLE OF CONTENTS

# 1. INTRODUCTION

The EnergyScape suite of projects that were commissioned by the Foundation for Research, Science and Technology (FRST) in 2007 aspired to provide energy researchers and government with a more complete and holistic interpretation of the New Zealand energy system. In support of this aspiration, FRST encouraged the EnergyScape team to develop a New Zealand energy research strategy. Developing such a strategy is inherently difficult considering that:

- National energy objectives[1] are not straight-forward
- National energy research strategy development is policy-driven i.e. a government activity
- Strategy is often confused with prioritisation
- New Zealand does not have a rigorous methodology for prioritising research

In light of the above considerations, the EnergyScape team recognised that the most constructive way to support the development of an energy research strategy would be to:

a) Develop a research prioritisation tool, and

b) Comment upon the current New Zealand energy research strategy from an 'energy researcher' perspective.

This report discusses the development and verification of a weighted-score matrix which the EnergyScape team developed in order to provide commentary on the broader energy research strategy. The report begins by considering the context and criteria that should be included in a research prioritisation tool, and then describes the workshop that was undertaken to verify the functionality of the tool.

Commentary on the New Zealand energy research strategy itself, from an 'energy researcher' perspective, is provided in the "Energy Research Strategy Commentary" report (AKL-2009-007).

[1] As defined in the "New Zealand Energy Strategy to 2050" (2008).

# 2. ROLE OF ENERGYSCAPE IN ENERGY STRATEGY DEVELOPMENT

The EnergyScape project is a collaborative research initiative that seeks to develop tools that can support energy policy development by considering the impact of integrated solutions for the long-term time horizon, at a regional level on a broad range of social parameters. To achieve this aim, the project generated three types of deliverable, namely:

1. A series of linked *analysis tools* (the EnergyScape framework) which can unify economic data, energy data, system assumptions and facilitate improved understanding of the complexities and dependencies of: resource depletion, energy substitution, transmission costs, conversion efficiencies, locality effects, scale, demand controls, environmental impact (on land, water and the atmosphere) and risk. The analysis tools include: the New Zealand Energy Asset Database; the New Zealand Energy Demand Database; a LEAP model of the New Zealand energy system from 2000 to 2050 complete with supporting interface and visualisation tools.

2. A compilation of New Zealand energy resource and asset knowledge into analysis documents which could be understood by an interested audience[2].

3. Supporting the advancement of the New Zealand energy research strategy through the development of a prioritisation tool (this report), and commentary in the “Energy Research Strategy Commentary” report.

It is well known that the ultimate responsibility for the development of national energy research strategies rests firmly in the domain of the Ministry of Research, Science and Technology (MoRST). Developing such a document is a difficult and controversial task, which requires input from a wide range of stakeholders.

The EnergyScape research team might be considered a key stakeholder in the next revision of the energy research strategy based on: their completion of a recent, significant stock-take of the New Zealand energy system; their representation of a large sector of the energy research community; and their exchange of ideas between industry and government regarding energy system directions.

The EnergyScape team considered that the most appropriate way to support the next revision of the energy research strategy, was by developing a research prioritisation tool, and providing commentary upon the current New Zealand energy research strategy from an ‘energy researcher’ perspective.

[2] Capable of being read by the interested public i.e. those with some familiarity with energy system concepts.

# 3. DEVELOPMENT OF A PRIORITISATION TOOL

Developing a strategy for national publically funded energy research is a difficult and controversial task. The task involves codifying the full range of research options so that they can be considered against numerous cross-cutting criteria. The resulting priorities are highly dependent upon the consensus opinion regarding how research can influence the national risks, opportunities and objectives. And then of course, the prioritised schedule of research must be traded against the available funding. In addition, it would be desirable if the development of the research strategy could provide a mechanism for a wide range of stakeholders (including research providers) to input into the prioritisation process.

To assist this difficult process, the EnergyScape team have developed a research prioritisation tool based loosely on the methodologies deployed within the EnergyScape research programme, to gather systems knowledge, spanning supply, distribution and demand, into a common reporting and analysis framework. It was observed that one of the benefits of this framework was the ability to consider a diversity of knowledge in the context of the whole system. It was suggested that something similar to this knowledge framework process may be useful for understanding the spectrum of opportunities existing within the energy research field.

Considering that the EnergyScape project was only trialling a prospective prioritisation support tool, its development process only involved preliminary discussions with stakeholders and an abbreviated literature review. Although different literature and different commentators had different emphases, the underlying **key principles** of energy research prioritisation were surprisingly universal. Our interpretation of these principles was:

A. Research should fill knowledge gaps or lead to innovation (i.e. fill need rather than fill research capacity).

B. Research should not be limited to technologies; market structures, environmental / economic and social impacts are equally relevant.

C. Research should fit within the strategic vision for New Zealand's energy system.

D. Research outcomes should carry unique New Zealand advantages.

E. Research outcomes should have sufficient value to more than offset research investments.

The literature indicated several methodologies for applying these principles into a semi-quantitative mechanism for prioritising energy research streams. A common and relatively easy methodology that appeared to have inherent merit was the "weighted-scoring matrix" methodology. This methodology could readily generate a prioritisation list that could be subjected to sensitivity analysis and segregated by research class. Since this methodology was in keeping with the EnergyScape philosophy, NIWA developed a sample research prioritisation matrix (see Appendix C) to illustrate how the prioritisation could be achieved.

The next section provides a description of all the criteria fields that were developed in order to define and rank research opportunities.

# 4. PRIORITISATION TOOL CRITERIA

The first few columns in the example matrix describe the nature of the proposed research stream including which research providers are recognised in the field and the status of both domestic and international research. The colour indications in these columns categorise the **status** of this research, namely:

- □ Clear – indicating 'fair knowledge', and therefore of lower priority.
- ■ Green - indicating there was 'potential opportunity' from greater knowledge.
- ■ Amber - indicating that knowledge 'could improve' and thereby yield opportunity / innovation.
- ■ Red - indicates that a 'knowledge gap exists' and definitely warrants consideration under the value test.

The **form of research** field indentifies how applied the proposed research string is. The following forms of research are recognised:

A. Blue skies – research is breaking new ground in previously unconsidered areas (cf. Marsden research fund).

B. Fundamental enabling – research that fills knowledge / skills gaps and indentifies opportunities using new or novel methodologies. Often this research is too broad or costly to be undertaken by the private sector, hence, is generally funded for the public good (e.g. Votes RS&T).

C. Applied - research that fills knowledge gaps and indentifies opportunities using recognised methodologies. This type of research often attracts both private sector and public sector funding.

D. Demonstration – research that demonstrates or trials 'new for New Zealand' technologies, informs potential end-users and enables enhanced uptake of products. This type of research often attracts both private sector and public sector funding.

E. Commercialisation - research that develops trialled technologies or intellectual property into marketable commodities. This type of research is dominated by the private sector often with support funding from the public sector.

F. Monitoring and systems – research that contributes to improved understanding of resources and systems. Most monitoring is undertaken by government agencies, and some systems research is supported by the public sector.

The **justification category** field broadly defines the rationale for funding of the research string. Many of the categories selected reflect research categories defined by MoRST:

**Table 1 – Research justification categories**

| | |
|---|---|
| Innovation (Niche / commercial opportunity) | The value of the research results from the international commercial or intellectual property value that may result from developing this particular expertise or knowledge in New Zealand. |
| Focus now | Research which, undertaken now, could have immediate benefit for New Zealand. In 2006, MoRST identified the following areas as 'focus now':<br>▪ Increasing renewable resources; geothermal, wind, marine, and bioenergy,<br>▪ Reducing energy use and improving efficiency,<br>▪ Understanding oil and gas formation processes and geological opportunities for carbon storage,<br>▪ Developing smart integrated electricity grids for distributed and variable energy sources. |
| New Zealand Lead (Ongoing) | Research that can only be, or is best, undertaken in New Zealand. Research that must be carried out in New Zealand to reflect our unique energy resources or energy uses. And, research that continues to identify market / technology trends in the context of national needs and continues to fill-in knowledge gaps that are required to support research prioritisation. An example of this type of research would be annual / bi-annual update of 'fast adaptor' technologies. |
| Critical capacities | Research that is essential to New Zealand achieving national aspirations. This justification category can be used to support 'capacity building'. In 2006, MoRST identified the following critical energy research capabilities that were not 'focus now':<br>▪ New energy source and carrier technologies<br>▪ Economic and whole-system modelling<br>▪ Acceleration of uptake and behavioural change for efficiency and energy/growth decoupling |
| Emerging opportunities | Research that links New Zealand with new and emerging energy developments overseas so that their relevance for New Zealand can be evaluated (MoRST, 2006). This justification category can be used to support ongoing 'fast adaptor' studies and 'international connectedness' work. |
| Diffusion | Research that supports the uptake of 'new technologies'. |
| System enhancements | The system enhancements needed to ensure that research contributes effectively are (MoRST, 2006):<br>▪ Enhanced coordination in research areas where capability is dispersed across research institutions and across different disciplines and technology options;<br>▪ Effective connections developed with overseas research teams and international initiatives, especially in those areas where New Zealand will be adopting or adapting technologies developed internationally; and<br>▪ Research capability is strongly linked with industry partners where appropriate, to ensure research is relevant to industry needs and stimulates industry investment in technology development and implementation activities. |

The **cost and duration** columns should provide research funders with a rough indication of the magnitude and duration of required funding. The cost and timeframes associated with each research stream are "indicative only", and not taken into account in the weighted result score. "Ongoing" projects will have nominal "10 year" duration for budgeting purposes.

The **latest start date** defines the latest date when the research string can be commenced without significantly impacting the potential value of the research. This provides an indication of how much research stagger / delay might be possible.

## 4.1 SCORING OF MATRIX CRITERIA

The categories developed for the criteria matrix are related to the prioritisation principles (see Section 3) as per Table 2. The categories have been selected so as to minimise overlap in scoring, i.e. motivation for each score would, ideally, only be applied once for each research stream.

**Table 2 – Relationship between criteria and principles**

| Criteria | Related principle | Suggested weighting |
|---|---|---|
| Research fills a knowledge gap | A | 2 |
| Research leads to innovation | B | 2 |
| Strategic fit<br>• Environment<br>• Economy<br>• Social | C | <br>2<br>4<br>2 |
| Relevant timeframe | C/D | 1 |
| New Zealand strength | D | 1 |
| Research value | E | 1 |
| Probability of favourable outcome | E | ** |

** - Provides a multiplier effect to the weighted score.

The score for each element in the matrix indicates the relative merit of the research stream compared with other research streams that are being considered. All scores are based on a scale from 0 to 10, with scoring fitting as a “normalised distribution” around the median / default of 5. The following provides a guide for applying scores to each criteria:

0 - Research has poor / little merit compared with other research

5 - Research is comparable with other research

6 – Research has benefit / merit compared with other research

8 – Research has exceptional benefit / merit compared with other research

10 – Research benefits are without comparison i.e. truly superb.

When a research string is part of a chain of research, the scores for each criterion generally reflect that of the entire research chain. However, research strings that occur earlier, or are further removed from realisation of the research benefit, will score slightly lower, due to benefits being less tangible for this string of research.

The **knowledge gap** criterion provides an indication of the level of discovery that is likely to result from undertaking the described research. The research may be filling in unknown / poorly understood information or testing new methodologies. A score of “0” would indicate that the research area is well understood, whilst “10” would indicate high uncertainty. A score of “5” should be applied if the research area is relatively mature area and not seeking credit for knowledge discovery.

The **innovation** criterion provides an indication of the market innovation and business potential associated with undertaking the research, i.e. will there be commercial applications of the research? Relatively immature research areas are likely to have some innovation potential (i.e. a rating of 6 - 8). Research that is undertaken for the purpose of supporting market innovation can score higher. Research that does not specifically target innovation will usually score “5” (i.e. a moderate level of innovation) or lower if research has limited commercial opportunity (e.g. “4” for resource mapping).

The **strategic fit** criteria encourage research that aligns with national objectives. These span three sustainability dimensions:

- The **environmental fit** criterion scores highly those projects that support movement towards national environmental aspirations e.g. low GHG lifecycle emissions, energy conservation, higher levels of recycling and improved water quality improvement. It should be noted that actions that externalise the environmental impact to foreign nations would score lower than the median (i.e. 0 - 4).
- The **economic fit** criterion scores highly those projects that support movement towards national economic aspirations e.g. increased exports, decreased imports and competitive advantage etc. Economic benefits can include using more ‘private’ capital[3] or improved ‘chain’ opportunities (e.g. market stability and demand-side management). It should be noted that a dollar gained from export may have less value than a dollar saved on imports by virtue of associated burden on the remainder of the economy. This criterion implicitly addresses issues of the reliability and resilience, since it is not possible to score well on economic fit if the outcome has low reliability / resilience.
- The **social fit** criterion rewards those research projects that improve the social conditions of New Zealanders (e.g. reduced inequality, increased self reliance, more stable ambient conditions, more frequent social interaction etc).

The **timeframe** criterion encourages research that will provide relevant outcomes within the foreseeable future. Research that only has short-term relevance, limited public benefit or that can be undertaken by private industry, scores lower than the median (i.e. 0 - 4). Research that cannot be realised within the next 10 to 15 years will also have a lower than median score. The distinction between median and higher scores is based on the urgency of the research, level of public good, and dependencies for other initiatives that cannot proceed without the outcomes of the research in question.

The **New Zealand strength** criterion defines whether a string of research must be undertaken domestically because it either: relates specifically to New Zealand conditions (e.g. resource analysis) or because it can convey a competitive advantage for New

[3] Capital spent by community members in the local community e.g. a collective of farmers buying a wind turbine, or a family home purchasing a PV system.

Zealand (e.g. coal lignite reserve development). There is some risk that this criterion may overlap with the economic fit criterion, so some care must be taken when assigning a score to this category.

The **research value** criterion measures how likely the benefits of a string of research will exceed the cost of research. Research that will likely lead to the development of an exported skill or product will score highly (6 - 10), whilst technology reviews and systems analysis have limited direct revenue potential and, hence, will score below the median.

The **probability of favourable outcome** criterion provides an indication of how likely each of the perceived research benefits will be realised. The vast majority of research (i.e. having a score of 5) is considered to have a 55 – 75 % probability of a favourable outcome. A score of 10 is given to research that has an almost certain outcome. The probability of a favourable outcome score has a multiplying influence on the weighted sum of other criteria, with the following multiplier applied:

0 - Weighted sum × 0.05
5 – Weighted sum × 0.6
10 – Weighted sum × 1

A **concluding comment** field has been provided so that a wrap-up comment can be added by assessors to confirm that the resulting score fits in the context of other research options.

# 5. VERIFICATION OF THE PRIORITISATION TOOL

The development of a weighting matrix for energy research opportunities could easily result in significant tension being generated between research providers who are competing over limited, common resources. To minimise the risk of this outcome, a two (2) day workshop was held by EnergyScape research providers to share understanding, build consensus and review the proposed energy research prioritisation tool.

The workshop had the following outline:

- Review of workshop intention
- Review of energy research priorities
- Consensus exercise #1: Questionnaire
- Consensus exercise #2: Scoring as a team
- Discussion of alternative methodologies
- Discussion of conclusions

## 5.1 REVIEW OF WORKSHOP INTENTION

The primary intention of the workshop was to consider the merits of the weighted scoring matrix as a tool for prioritising energy research opportunities. It was important to recognise that the proposed methodology had not been tested, and, therefore, was open to suggestion / change - nothing had been "carved in stone".

The EnergyScape research strategy workshop was attended by a small number of stakeholders, representing university and CRI interests. The selection of such a small group with a broad diversity of specialisations was undertaken in order to test the capacity for consensus forming. Thus, the resulting weighted scoring matrix does not represent a 'national view'. The list of attendees is provided in Table 4.

It was recognised that, in the absence of a lead-in debate on common, national research objectives, attendees would instinctively promote their own research strings as having higher priority relative to other research strings. Depending on the level of consensus that can be achieved by the participants, one of the following three potential outcomes is likely to take precedence:

A. The prioritisation matrix is populated by consensus opinion and can provide a different list of priorities depending upon the agreed weighting criteria applied. If this model is successful, it can be further adapted and updated to include more detailed definitions of research projects and research strings.

B. Many high-priority research strings are identified. In this case, the list can be forwarded to FRST / MoRST with an indication of the required budget and justification for a greater level of national research spending.

C. The participants cannot agree on prioritisation. In this case they come to understand the difficulties of the FRST / MoRST roles and agree to leave this prioritisation activity (with associated research funding uncertainties) to these authorities.

**Figure 3 – EnergyScape workshop participants in action**

**Table 4 – List of attendees**

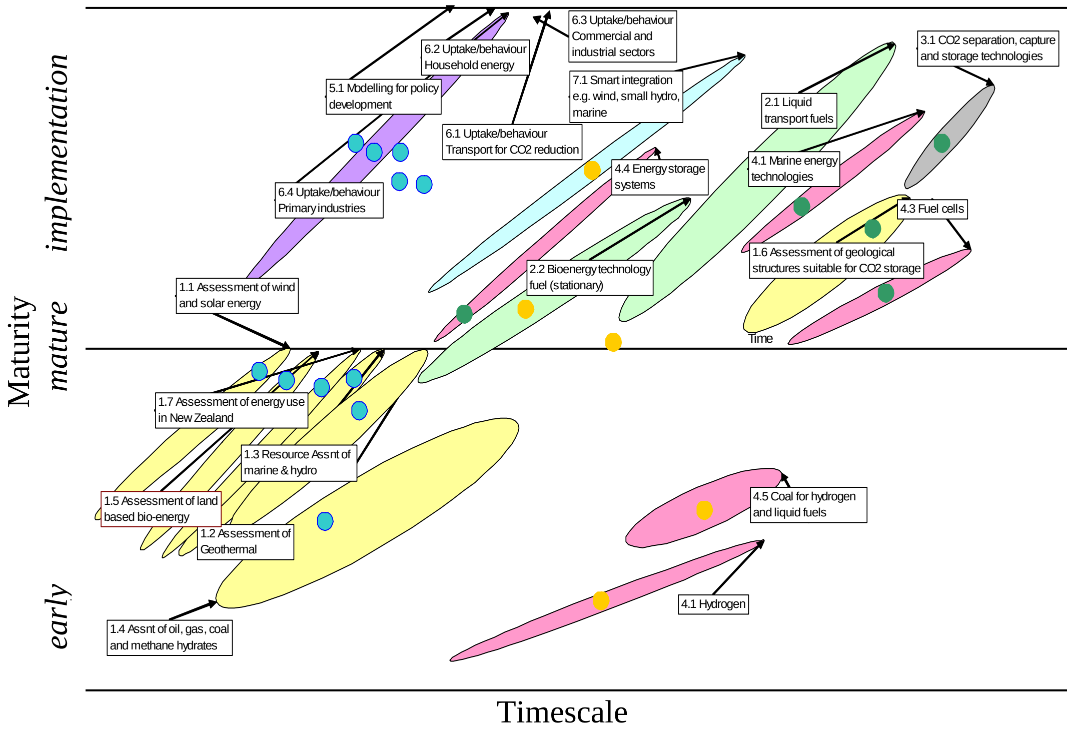
| Participant | Organisation | Specialisation |
|---|---|---|
| Rilke de Vos | NIWA | Pathway analysis / Methane hydrates |
| Stefan Fortuin | NIWA | Pathway analysis / Renewables |
| Craig Stevens (part time) | NIWA | Renewables |
| Murray Poulter (part time) | NIWA | Renewables / Electricity |
| Robert Holt (Day #1) | IRL | H2 / Distribution |
| Peter Hall | Scion | Biomass |
| Michael Jack | Scion | Biomass |
| Tony Clemens | CRL Energy | H2 / Coal |
| Stefan Harms | CRL Energy | Secondary conversion |
| Pieter Rossouw | CRL Energy | End-use forecasting |
| Peter King | GNS | Gas and oil |
| Colin Harvey | GNS | Geothermal |
| Susan Krumdieck | Uni. of Canterbury | Transportation |

## 5.2 REVIEW OF ENERGY RESEARCH PRIORITIES

In this exercise, the workshop participants were encouraged to roughly map out what they considered were the national research priorities over time-maturity axis. The exercise aimed to generate a subjective list of the key research strings relating to New Zealand's energy research priorities in a free and flexible manner. This list could then be worked upon, via the weighted scoring matrix process, in order to generate the desired objective list of research priorities.

A map of the MoRST energy research priorities (indicated in Figure 5) and a list of twenty potential research areas was provided as a way of stimulating the initial workshop discussions.

**Figure 5 – Mapping of MoRST (2006) energy research priorities**




The early discussions addressed the desired direction for New Zealand's research, and responses from the workshop included:

- Steady economic growth – likely to require either import control or uplift in petroleum exports
- Reduced carbon emissions (absolute basis)
- Improved media representation of issues – more reality and less political hype
- Reduced fossil fuel consumption (per capita basis)
- Demand side management (SHW, Insulation) – c.f. California (per capita basis)
- Greater energy efficiency (per capita basis)
- Decreased energy cost / unit income

When participants were challenged to nominate some ‘high priority’ research areas, with a justification that the whole group could endorse, a wide cross-section of proposals were offered and much constructive discussion held. The discussion of perceived risks, opportunities, barriers and solutions proved to be particularly interesting and enriching – gaining a greater appreciation of the complexities and issues surrounding energy system development and national vibrancy. Some of the topics of interest included:

- How to compare higher risk / high reward with lower risk / low reward options.
- The relationship between oil and gas exploration and national economic growth.
- Acknowledgement of the “resource curse”[4].
- What drivers are likely to engender a change in New Zealand’s energy system?
- When should a situation be considered an emergency? e.g. imminent gas shortfall.
- Where does public good end and private interest start?
- How should government manage the likelihood of under-writing, e.g., an LNG terminal, gas generation or aggressive demand-side management?
- The role of biomass energy in New Zealand’s transport future.
- Can we change our demand for vehicles and kilometres travelled?
- What is the probability of synthetic oil production from coal-to-liquids (CTL) or gas-to-liquids (GTL) in New Zealand.[5]

An outcome that had not been anticipated was the desire of participants to distinguish between “Pull” and “Push” research:

A. “Pull” research = research for long-term benefit of New Zealand (i.e. optimising existing products, processes and technologies),

B. “Push” research = research that helps New Zealand to avoid risks (i.e. how to cope with peak electricity demands over the existing transmission network).

Essentially, the participants indicated that there is much research that could aid New Zealand for long-term gain (research that “pulls” us forward), but that we also face considerable risks that must be addressed in the shorter time-frame (research that will be “pushed” upon us by external factors). The group believed that it is vital that this latter research category is not overlooked and that it requires urgent attention.

After all the above discussion, the participants did not feel a great urgency to compile an exhaustive list of ‘high priority’ research areas, but did suggest sufficient research strings to form a ‘subjective’ list of priorities (see Table 6 below):

[4] The resource curse (also known as the paradox of plenty) refers to the paradox that many countries and regions with an abundance of natural resources tend to have less economic growth and worse development outcomes than countries with fewer natural resources. This is hypothesized to happen for a variety of reasons, not the least of which is increased mismanagement (e.g. corruption) and low efficiency (because relative prices are low). http://en.wikipedia.org/wiki/Resource_curse (accessed 11/11/2008).

[5] Particular reference was made to “Alternative Liquid Fuels”, Michael Taylor (MED, 2007)

## Table 6 – Identified high-priority energy research opportunities

* - Indicates "push" research

| Research string | Comment on justification |
|---|---|
| Energy system planning (i.e. long-term impacts of strategy on economic growth and GHG emission profile) | Energy policy planning can only be effective if understanding of energy systems and economy responses is sound |
| Better data collection (particularly at regional level) | Data on New Zealand's transport sector is particularly ambiguous and often unclear, hence, planning is difficult. Since resource management and infrastructure planning is undertaken at a regional level, data is required to this level. |
| * Energy system risk analysis | Energy policy planning can only be effective if understanding of impending risks to energy system & economy is sound |
| * Defining the impact of crude oil prices on the economy | The New Zealand economy is highly oil dependent (more so than much of the OECD). With great uncertainty surrounding the future oil price, New Zealand should understand the economic vulnerability and prepare contingency plans accordingly. |
| Wealth inequality impacts | New Zealand is already struggling with a growing gap between the wealthier and poorer. As base living costs (food, shelter and transport) increase, this gap is likely to grow. Through encouraging different urban forms and public transport, some of these impacts can be reduced. |
| Reinvestment of revenue from extraction of indigenous resources | In order for New Zealand to benefit from the extraction of indigenous resources, we must learn how to improve the recirculation of revenue gained from these investments. If New Zealand does not learn how to lever from historical investment, then we may continue to suffer from the 'resource curse'. |
| * Transition planning – Identifying marker decision points pertaining to risks, and developing response plans | Having an awareness of risks and contingency planning is basic risk management, which is employed at most corporations across the country. New Zealand needs to undertake similar risk management to avert awkward energy system decisions and poor, under-duress, decision making regarding the future of New Zealand energy systems. |
| * Review trade position e.g. consider environmental taxes on imports | "Free-trade" may sound like a highly desirable objective, until the limitations on import control and implications for local domestic manufacture are realised. Equally, environmental taxes (e.g. carbon tax on imported products) are also useful for maintaining price parity, and not compromising our economic position. |
| Increasing New Zealand content of construction activities | To maximise the benefit of foreign direct investment in New Zealand, there should be greater control over the minimum level of New Zealand equity and greater control and encouragement of levels of New Zealand content in construction activity, especially by state-owned entities. |
| Supporting a transport transition (e.g. public and active transport networks, freight networks and new technology) | 50 % of our energy demand is transport related and is largely based on imports. Any improvements in efficiency have significant economic implications for New Zealand. Additional health (with associated economic impacts) effects are also favourable. |
| Supporting a transport transition - urban form planning | Urban form planning has a greater potential to reduce vehicle related GHG emissions than changes in vehicle technology, yet, to date, has been largely ignored as a GHG mitigation measure. New Zealand needs to assess and analyse the impact of urban form planning decisions. |
| * Understand benefits / issues with imposing flex fuel requirement on a % of vehicle imports | If New Zealand wishes to reduce GHG emissions associated with petrol by substituting with ethanol (either Brazilian import or domestically produced) then a greater proportion of flex-fuel vehicles in the fleet would be valuable. New Zealand could regulate the minimum % of imports which have flex-fuel capacity. This may be an alternative means of reducing the average age (and therefore improving fuel efficiency) of New Zealand vehicle fleet. |
| Developing pathways for enhancing uptake and domestic manufacture of parts supporting new vehicle technologies (e.g. car guidance systems, electric vehicles, CNG conversions etc.) | Few countries have 'clean' enough electricity to justify accelerating electric vehicle (EV) technology. New Zealand must play an active role in advancing the uptake of this technology if this is to be a mid- to long-term solution for New Zealand. Supporting parts manufacture and retrofitting may be a good expansion opportunity for our small-medium enterprise (SME) manufacturing sector. |
| * Development of collaborative planning tools | In order to successfully implement policy, there must be buy-in from key-stakeholders and the public. New Zealand has a need for better systems of defining why policies are instituted and building support from system participants. |
| * Improving media representation and stimulating national dialogue | Required in order for decision makers to gain a better grounding in issues, and to assist the public in lending support for policies. |

| | |
|---|---|
| Energy education | The decision makers of the future need to understand "energy pathway"; efficiencies and the issues associated with life cycle analysis if they are to be able to support and understand the complex balancing issues that modern governments must address. |
| Understanding the opportunity for synthetic fuel production options (from gas) | New Zealand used to be known as a "gas exploration basin", a view which ultimately led to the belief that our transport future should be based on gas (i.e. Liquids Fuel Trust Board). This opportunity is still real for New Zealand, albeit that gas reserves in New Zealand are currently low due to limited historic exploration. |
| Understanding the opportunity for synthetic fuel production options (from coal) | Should oil prices remain >$50/bbl, then New Zealand could produce petroleum / diesel from lignites with significant economic benefit to the country. The realities and pitfalls (including GHG emissions) should be openly evaluated. |
| Defining resource limits | Resource limitations may define the ultimate extent of development and may refine national thinking on desired levels of sustainability and energy efficiency i.e. investing now to offset future consumption and reduce financial uncertainty to fuel prices. Resources of particular interest include: water, gas, air pollutants and world GHG emissions. |
| * Enhancing understanding of biomass / coal gasification limitations / opportunities e.g. SNG production from biomass | Gasification is a fundamental technology that underlines many of New Zealand's potential alternative fuel supply options. Understanding minimum scale, costs and technical limitations for this technology is essential for effective modelling of future energy opportunities. |
| Supporting opportunities to develop IP in the fuels from wastewater and micro-algae sector. | Developing wastewater and micro-algae energy systems could provide an efficient mechanism for using agricultural and human waste whilst simultaneously increasing self-reliance. |
| Reduce geological uncertainty (gas) | A gas shortfall is imminent. Improved understanding (including seismic) is likely to provide a basis for more investment in the exploration sector. |
| Understanding potential of generating transport fuels from purpose-grown (or existing) forest. | This technology has potential to provide an alternative form of income for New Zealand and, largely, substitute oil imports. |
| Reduce geological uncertainty (oil) | One of the key mechanisms for encouraging private equity investment to undertake oil exploration is to undertake research that demonstrates the potential of local geological reservoirs (e.g. Seismic studies and understanding of oil kitchen function)[6]. |
| Reduce geological uncertainty (CSS) | Many nations believe that demonstrating the capacity of carbon storage & sequestration will release the potential to use fuels that were previously considered 'dirty'. New Zealand has indicated that CSS is a high priority. |
| Review benefits of a National oil company OR stronger regulation? | As the value of oil increases, and competition for drilling ships / capital investment increases, many nations are nationalising their petroleum assets. In this way nations can control the rate of development of assets, and realise the full value of assets, rather than just the royalties. An alternative mechanism to yield these benefits could be increased regulation on % New Zealand ownership, % New Zealand construction content etc. New Zealand should review the implication of a revised O&G management strategy on New Zealand's economic viability. |
| Understanding petroleum development barriers e.g. scale of access / risks, access to drill ships | As indicated above, reducing royalties on access to petroleum reserves has not significantly changed the exploration interest in New Zealand, due, in part, to increased competition for drilling ships and capital.<br>New Zealand should quantify the implications of these barriers on the economic transformation plans. Further, since the only developed exploration region is Taranaki, an understanding of the additional infrastructure costs to develop other areas should be addressed. |
| Review benefits of a nationalised electricity system e.g. facilitate investment | Many of the touted benefits of privatisation (e.g. greater competition, more suppliers etc.) have not been realised, whilst, simultaneously, introducing significant delays in investment and planning due to uncertainty associated with 'guessing' the actions of other market participants. In terms of ensuring greater energy security and controls for intermittency, there may be benefits associated with nationalising the electricity system. |
| Renewable energy potential mapping | Enables the identification of potential sites for future investment and supports planning regarding where energy may be supplied from. Understanding these resources also enables planning regarding control of intermittency issues. |
| Exploring deep geothermal potential | This technology has significant potential and, if developed in the shorter-term, could assist with avoiding a gas shortfall whilst maintaining a low-carbon drive. |

[6] Other supporting incentives include: Reduced royalties (already done by New Zealand), politically stable nation (New Zealand is perceived as this) etc.

| | |
|---|---|
| Modelling electricity intermittency – demand relationships | New Zealand has significant hydro generation (albeit with limited storage), which may well support efficient electricity demand-supply balancing. The myth that greater renewables penetration will result in intermittency issues needs to be re-dressed with modelling. |
| Electricity market regulation (wind-hydro interaction) | Currently, electricity generation asset ownership encourages maximising the individual value of assets without recognising the 'national' economic benefits of regulating "reserve" generation. New Zealand should consider the benefit of implementing a "reserve" market. |
| Improving "service – value" matching | New Zealand uses a lot of high-grade electricity for low-grade heating service (eg. water heating). Although electricity is relatively cheap in this country, we are using far more of it than we need to … there is much scope for increasing the supply of low-grade energy services from lower grade resources e.g. solar, biomass and gas. |
| Electricity demand-side management | In addition to increasing the generation of electricity to meet forecast demand, New Zealand must increasingly concentrate on reducing / managing electricity demand, though; efficiency improvements, substitution of alterative fuels, modifying end-use habits etc. (see also service – value matching above). Reducing demand is very often more cost-effective than increasing supply, and, therefore, has economic benefit for New Zealand. |
| End-user understanding | Limited knowledge of options, distribution of mis-information and pervasiveness of myths all adversely affect the national capacity to achieve optimal solutions. |
| PV / SHW integration systems e.g. smart meters | Internationally, there has been tremendous interest and recognition that personal energy generation systems (e.g. SHW and PV) are likely to play an increasing role in energy generation[7]. Understanding these trends and providing for them (e.g. installing appropriate smart meters) would be beneficial for New Zealand. |
| Electricity storage potential | Energy storage is linked to the pervasive uptake of renewable energy supplies (e.g. buffering variable and intermittent generation). The capacity of hydro-dams to play this role is already limited at times (in winter). Opportunities for large energy-storage (including load deferral) and understanding its benefits enable more cost-effective matching of supply and demand (e.g. reduced transmission bottlenecks, peak loads, reserve generation capacity needed, and increased grid stability and reliability). |
| * Electricity market regulation (feed-in tariffs) | Electricity market regulators and central government have, for a long time, recognised the benefit of increased, small-scale, distributed generation (namely from increased investment, lower carbon footprint and supply diversity).<br>A direct and proven mechanism for stimulating the uptake of such distributed generation is regulation of feed-in prices. If New Zealand wants to stimulate DG uptake, then such regulatory initiatives should be considered. |
| Understanding opportunities for Huntly | Huntly is a significant GHG emissions contributor (albeit minor when considering transport and agriculture) which may well be able to reduce GHG footprint without undue cost e.g. switching operation of Huntly to 'peaking only' or fuelling with gas rather than coal, or providing partial oxygen feed. Considering that Genesis is a SOE, the government could study how it can reduce New Zealand's GHG footprint through absorbing the carbon abatement cost at Huntly. |
| Capability building | New Zealand has, for many years, not sufficiently supported energy research. Consequently, the pool of skilled researchers is limited. If New Zealand is to be well positioned to address future energy system changes, there will need to be investment in developing domestic skills to support the required analysis / investment. |
| Understanding the difference in value to New Zealand of domestic -versus-international expenditure on fuels | Money spent domestically has significant kick-on effects associated with provision of services and reduced sensitivity to the dollar market. Consequently, New Zealand could afford to pay a premium for domestic production whilst simultaneously enhancing economic growth. |
| Developing regional energy & GHG balances | Regional councils are responsible for infrastructure planning and resource management, but currently don't have sufficient tools to understand impacts of their decisions. |

This list of 'high-priority' research demonstrates that the research community is aware and actively considering the many options available for New Zealand. Whilst this table is not a strategy recommendation, it does illustrate how the prioritisation tool can engender discussion and identify relevant research areas. It is striking to see the difference in focus

[7] These devices are considered to be approaching cost parity with grid electricity, and people are prepared to pay a premium for: self-reliance; assurance regarding cost; greater sustainability.

and extent of diversity in this list compared to the lists of "focus now" and required "critical capacities" identified in the MoRST energy research roadmap.

## 5.3 CONSENSUS EXERCISE #1: QUESTIONNAIRE

In preparation for the EnergyScape workshop, NIWA prepared a questionnaire with supporting literature (see Appendix A) aimed at stimulating discussion and at encouraging consensus-forming thought. The questionnaire invited consideration of the future state of five of New Zealand's major energy-consuming sectors (society, transportation, natural-gas industry, electricity generation industry, greenhouse-gas emitters) and ended by asking questions regarding energy research priorities. Within each of these sectors, the questions began by establishing the participant's perception of energy-consumption trends and alternative options available for mitigating future risks by the years 2015 and 2030. The final set of questions for each category asked for the participant's opinion of the future costs for the various sector services and raw materials.

The intention of the initial questions in each sector was to get the participant to think about drivers and influences that may shape the future development of the sector. The last set of sector questions attempted to test the participant's awareness of service or input material costs. Overall, the questions were intended to raise awareness of some of the critical issues facing each sector, namely:

- New Zealand Society: economic prosperity is proposed to be strongly linked to social vibrancy in the current structure.
- Transportation: there is, clearly, a heavy dependence on imported oil, and, forecasts suggest market volatility and increasing costs.
- Natural Gas: New Zealand has rapidly diminishing gas reserves.
- Electricity Generation: generators allege that end-user demand continues to grow strongly, whilst planning appears to remain un-guided and demand-side management is still under-utilised.
- Green-House Gas Emissions: New Zealand has not been successful at reducing GHG emissions to date and may face legislative risks.

Although every effort was made to formulate questions that could be answered by a wide audience (including general public), it was recognised that it was really only suitable for participants with a relatively good understanding of the energy sectors. In order to aid in receiving informed answers and improve understanding / knowledge pertaining to the questionnaire, a "supporting material" document was provided, covering topics such as past-price developments and research forecasts.

***New Zealand Society***

The New Zealand society questions suggested that there were high levels of uncertainty regarding future 'wealth gap' and national 'economic robustness'. Further, all participants expected the New Zealand population to grow faster than the "mid-mid" scenario from Stats NZ:

**Table 7 – Responses to New Zealand Society questions**

| | By 2015 | | | By 2030 | | |
|---|---|---|---|---|---|---|
| | Yes, by 2015 | Not by 2015 | Unsure by 2015 | Yes, by 2030 | Not by 2030 | Unsure by 2030 |
| Will New Zealanders be better off financially than now? | 33 | 0 | 67 | 67 | 0 | 33 |
| Will New Zealand have a healthy environment (i.e. clean, green image)? | 67 | 0 | 33 | 67 | 0 | 33 |
| Will the wealth gap (between significant 'wealthy' and 'poor' NZ'ers) have grown? | 33 | 67 | 0 | 0 | 0 | 100 |
| Will New Zealand population be greater than 4.4 million by 2015 and 4.85 million by 2030 (i.e. StatNZ mid-mid estimate)? | 100 | 0 | 0 | 100 | 0 | 0 |

### *Transportation Sector*

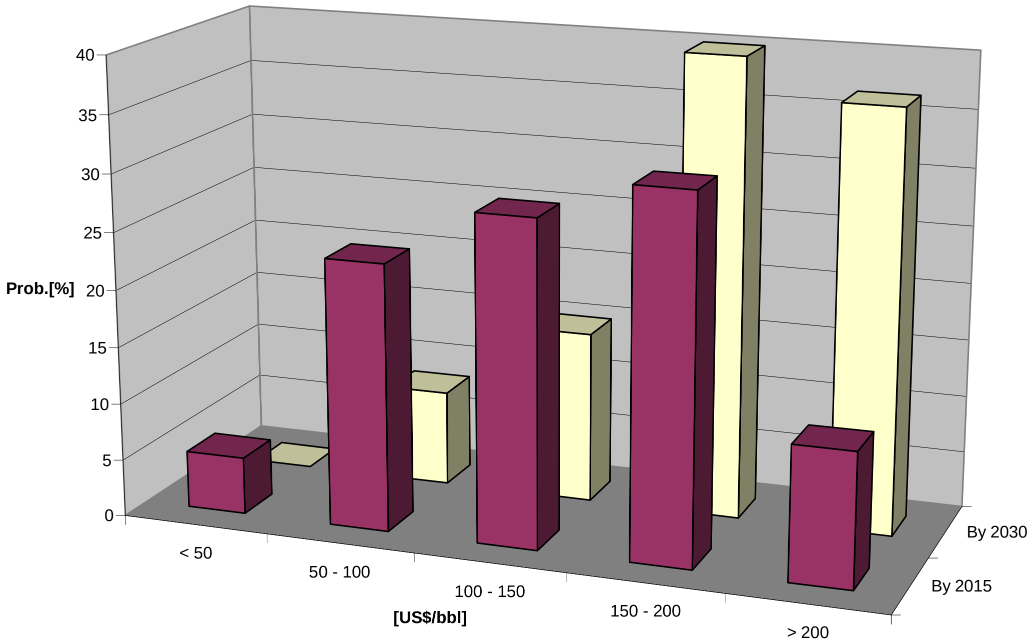
The questions pertaining to expectations for the future of New Zealand's transport sector highlighted the concern that New Zealand would not respond pro-actively to increases in crude-oil pricing. There was suggestion that fuel-side initiatives (e.g. Gas-to-liquids, biomass-to-liquids and coal-to-liquids conversion technologies) will only occur after international fuel prices have hurt the New Zealand economy. Further, there was little expectation of pre-emptive demand reduction through strong public / active transport or electric vehicle uptake or renewal of urban form.

**Table 8 – Some responses to New Zealand transport questions**

| | By 2015 | | | By 2030 | | |
|---|---|---|---|---|---|---|
| | Yes, by 2015 | Not by 2015 | Unsure by 2015 | Yes, by 2030 | Not by 2030 | Unsure by 2030 |
| Will world production of oil (conventional) have reached maximum (i.e. peaked?) | 67 | 33 | 0 | 67 | 33 | 0 |
| Will international oil demand exceed supply (both conventional and unconventional)? | 33 | 33 | 33 | 67 | 0 | 33 |
| Will transport demand be reduced by economic pressures? | 33 | 0 | 67 | 67 | 0 | 33 |
| The average petrol consumption of a 'NZ new' vehicle is <6L/100km (2015) and <4L/100km (2030)? | 0 | 100 | 0 | 67 | 0 | 33 |
| Will more than 20% of passenger transport be by public transport? | 33 | 67 | 0 | 67 | 33 | 0 |
| Will New Zealand have a synthetic crude plant based on coal? | 0 | 100 | 0 | 33 | 33 | 33 |
| Will New Zealand have a synthetic crude plant based on gas? | 0 | 100 | 0 | 0 | 33 | 67 |
| Will New Zealand have a synthetic crude plant based on woody biomass? | 0 | 100 | 0 | 0 | 33 | 67 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Will New Zealand produce more than 10% of oil needs from biomass? | 0 | 100 | 0 | 33 | 67 | 0 |
| Will algae derived biofuels be used to move more than 10% of freight? | 0 | 100 | 0 | 33 | 33 | 33 |
| Will active transport (e.g. cycling & walking) be a major (>10%) component of commuting? | 0 | 100 | 0 | 33 | 67 | 0 |
| Will urban form have changed significantly to noticeably reduce the need for private transport? | 0 | 100 | 0 | 33 | 33 | 33 |
| Will an electric car be your/your family's main form of transport? | 33 | 33 | 33 | 67 | 0 | 33 |

**Figure 9 – Crude oil price probability forecast**




Even though the discussion in the group had highlighted and agreed that the 'world response' to higher oil prices would be to build more gas-to-liquids and coal-to-liquids production facilities (which should be able to produce at less than $ 90 /bbl), collectively, the participants envisaged far higher prices which continued to increase beyond 2015 to 2030. This result was a little surprising since there were no known "peak oil zealots" in the group, but does indicate a general consensus of concern from scientists in the field.

### *Natural Gas Sector*

The responses to the gas questions indicated similar sentiments as that discovered in response to transport sector questions, namely; that supply-side constraints are unlikely to be lifted pro-actively, and, hence, solutions are likely to be “reactive and sub-optimal” (e.g. LNG terminal). As a result of increasing “pinch” gas supplies, followed by the requirement for LNG terminal investment, the gas price is considered to rise to between 6 – 9 $/GJ by 2015, and increase well beyond that by 2030.

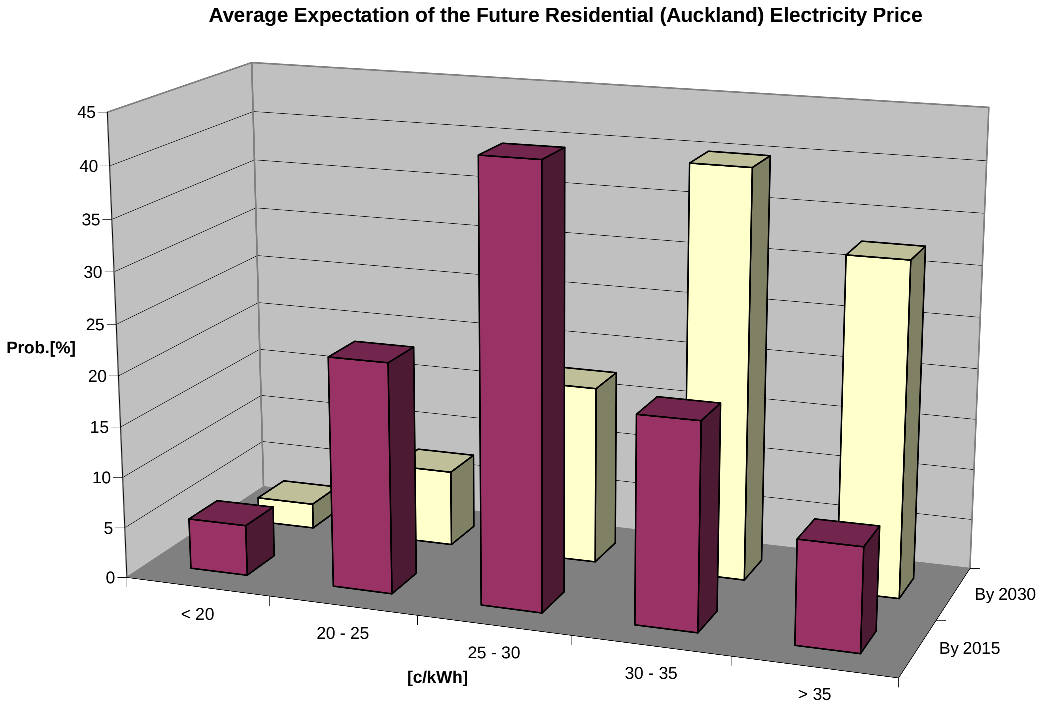
**Table 10 – Some responses to New Zealand gas sector questions**

| | By 2015 | | | By 2030 | | |
|---|---|---|---|---|---|---|
| | Yes, by 2015 | Not by 2015 | Unsure by 2015 | Yes, by 2030 | Not by 2030 | Unsure by 2030 |
| Will New Zealand have discovered another large (>70% of Maui) natural gas reserve? | 0 | 33 | 67 | 67 | 33 | 0 |
| Will a lack of new gas finds compromise electricity generation in New Zealand? | 0 | 33 | 67 | 67 | 33 | 0 |
| Will New Zealand be using methane hydrates? | 0 | 67 | 33 | 33 | 33 | 33 |
| Will New Zealand have built an LNG terminal and regularly import LNG? | 0 | 100 | 0 | 0 | 33 | 67 |
| Will New Zealand have a synthetic crude plant based on gas? | 0 | 100 | 0 | 0 | 33 | 67 |
| Will New Zealand export gas as fertiliser and methanol? | 67 | 33 | 0 | 33 | 33 | 33 |

### *Electricity Generation Sector*

The responses to the questions pertaining to the future average Auckland electricity price illustrated an expectation of continued increases in retail electricity pricing. The responses to the primer questions (not shown here) indicated an expectation that many renewable energy initiatives will not be strongly taken up by 2015, with doubts remaining regarding uptake prior to 2030. In addition, there was a low belief among the respondents that effects of demand-side measures (e.g. insulation, eco light bulbs, solar heaters) and distributed generation will be significant in comparison to electricity demand growth (e.g. heat pumps, computers etc.).

**Figure 11 - Responses on the average electricity price development**




### *GHG Emissions*

The responses to the greenhouse gas emission expectation questions illustrated the belief that a global emissions trading market would be developed, but that its effectiveness would be questionable. For example, the participants were unanimous in the belief that New Zealand would fail to meet Kyoto obligations by 2015, and no-one believed that world deforestation would be reversed to afforestation.

**Figure 12 - Responses on greenhouse gas emissions**

| | By 2015 | | | By 2030 | | |
|---|---|---|---|---|---|---|
| | Yes, by 2015 | Not by 2015 | Unsure by 2015 | Yes, by 2030 | Not by 2030 | Unsure by 2030 |
| Will agriculture be in the New Zealand emissions trading scheme? | 33 | 33 | 33 | 100 | 0 | 0 |
| Will carbon capture and storage exist for at least one large (> 150 MW) thermal plant in New Zealand? | 33 | 67 | 0 | 33 | 0 | 67 |
| Will a global Emission Trading market exist? | 67 | 0 | 33 | 100 | 0 | 0 |
| Will global deforestation be reversed to afforestation? | 0 | 100 | 0 | 33 | 0 | 67 |
| Will New Zealand be meeting internationally its agreed GHG emission targets (e.g. Kyoto)? | 0 | 100 | 0 | 33 | 0 | 67 |
| Will New Zealand be one of the first truly carbon neutral nations? | 0 | 67 | 33 | 0 | 33 | 67 |

After reviewing the results of the questionnaire, and a few suggestions regarding question structure, most were impressed with the level of consensus found. It was therefore not surprising that the ranked list of twenty proposed research priorities matched with the expectations of the group. The highest priority research areas included: energy planning / risk management; transport transition; electricity market regulation, electricity demand-side management, urban planning, understanding coal-to-liquids for New Zealand and fuels from timber.

The only outlier that attracted significant discussion was the relatively low priority for fossil fuel research modelling. Some of the participants defended the result on the basis that, currently, little of the value associated with discovery and development of fossil fuel reserves is captured by New Zealand – the reserves are mostly developed using foreign capital and royalties are low. It was widely acknowledged that the discovery and utilisation of conventional fossil fuels is an appropriate and realistic solution for New Zealand, but doubt remained regarding how much economic benefit the nation would realise.

## 5.4 CONSENSUS EXERCISE #2: SCORING AS A TEAM

The second exercise, targeting the development of consensus, involved participants collectively scoring a research string in accordance with the criteria defined in Section 4. By scoring a string of research as a team, the participants gained further appreciation of how different groups valued their respective research contributions and learned how to consider the merit of research from a national context. Owing to the specialised nature of some of the EnergyScape research strings, this was the only way to reach an unbiased consensus on the future of research relating to, e.g., "methane-hydrate resource mapping" and the "bioenergy resource land-use change".

The process involved reviewing the intention and benefits of a research string as a group before applying scores to each research criterion. Three areas received substantial discussion:

- Breadth of scope for research strings
- Determination of national value
- Weighting factors

Participants quickly understood that the breadth of each proposed research string could be as wide or tight as desired because the scoring responded accordingly. To improve the clarity of the matrix, research sub-strings were shown more clearly using the "+" identifier that is commonly associated with sub-folder filing.

As per the "review of research opportunities" discussions on "push" and "pull" research, it was agreed that the perceived national value of research could be measured by economic growth opportunities and by the generation of national risk abatement options. The evaluation of all research strings must also consider the probability of the research actually delivering the expected benefits (providing a "reality check").

When the weighted-scoring matrix is completely populated with scores, the overall score can be tested for sensitivity by adjusting the weighting factors associated with each of the criteria specified in Section 4. The result of interest, therefore, is not the weighted score for each research string, but the "prioritisation class". The strategy support tool's spreadsheet has been developed to highlight this sensitivity analysis feature.

After participating in a team scoring exercise, there was a general consensus among the participants that: the weighted-scoring matrix system did enable an objective means of identifying and prioritising national energy research strings, with the proviso that participants using the matrix had a full appreciation of all the research strings identified.

## 5.5 DISCUSSION OF ALTERNATIVE METHODOLOGIES

The weighted-scoring matrix is only one method available for prioritising national energy research strings. Even though this methodology is quite mechanistic, obtaining a prioritised list of research still requires the holistic understanding and subjective analysis by those applying the tool. In order to consider how well this tool worked, the workshop group also discussed a range of alternative methodologies, namely:

- Iterations of the research opportunities mapping exercise
- Pathway mapping (leading to the identification of knowledge gaps)
- Research themes analysis (as used by SCION)
- Research needs pathway (as used by CRL Energy)
- Identifying the total labour pool of skilled researchers

The review of a research opportunities mapping approach to research prioritisation provides a quick, subjective assessment of what research has priority in New Zealand. Undertaking this type of assessment is a useful first-cut assessment from which to benchmark other methodologies.

Highlighting of "knowledge gaps" on a pathway map only provides a limited view of research priorities, and is certainly not broad enough to be used for research prioritisation (see Appendix B).

The analysis of research themes, undertaken by SCION in their bioenergy strategy document, provides a very good overview and understanding of the priorities within one energy sector. It does not, however, enable prioritisation of research between multitudes of energy sectors.

The research needs pathway analysis, undertaken by CRL Energy for the hydrogen strategy document, develops a vision pathway that enables a technology to "emerge". This type of analysis and overview enables research funders to gain a better understanding of the likely research barriers and needs, but does not enable prioritisation of research between multitudes of energy sectors. This type of analysis must be complemented by an assessment of the need for the nation to develop the technology in question in order to feed into a research strategy.

An analysis that reviews the total labour pool of skilled researchers in the country provides a good indication of the minimum research budget (labour only) that should be allocated (i.e. it lists all researchers that should be funded and the percentage of FTE that should be funded). This simple type of analysis assumes that the key researchers are already working in the fields of research that New Zealand needs in order to achieve desired objectives. This is unrealistic. In order to steer research funding toward the areas of need, the funding agency could distribute funding in proportion to the sector's influence on the economy.

It was agreed that none of the alternatives considered had significant merit when compared with the weighted-score matrix methodology. It was agreed that if some consensus of research priorities could be reached by the assembled (small, but diverse) group, then this tool would have succeeded in:

- Facilitating a consistent prioritisation methodology
- Enabling prioritisation across a diverse group of interests
- Enabling a cross-section of opinions to share visions and gain consensus of New Zealand's preferred strategy
- Providing 'a portion of the science community' with an opportunity to have a say in research prioritisation.

## 5.6 WORKSHOP CONCLUSIONS

In the last phase of the workshop, an evaluation of the weighted score matrix methodology was undertaken. Discussions pertained to whether or not the tool was capable of supporting the development of an Energy Research Strategy for New Zealand.

Put simply, there was consensus amongst the participants of the workshop that the weighted-scoring methodology provided a robust method for codifying and prioritising energy research string proposals. It was concluded that when the support tool is applied by a group of stakeholders and reviewed collectively, it provides a mechanism for communicating a consensus opinion. In this case, since the tool has been pre-populated with input from the EnergyScape team, the resulting list of research priorities expresses a consensus opinion from one sector of the science community.

As with many tools, the process of application can have as much or more value than the tool. In this case, when assessors are completing the matrix they must consider a broad range of energy interests and think holistically. This facilitates clarification of national objectives and risks.

The participants agreed that the weighted-scoring methodology could be a useful tool for prioritising national energy research, because:

- It enables collaborative contribution to research planning
- It enables national objectives and risks to be clarified
- It codifies research priorities for further prioritisation
- It provides guidance on research funding levels.

# 6. CONCLUSIONS

The EnergyScape team has developed and trialled a ‘weighted score matrix’ methodology to support the prioritisation of a national energy research strategy. The methodology and prioritisation criteria used for the tool were defined after undertaking a brief literature review that considered the role and purpose of collaborative research tools to defining research strategies.

The limitations and capacities of the resulting weighted-score matrix tool were reviewed and trialled during a two day workshop. The workshop was attended by a small, but diverse, group of energy researchers who undertook several consensus-building exercises and reviewed the merits of the tool. The conclusions of this workshop with regard to the tool verification was that “the weighted scoring methodology provides a robust method for codifying and prioritising energy research proposals”.

The methodology has been trialled successfully by representatives of the EnergyScape team, with the observation that when the tool is applied by a group and reviewed collectively, it provides a mechanism for communicating a consensus opinion. The weighted score matrix methodology appears to be a useful tool for prioritising national energy research that could now be adapted and trialled by government agencies.

# 7. REFERENCES

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# APPENDIX A: ENERGY SYSTEMS EXPECTATIONS QUESTIONNAIRE & SUPPORTING DOCUMENTATION

## Expectations for the New Zealand energy landscape

This short questionnaire seeks to identify areas of consensus and debate in the perception of New Zealand's likely energy future - both prior to 2015 and approaching 2030.
The questions are arranged by energy sector, with Yes / No / Unsure questions that are intended to stimulate thinking about future possibilities, and questions where a probabilistic spread is required. Answer the cost questions as if costs were in 2008 dollars.
Your answers to this questionnaire can be submitted electronically and sent to the EnergyScape team (i.e. send button) or printed for your records (i.e. print button).

### Participant details:

If you would like to receive result of this survey, please provide your name and e-mail address:

Name ______ Email ______

**What is your relationship with the energy sector?**

○ Supplier ○ Major End-user ○ General Public ○ Other, please specify: ______

○ Distributer ○ Regulator ○ Researcher

### New Zealand society:

| | By 2015 Yes / No / Unsure | | | By 2030 Yes / No / Unsure | | |
|---|---|---|---|---|---|---|
| Will New Zealand be economically vibrant? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will New Zealand have a healthy environment (i.e. clean, green image)? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will New Zealand have minimal social inequality? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will New Zealand population be greater than 4.4 million by 2015 and 4.85million by 2030 (i.e. StatNZ mid-mid estimate)? | ○ | ○ | ○ | ○ | ○ | ○ |

### Transport sector

| | By 2015 Yes / No / Unsure | | | By 2030 Yes / No / Unsure | | |
|---|---|---|---|---|---|---|
| Will world production of oil (conventional) have reached maximum (i.e. peaked?) | ○ | ○ | ○ | ○ | ○ | ○ |
| Will international oil demand exceed supply (both conventional and unconventional)? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will transport demand be reduced by economic pressures? | ○ | ○ | ○ | ○ | ○ | ○ |
| Average new vehicle petrol consumption <4L/100km? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will more than 20% of passenger transport be by public transport? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will New Zealand have a synthetic crude plant based on coal? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will New Zealand have a synthetic crude plant based on gas? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will New Zealand produce more than 10% of oil needs from biomass? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will algae derived biofuels be used to move more than 10% of freight? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will active transport (e.g. cycling & walking) be a major (>10%) component of commuting? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will urban form have changed significantly to noticeably reduce the need for private transport? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will an electric car be your/your family's main form of transport? | ○ | ○ | ○ | ○ | ○ | ○ |

**What do you expect the crude price to be in 2015?** (provide a probability distribution)

| Price (US$/bbl) | < US$ 50 | US$ 50-100 | US$ 100-150 | US$ 150-200 | > US$ 200 | Total: 100% |
|---|---|---|---|---|---|---|
| Probability (%) | | | | | | |

(If you don't have a forecast, feel free to leave this table empty)

**What do you expect the crude price to be in 2030?** (provide a probability distribution)

| Price (US$/bbl) | < US$ 50 | US$ 50-100 | US$ 100-150 | US$ 150-200 | > US$ 200 | Total: 100% |
|---|---|---|---|---|---|---|
| Probability (%) | | | | | | |

(If you don't have a forecast, feel free to leave this table empty)

## Gas Supply

| | By 2015 Yes / No / Unsure | | | By 2030 Yes / No / Unsure | | |
|---|---|---|---|---|---|---|
| Will New Zealand have discovered another large (>250 PJ) natural gas reserve? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will New Zealand be using methane hydrates? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will New Zealand have built an LNG terminal and regularly import LNG? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will New Zealand have a synthetic crude plant based on gas? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will New Zealand export gas as fertiliser and methanol? | ○ | ○ | ○ | ○ | ○ | ○ |

**What do you expect the wholesale gas price to be in 2015?** (provide a probability distribution)

| Price (NZ$/GJ) | < NZ$ 6 | NZ$ 6 - 9 | NZ$ 9 - 12 | NZ$ 12 - 15 | > NZ$ 15 | Total: 100% |
|---|---|---|---|---|---|---|
| Probability (%) | | | | | | |

(If you don't have a forecast, feel free to leave this table empty)

**What do you expect the wholesale gas price to be in 2030?** (provide a probability distribution)

| Price (NZ$/GJ) | < NZ$ 6 | NZ$ 6 - 9 | NZ$ 9 - 12 | NZ$ 12 - 15 | > NZ$ 15 | Total: 100% |
|---|---|---|---|---|---|---|
| Probability (%) | | | | | | |

(If you don't have a forecast, feel free to leave this table empty)

## Electricity Supply

| | By 2015 Yes / No / Unsure | | | By 2030 Yes / No / Unsure | | |
|---|---|---|---|---|---|---|
| Will New Zealand have a nuclear power plant? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will New Zealand have a large (>150 MW) marine generation plant (tidal or wave)? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will photovoltaic cells be cost competitive with grid power? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will more than 15% of homes have solar hot water heating? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will coal generation contribute more than 1,000MW of electricity generation? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will coal cogen (e.g at coal to liquids plant) contribute to electricity generation? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will electricity for transport use (electric vehicle charging) be taxed? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will effects of energy efficiency measures (e.g. insulation, eco-bulbs, solar heaters) be greater than electricity demand growth (e.g. heat pumps, computers etc.)? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will more than 20% passenger of trips be with electric vehicles? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will more then 20% of residences have a battery bank for car recharge or peak load levelling? | ○ | ○ | ○ | ○ | ○ | ○ |
| Will electricity growth be greater than the historical trend in urban areas? | ○ | ○ | ○ | ○ | ○ | ○ |
| Grid electricity (excluding Manapouri to Rio Tinto) is > 75% renewable? | ○ | ○ | ○ | ○ | ○ | ○ |
| Large electricity storage systems (e.g. pumped storage or redox batteries) will provide peak load levelling for the grid? | ○ | ○ | ○ | ○ | ○ | ○ |

**What do you expect the residential (Auckland) electricity price to be in 2015?** (provide a probability distribution)

| Price (c/kWh) | < 20c | 20 - 25c | 25 - 30c | 30 - 35c | > 35c | Total: 100% |
|---|---|---|---|---|---|---|
| Probability (%) | | | | | | |

(If you don't have a forecast, feel free to leave this table empty)

**What do you expect the residential (Auckland) electricity price to be in 2030?** (provide a probability distribution)

| Price (c/kWh) | < 20c | 20 - 25c | 25 - 30c | 30 - 35c | > 35c | Total: 100% |
|---|---|---|---|---|---|---|
| Probability (%) | | | | | | |

(If you don't have a forecast, feel free to leave this table empty)

## GHG Emissions

| | By 2015 Yes / No / Unsure | By 2030 Yes / No / Unsure |
|---|---|---|
| Will agriculture be in the New Zealand emissions trading scheme? | ◯ ◯ ◯ | ◯ ◯ ◯ |
| Will carbon capture and storage exist for at least one large (>150MW) thermal plant in New Zealand? | ◯ ◯ ◯ | ◯ ◯ ◯ |
| Will a global Emission Trading market exist? | ◯ ◯ ◯ | ◯ ◯ ◯ |
| Will global deforestation be reversed to afforestation? | ◯ ◯ ◯ | ◯ ◯ ◯ |
| Will New Zealand be meeting internationally its agreed GHG emission targets (e.g. Kyoto)? | ◯ ◯ ◯ | ◯ ◯ ◯ |
| Will New Zealand be one of the first truly carbon neutral nations? | ◯ ◯ ◯ | ◯ ◯ ◯ |

**What do you expect the carbon price to be in 2015?** (provide a probability distribution)

| Price(NZ$/ton$CO_2$) | < NZ$ 10 | NZ$ 10 - 30 | NZ$ 30 - 50 | NZ$ 50 - 100 | > NZ$ 100 | Total: 100% |
|---|---|---|---|---|---|---|
| Probability (%) | | | | | | |

(If you don't have a forecast, feel free to leave this table empty)

**What do you expect the carbon price to be in 2030?** (provide a probability distribution)

| Price(NZ$/ton$CO_2$) | < NZ$ 10 | NZ$ 10 - 30 | NZ$ 30 - 50 | NZ$ 50 - 100 | > NZ$ 100 | Total: 100% |
|---|---|---|---|---|---|---|
| Probability (%) | | | | | | |

(If you don't have a forecast, feel free to leave this table empty)

## Research Priorities

Rank the following research strings in order of priority for public funding (1-most important; 2-etc., feel free to leave less important items unranked/blank)

| | By 2015 | By 2030 |
|---|---|---|
| Energy system planning | | |
| Impact of crude oil prices on the economy | | |
| Fuels from timber | | |
| Electricity market regulation (feed-in tarrifs) | | |
| Electricity demand side management | | |
| Electric vehicle technology | | |
| Renewable energy potential mapping | | |
| Fossil fuel source mapping | | |
| Wealth inequality impacts | | |
| PV integration systems e.g. smart meters | | |
| Synthetic fuel production options (from gas) | | |
| GHG abatement potential (eg. POx Huntly) | | |
| Synthetic fuel production options (from coal) | | |
| Fuels from micro-algae | | |
| Gasification design (biomass & coal) | | |
| Electricity storage potential | | |
| Electricity market regulation (wind-hydro interaction) | | |
| Carbon storage & sequestration potential | | |
| H2 utilisation pathways | | |
| Urban planning changes | | |
| Other: | | |

# SUPPORTING MATERIAL FOR QUESTIONNAIRE

Below is a series of graphics which may give the reader some insight into historic and projected developments relevant to New Zealand's energy supply. The material loosely follows the order defined by the questionnaire.

## *Item 1 - An important parameter that affects future growth expectations is the range in population forecasts.*

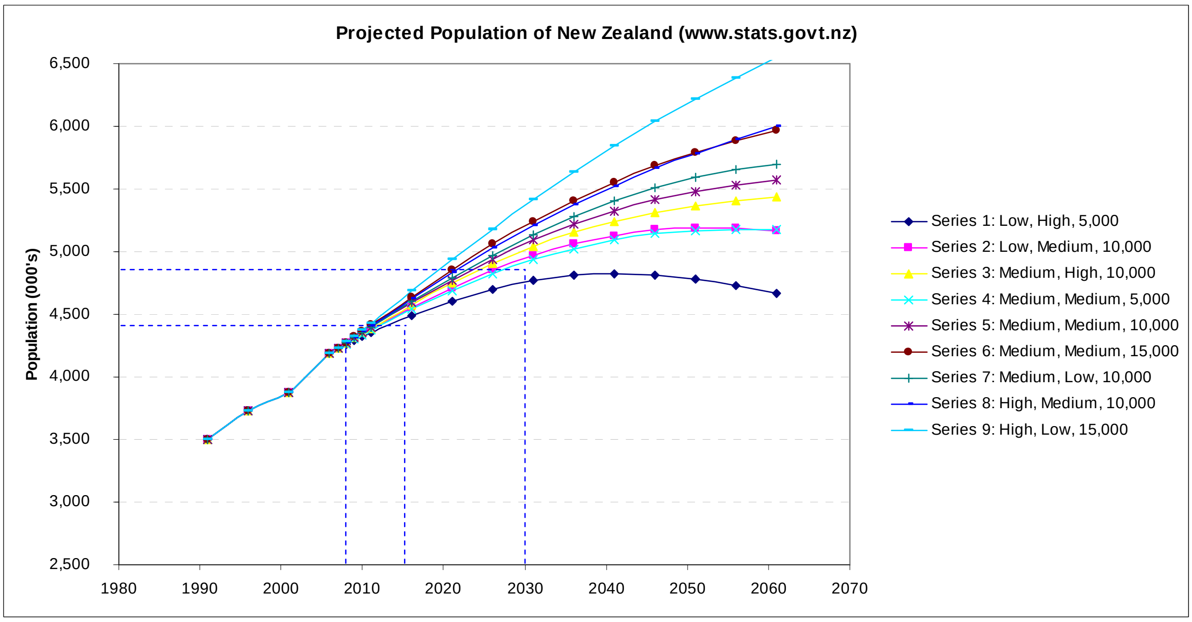



**Figure A: New Zealand population forecasts**

StatsNZ provides a range of projections, for example Series 5: assumes *medium* fertility, *medium* mortality and long-run annual net migration of *10,000*)

*Item 2 – New Zealand's economic prosperity has been steadily declining since the 1970s, much of this is due to declining exports (as % GDP).*

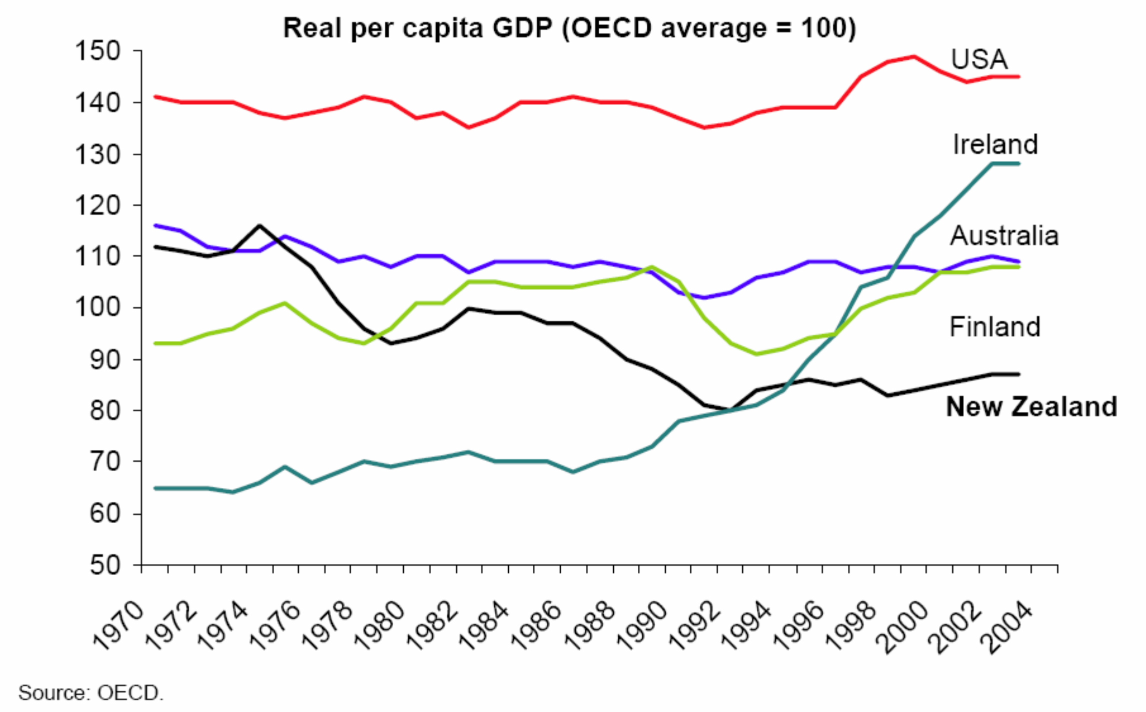



**Figure B: GDP trends in select OECD countries**

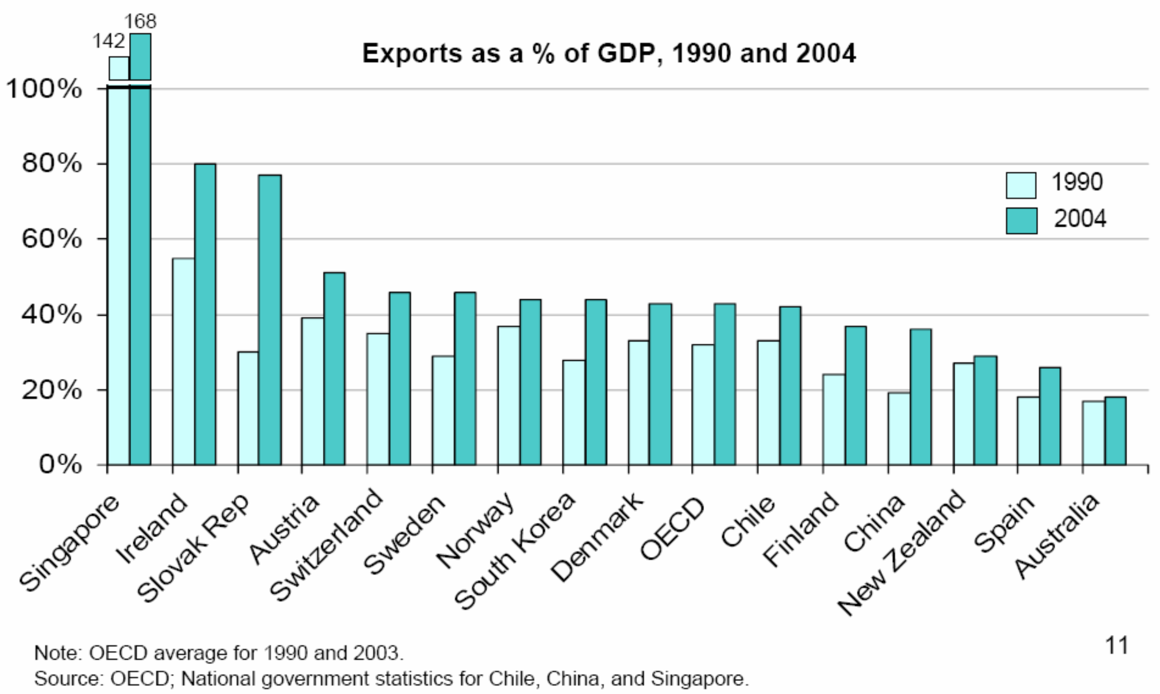



**Figure C: Export as %GDP trends in select OECD countries**

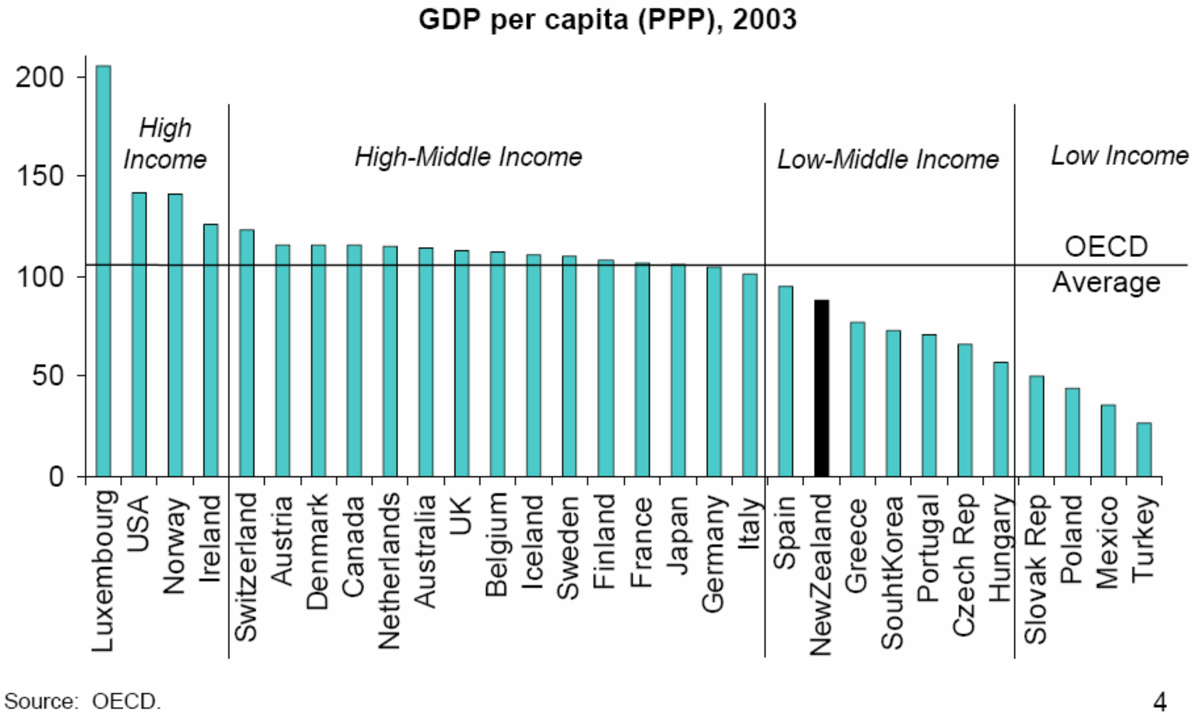



**Figure D: GDP per capita in select OECD countries**

Source: http://www.nzinstitute.org/Images/uploads/Aucklands_role_in_NZ_productivity_challenge_280206.pdf

***Item 3 - There is much speculation that the total world oil production capacity has peaked or will soon peak. This at a time when demand for oil products continues to grow rapidly.***

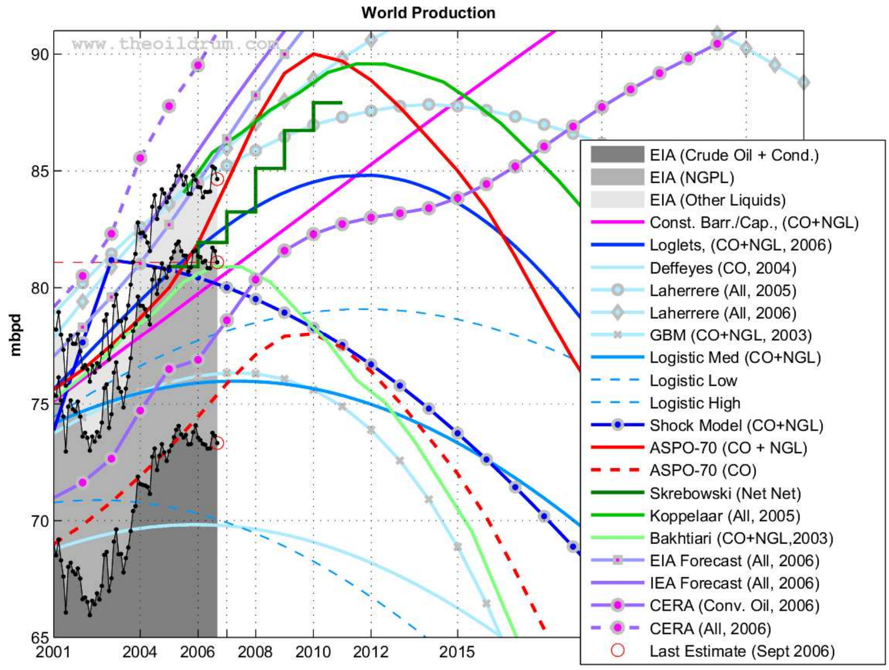



**Figure E: An update on the last production numbers from the EIA along with different oil production forecasts. *World oil production (EIA Monthly) and various forecasts (2001-2027).***

Source: http://www.theoildrum.com/story/2006/11/30/8324/0934 (accessed 23-10-2008)

This graph shows historical and projected oil production volumes from various sources. It indicates that most expect the oil production volumes to decrease, it seems uncertain when this will happen. Some expect no production decrease.

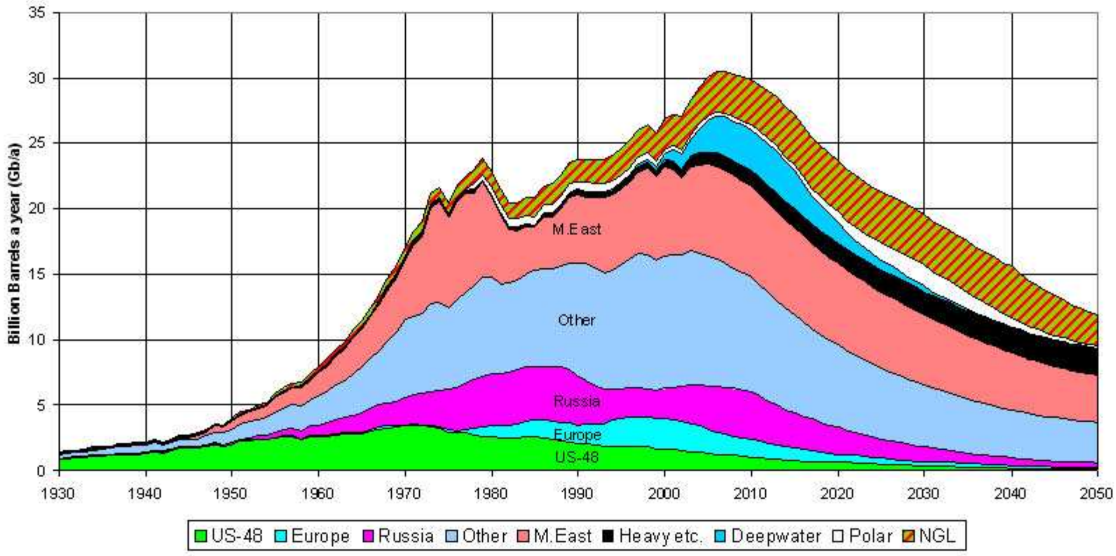



**Figure F: The 2004 oil and gas liquids as presented by Uppsala Hydrocarbon Depletion Study Group**

Source: [www.peakoil.net/uhdsg/weo2004/TheUppsalaCode.html](www.peakoil.net/uhdsg/weo2004/TheUppsalaCode.html)

This graph illustrates where future oil and gas production may come from. The graphic assumes that oil from Deep water, Polar Regions and Natural Gas Liquids is included in the outlook as part of different countries production of oil. Further it is assumed that the Middle East will maintain the "sustainable production scenario". Production from tar sand will continue, but the increase will be slower than IEA. The increase in the polar production around 2030 is from discoveries not yet made, in the belief that as drilling starts in Alaska, something will be found in Russia.

8NOV2008
NZ HERALD

# US$200 oil by year 2030 predicts IEA

The International Energy Agency has nearly doubled its forecast for the price of oil over the next 20 years, citing rising demand in the developing world as well as surging costs of production.

According to a summary of the agency's World Energy Outlook report due to be published next week, the IEA has hiked its forecast for the price of a barrel of oil in 2030 to just over US$200 ($340) in nominal terms, compared with its forecast last year of US$108 a barrel. Measured in constant dollars, the IEA forecasts oil at US$120 a barrel in 2030, up from last year's forecast of US$62.

The predictions come after crude oil prices touched a peak of US$147.27 a barrel in mid-July before diving 56 per cent to trade around US$65 yesterday.

The IEA — an energy policy adviser for its 26 member countries, including the United States, Canada, Australia, Germany and Britain, as well as 17 other European countries — said spending on oil as a share of global economic output would rise to 5 per cent over the period, compared with 4 per cent last year.

"The only time the world has ever spent so much of its income on oil was in the early 1980s, when it exceeded 6 per cent," the IEA said.

The IEA cut its forecast for global oil demand growth to 1 per cent a year on average over the next two decades.

It now sees demand growing from 85 million barrels a day last year to 106 million barrels a day in 2030. That compares with last year's forecast of 116 million barrels a day by 2030.

Higher prices, slower economic growth and Government policies over the past year have helped cool demand in the developed world. Nearly all the growth in demand for oil over the period would come from China, India, and the Middle East, the IEA said.

Demand for all forms of energy is forecast to grow 1.6 per cent a year over the period to around 17 billion tonnes of oil equivalent a year, with half the new demand coming from just two countries: China and India.

Last year, the IEA forecast energy demand to grow 1.8 per cent annually over the period.

Despite the lowered growth forecast, the IEA lifted its estimate of the investment in energy infrastructure needed to meet the rising global demand for energy by 2030. It said the world needed to invest US$26 trillion over the period, US$4 trillion more than last year's forecast.

The agency said there would be enough oil for decades to come but warned that global prosperity and the state of the planet hang on radical change in energy production and use.

"The world's energy system is at a crossroads. Current global trends in energy supply and consumption are patently unsustainable — environmentally, economically, socially.

"But that can — and must — be altered: there's still time to change the road we're on.

"The future of human prosperity depends on how successfully we tackle the two central energy challenges facing us today: securing the supply of reliable and affordable energy and effecting a rapid transformation to a low-carbon, efficient and environmentally benign system of energy supply."

The IEA pointed to huge strides being made in electricity production, and projected that "modern renewable technologies grow most rapidly, overtaking gas to become the second-largest source of electricity, behind coal, soon after 2010". *AP, AFP*

> **The world's energy system is at a crossroads. Current global trends in energy supply and consumption are patently unsustainable.**
> INTERNATIONAL ENERGY AGENCY

***Item 4 – There are indications that world oil consumption may be influenced by economic conditions. The US has witnessed a 4% decline in transport fuel consumption, and Japan an even greater decline over the past year. Some of this may be attributed to cyclone damage and associated loss of economic productivity.***

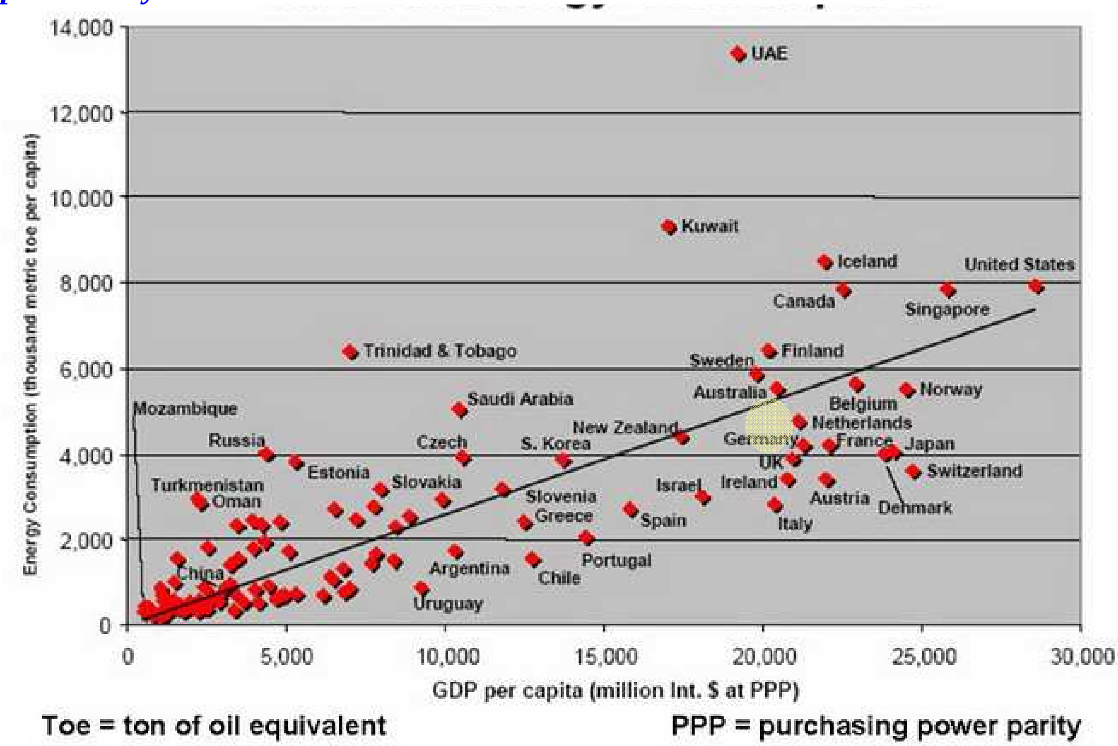



**Figure G: GDP vs. Energy intensity in various countries**

Source: http://www.iea.org/textbase/nppdf/free/2008/key_stats_2008.pdf).

This graphic suggests that there is a strong relationship between energy intensity and economic activity. It is postulated that resource depletion will result in comparative energy prices increases, will more strongly adversely affect those countries with higher energy intensity per GDP.

***Item 5 – It is suggested that technical (e.g. low resistance tyres, GPS traffic systems, regenerative breaking) and behaviour change (e.g. purchasing smaller cars, higher vehicle occupancy) might reduce the average fuel consumption of new vehicles.***

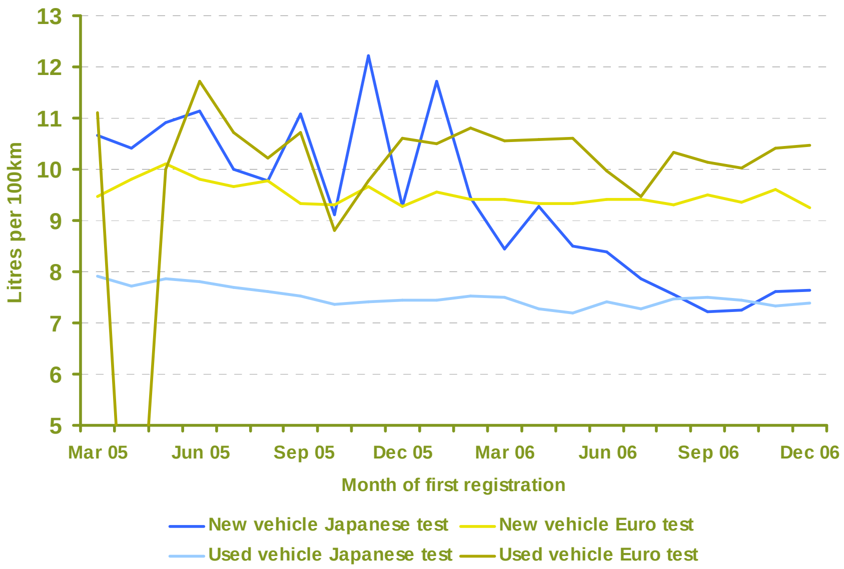



**Figure H: Average New Zealand vehicle petrol consumption trend**

Source: Ministry of Transport, 2008.

**Figure I: Average New Zealand vehicle petrol consumption trend**

Source: Ministry of Transport, 2008.

The sample and time span of ‘new vehicle’ fuel economy is not sufficient to draw conclusions.

Based on current rates of fleet turn-over it will take between 8 and 10 years for ‘new vehicle’ economies to be seen in the fleet economy.

***Item 6 – If oil access is restricted, oil production from coal, gas and biomass could be achieved. The total oil production possible from these resources is considerably greater than total historic oil production. These production methods also increase GHG emissions.***

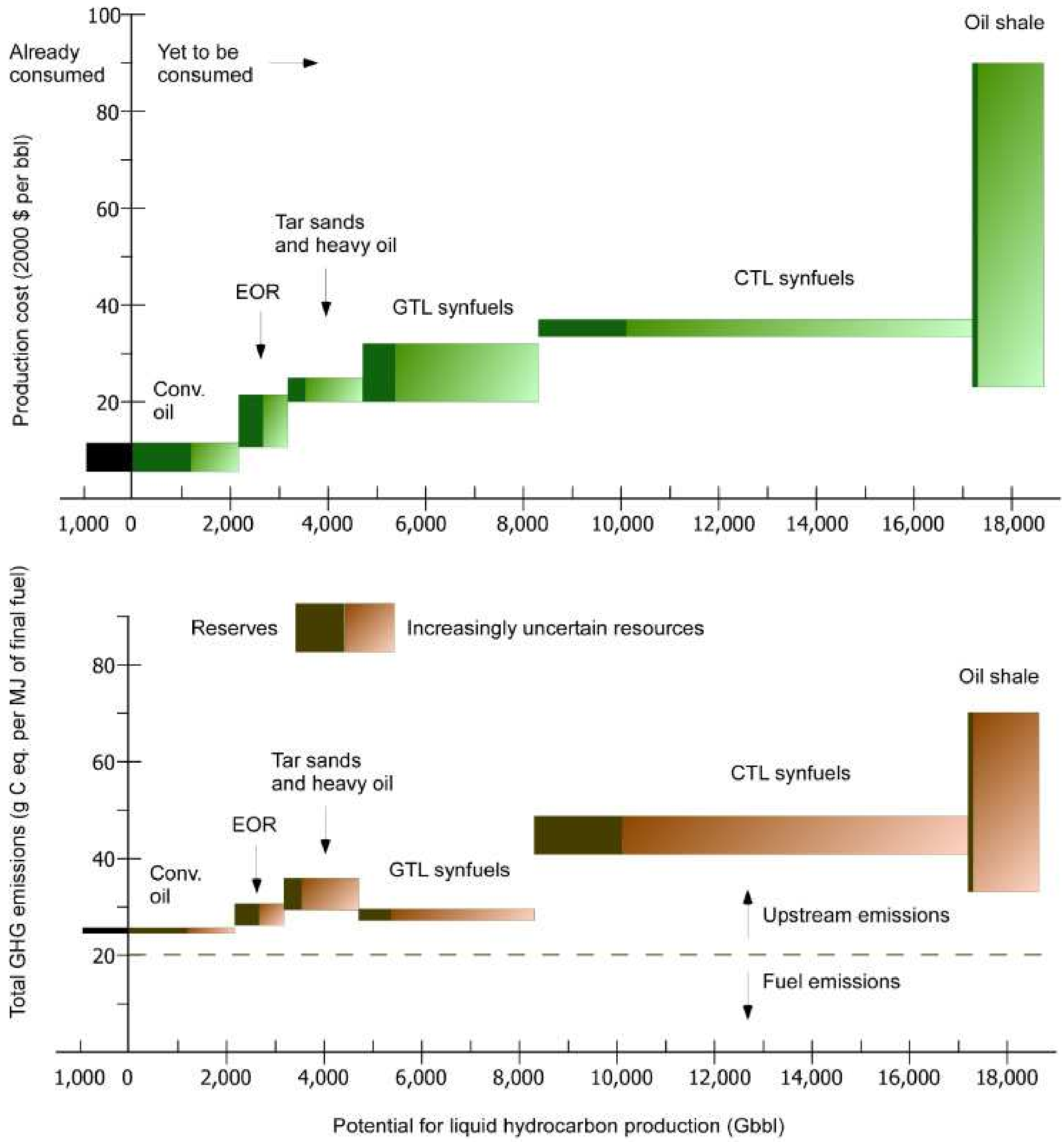



**Figure J: Global supply of liquid hydrocarbons from all fossil resources and associated costs in dollars (top) and GHG emissions (bottom)**

Source: Farrell and Brandt (2006)

The two graphs show the oil already consumed (black to the left of the y-axis) and the quantities in reserves and uncertain resources (to the right). The production costs (top) and GHG emissions

EOR is enhanced oil recovery, GTL and CTL are gas-and coal-derived synthetic liquid fuels. The CTL and GTL quantities are theoretical maxima because they assume all gas and coal are used as feedstock for SCPs and none for other purposes. The lightly shaded portions of the graph represent less certain resources. GHG emissions in the lower figure are separated into fuel combustion (downstream) and production and processing (upstream) emissions by a dashed line. Results are based on costs and conversion efficiencies of current technologies available in the open literature. Gas hydrates are ignored due to a lack of reliable data. The GTL cost estimates assume a range of $0.5 to $2 per MBTU.

New Zealand was once considered to be a gas exploration basin, has significant coal (lignite) reserves, and has significant biomass growing potential, so could well establish an alternative oil production system.

***Item 7 – The New Zealand government is targeting an increase in active transport from 17 to 30% of all trips by 2040. The Auckland regional council believes it is unsafe to increase active transport so is not targeting an increase in active transport.***

***Item 8 – Changing urban form is potentially one the most significant influences on transport energy consumption, and is the often the factor that defines the different transport energy intensities of different countries. New Zealand has few active programs reviewing urban form impact on transport energy requirements.***

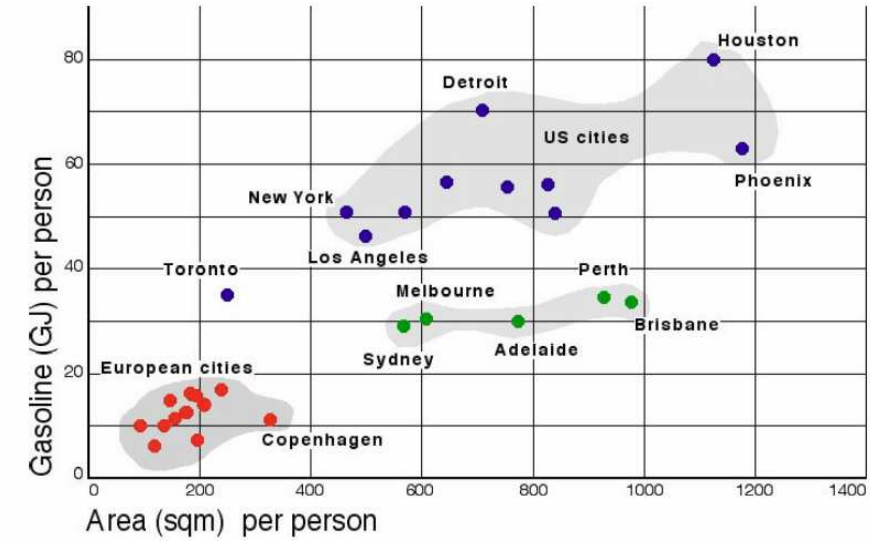



**Figure K: Relationship between urban footprint and fuel consumption**

Source: http://www.cnu.org/sites/files/Dittmar.pdf

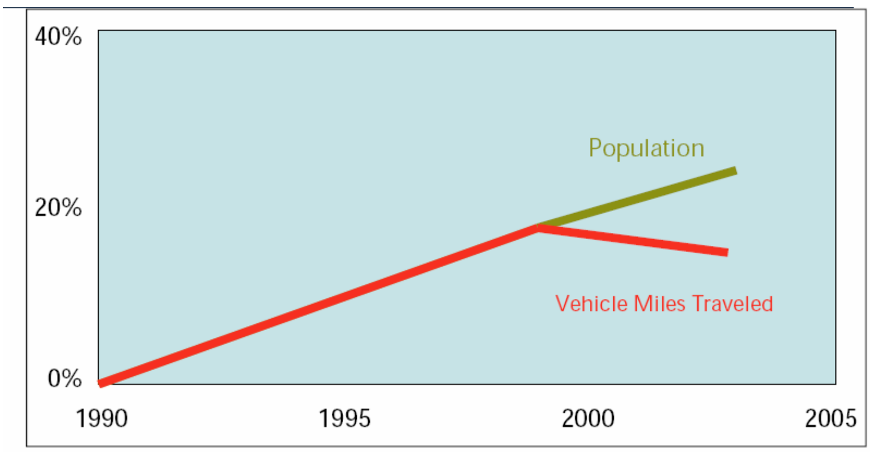



**Figure L: Relationship between vehicle traffic growth and population in Portland Metropolitan area**

Source: http://www.cnu.org/sites/files/Garrick.pdf

***Item 9 – Electric vehicles enable substitution of energy source for passenger transport to shift from petroleum to electricity. If electricity is sourced from renewable sources, this could dramatically reduce the emissions intensity. Electric vehicles are unlikely to provide a significant proportion of freight transport services.***

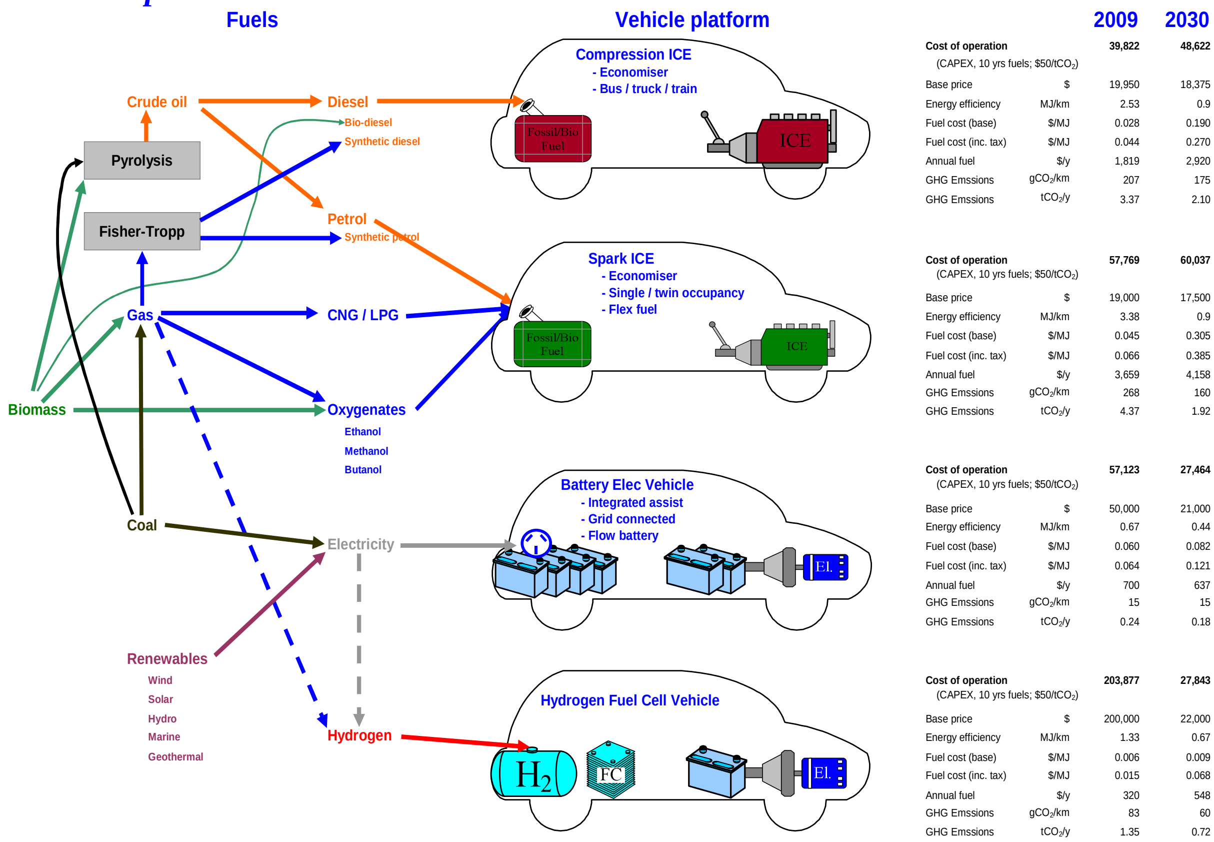



**Figure M: Comparison of vehicle types, and future cost of operation**

Source: EnergyScape 2008

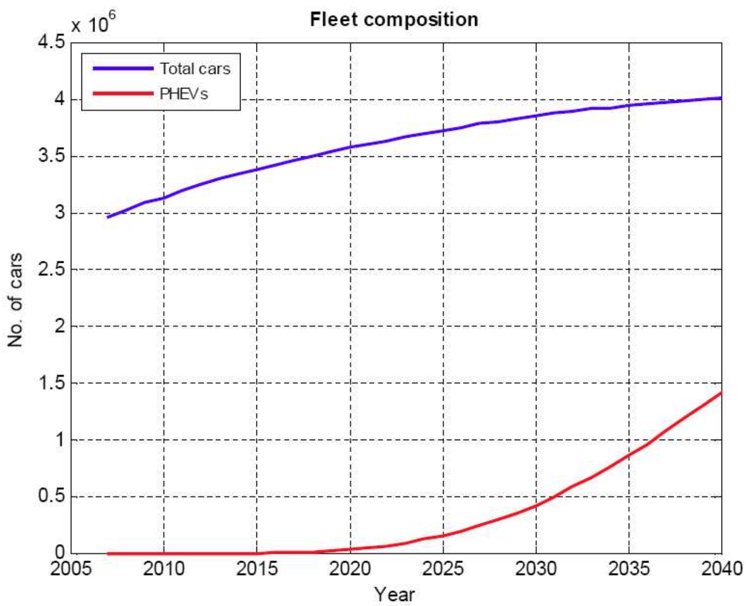



**Figure N: Projected (electric) vehicle fleet composition**

Source: Impact of Plug-in Hybrid Vehicles on the New Zealand Electric Grid
Erwan Hemery and Bruce Smith, 31 March 2008

Although electric vehicles are available for purchase now, the makers of the graph expect a significant uptake only to happen many years later.

***Item 10 – Crude oil price is responsive to a wide range of influences. Historically prices have responded to changes in the demand-supply balance associated with political instability. It is speculated that recent price spikes are attributed to an increase in oil scarcity relative to demand.***


**Figure O: Factors influencing real crude oil prices (1970 – 2008)**

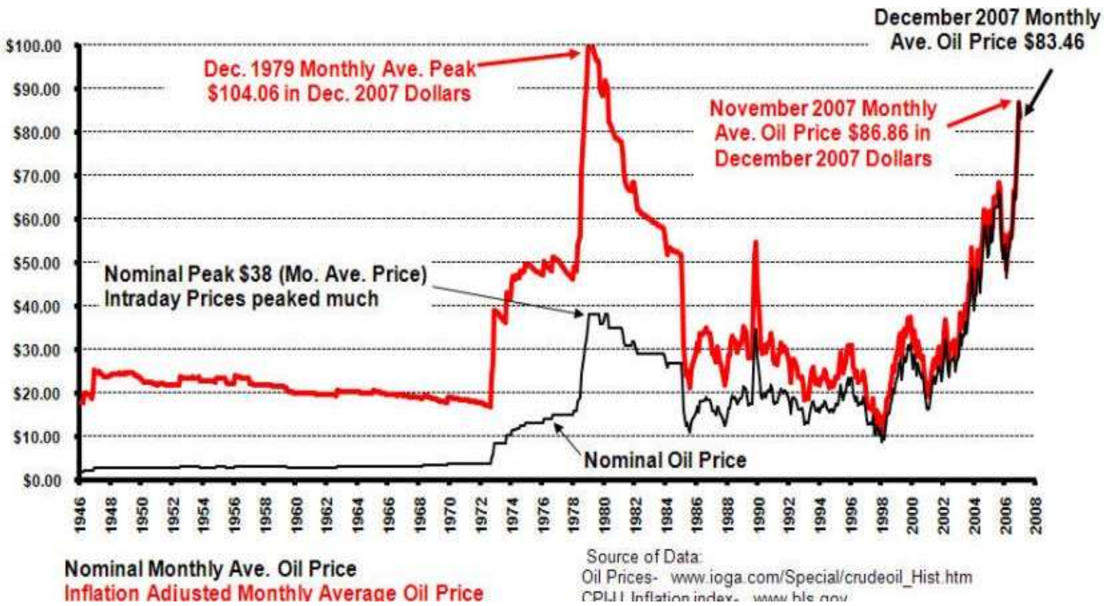



**Figure P: Long term oil price development not inflation adjusted (top) and inflation adjusted (bottom)**

Source: http://www.crudeoilprice.com/Crude-oil-prices-1970-2008.gif and http://www.crudeoilprice.com/Inflation-adj-oil-prices-chart.jpg (accessed 23-10-2008)


**Figure Q: Recent oil price development**

US Energy Information Administration (http://tonto.eia.doe.gov/dnav/pet/hist/rbrted.htm, accessed 23-10-2008)

# GAS SECTOR INFORMATION

***Item 11 – New Zealand's economic prosperity has for many years been supported by access to cheap gas, in particular from the Maui (4,100 PJ and ~200 PJ/y) field.***

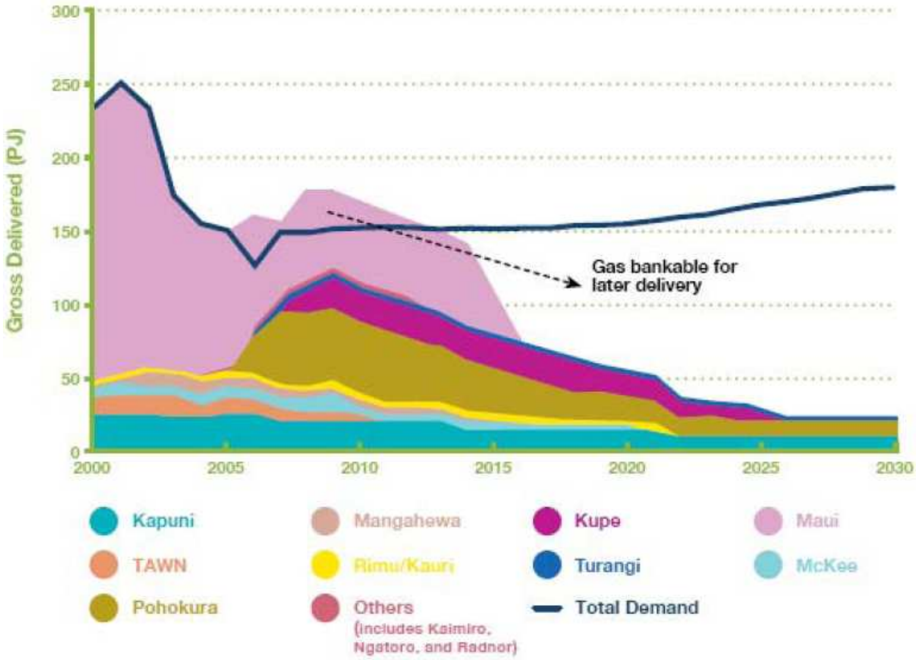



**Figure R: Estimated production profile based on current discovery**

Source: MED Energy Outlook to 2030

After the re-determination of Maui in 2003 industrial activity (e.g. Methanex) slowed production and demand. Even with the reduced consumption rates, the outlook of gas supply meeting gas demand is short-lived.

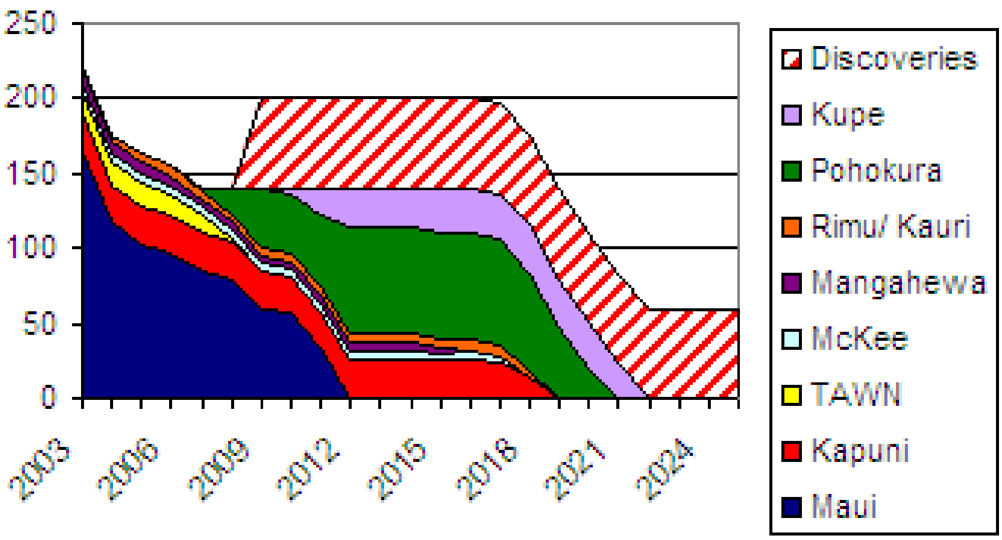



**Figure S: Potential delay in gas shortage, based increased exploration**

MED assume that with increased interest in gas exploration, a 60 PJ/y gas discovery rate is possible. The current national demand is around 150 PJ/y.

***Item 12 – A significant proportion of gas use is for fertiliser and methanol production. These production systems enable New Zealand to profit from gas exploration. If international demand / prices for methanol and fertiliser continue to increase, the demand of gas will also increase.***

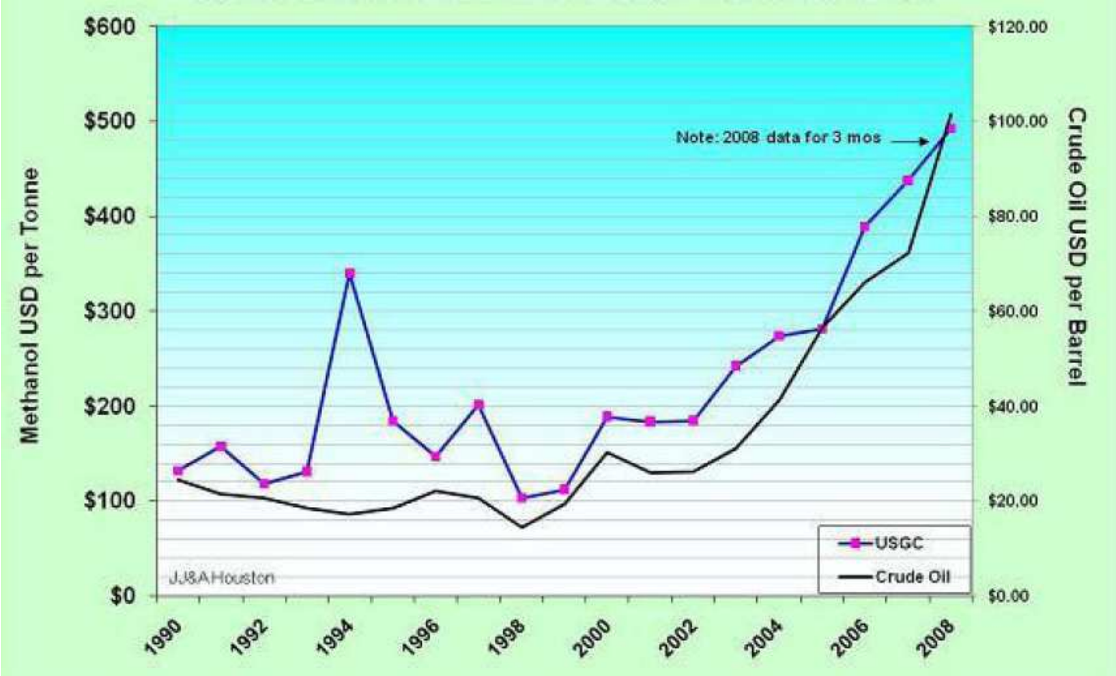



**Figure T: World oil and methanol prices**

Source: Methanex

International methanol prices have driven Methanex from lowest price gas bidder to highest price gas bidder.

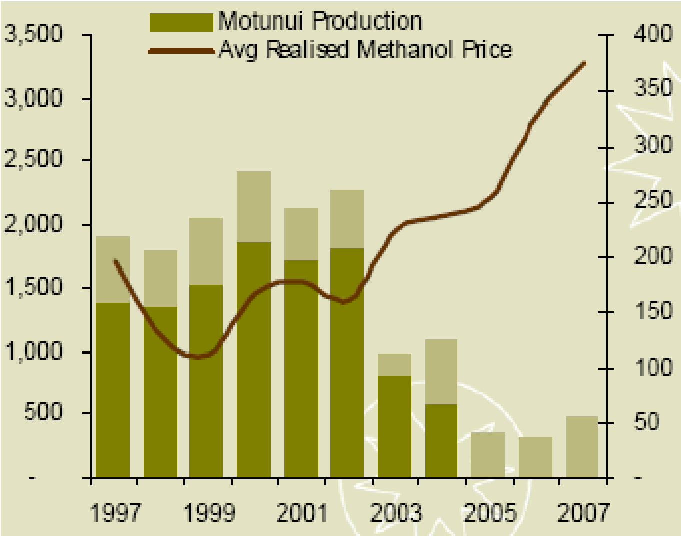



**Figure U: Methanex New Zealand production and pricing**

International methanol prices have stimulated Methanex to re-start methanol production. The gas supply-demand balance will therefore contract, with the following potential outcomes:

- Potential shortfall before 2015 if Methanex runs for long even with 60 PJ/y discovery rate.
- Shortfall not too far after 2015 even without Methanex running.
- Contact Energy got little response from the RFP for gas to Otahuhu C.
- Expectation that there will be little extra gas after 2015 or just unwillingness to price gas at that horizon?

Ultimately, shortfall will depend on Methanex and how big new discoveries will be – and where they will be located?

### *Item 13 – The electricity generation sector use gas to support existing assets. As gas supply tightens these assets either become unprofitable or pass on higher electricity pricing to the market.*

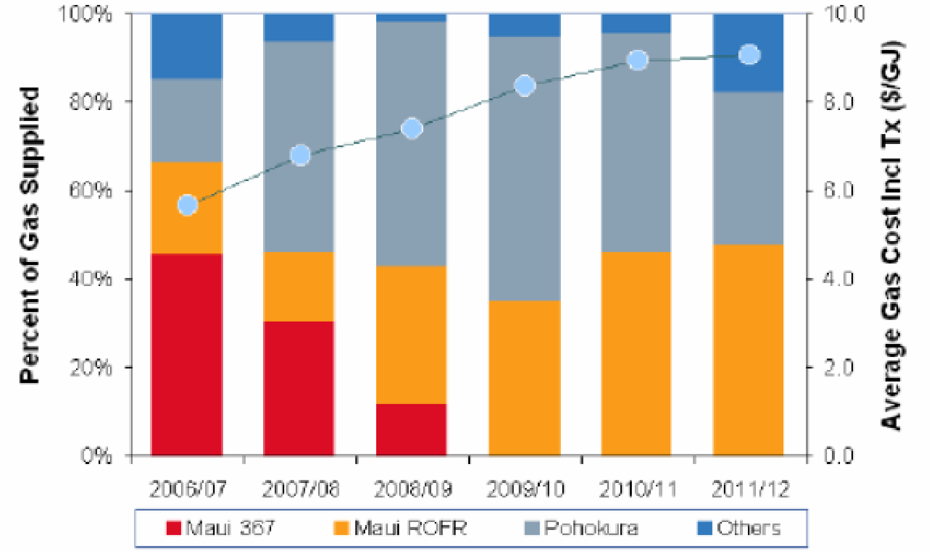



**Figure V: Gas price forecast by electricity generator**

Source: www.contact-energy.co.nz

As electricity generators move from Maui contracts to contestable contracts the wholesale price of gas has shifted upward from just above 7 $/GJ in excess of 9 $/GJ. If gas supply tightens, the price could well increase.

***Item 14 – LNG imports will only be economically viable if domestic gas price remains above import price for a sustained period. Because New Zealand would only be a small consumer (in world terms) it would not sustain a permanent shipping route, therefore would have to buy from "non-permanent" contract market.***

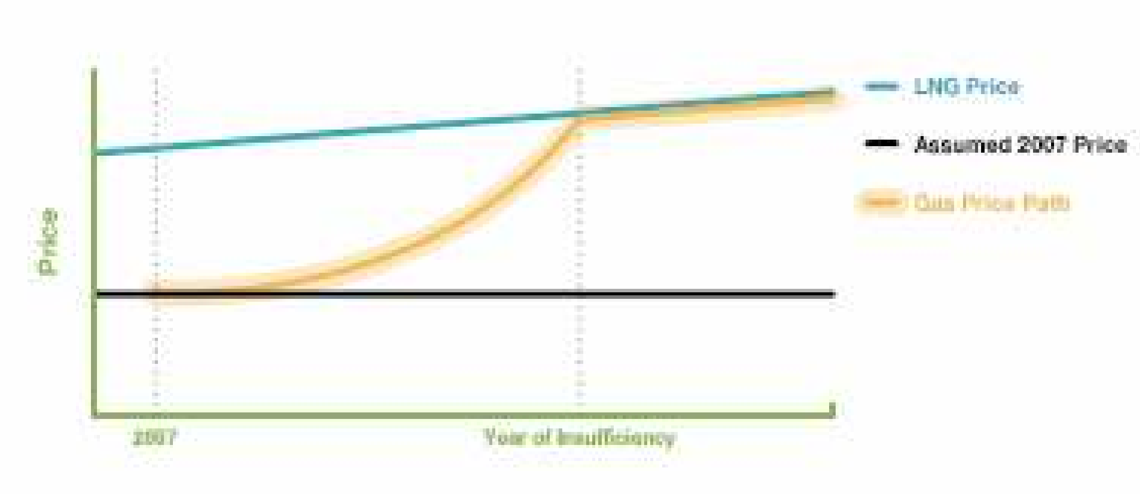



**Figure W: Gas price forecast by electricity generator**

Less than 10 "non-permanent" contract LNG sales have ever been made. Prices for these sales have typically been >12 $/GJ.

# ELECTRICITY SECTOR INFORMATION

***Item 15 – The future of the electricity sector has some influences that are likely to increase grid-supplied electricity demand (e.g. electric vehicles, new appliances), and some that are likely to decrease grid-supplied (e.g. Solar hot water and photovoltaic installations, energy efficiency e.g. insulation, Compact lighting).***

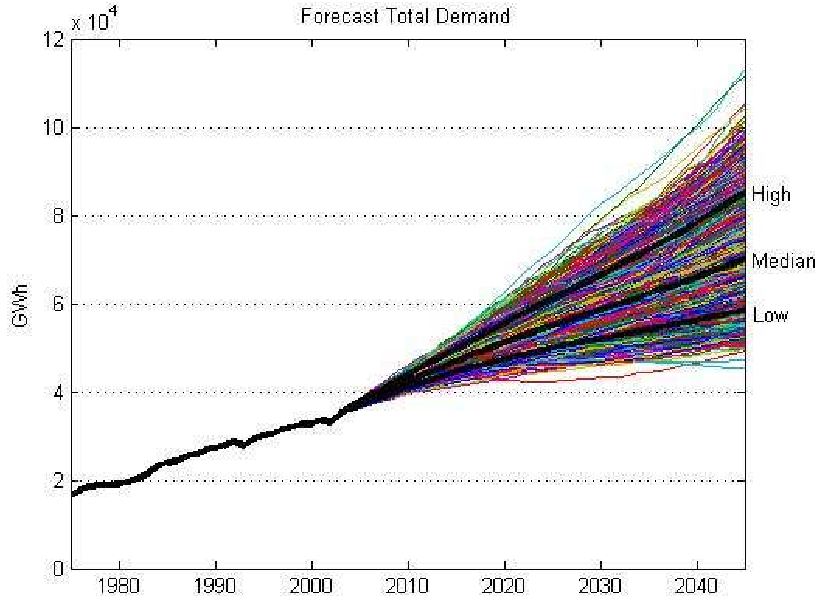



**Figure X: Electricity demand forecast (New Zealand).**

Source: http://www.electricitycommission.govt.nz/opdev/modelling/pdfsmodelling/total-forecast.jpg

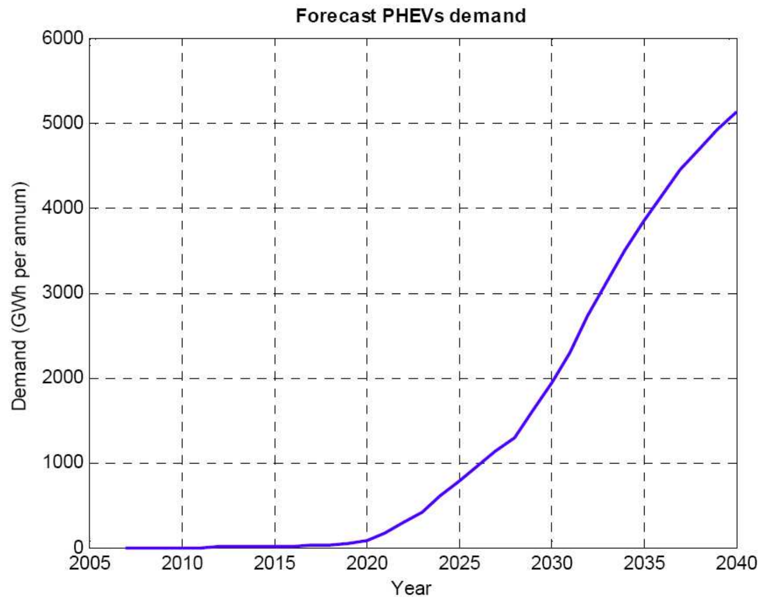



**Figure Y: Projected (electric) vehicle fleet electricity demand (bottom).**

Source: Impact of Plug-in Hybrid Vehicles on the New Zealand Electric Grid
Erwan Hemery and Bruce Smith, 31 March 2008

# GHG EMISSIONS INFORMATION

***Item 16 –The transport and storage phases of carbon capture and sequestration (CCS) technology are reasonably developed at commercial scale. The separation technology has been demonstrated, but is still not cost effective.***

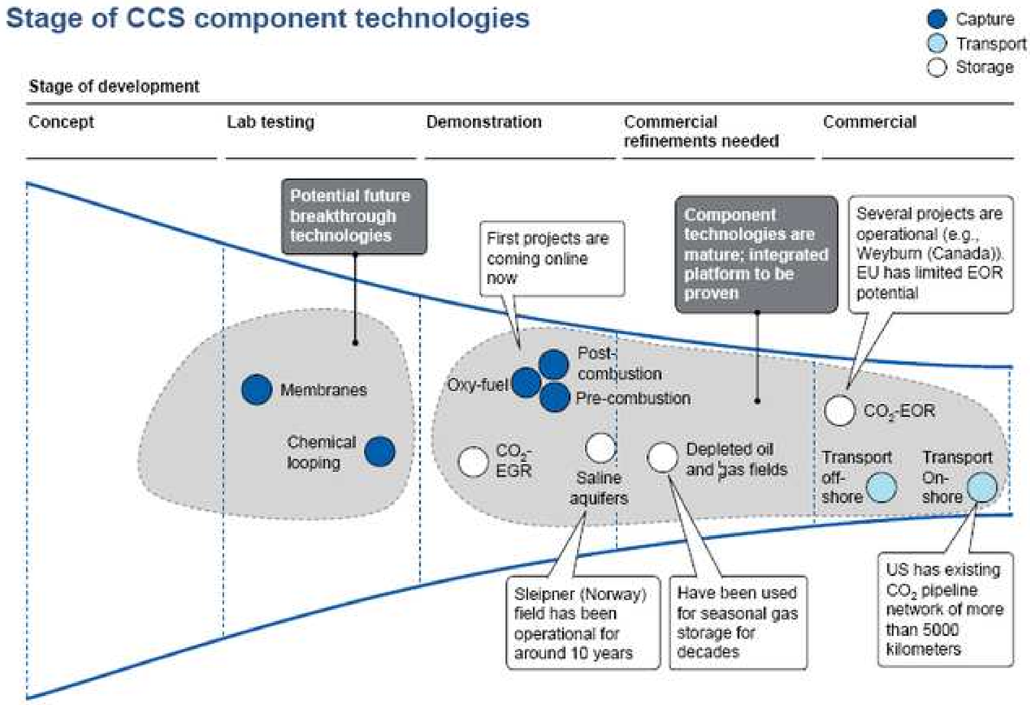



**Figure Z: Stages of CCS component technologies**

Source: McKinsey

CCS costs in the reference case scenario down to around €30-45 (US$43-65) per tonne of $CO_2$ abated by 2030—costs which are in line with expected carbon prices in that period. Early CCS demonstration projects will have a significantly higher cost of €60-90 per tonne, according to the report. Early full commercial-scale CCS projects—potentially to be built soon after 2020—are estimated to cost €35-50/tonne $CO_2$ abated.

*Item 17 –There is still much uncertainty regarding the likely price of greenhouse gas emission pricing in New Zealand.*

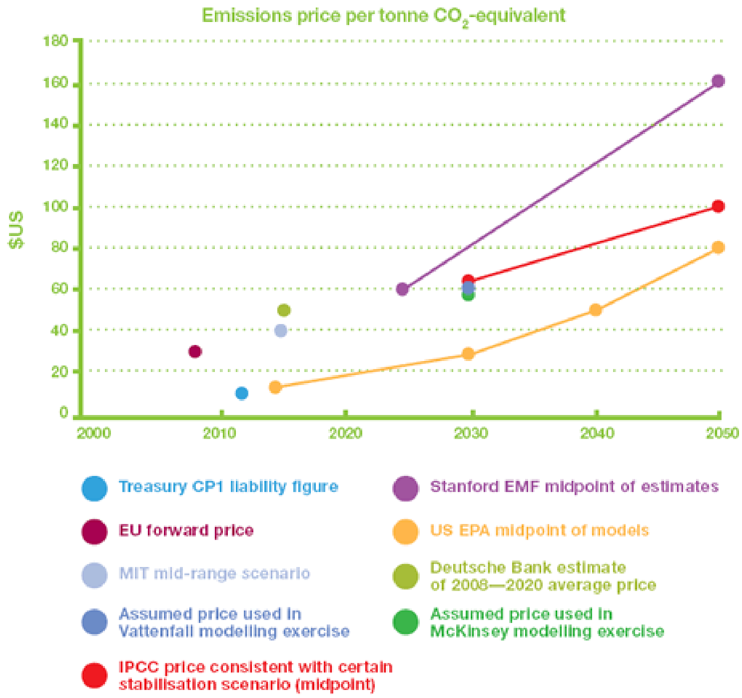



**Figure AA: GHG emission pricing according to MED**

Source: MED, New Zealand Energy Strategy to 2050 – Powering Our Future, http://www.med.govt.nz/templates/MultipageDocumentPage____32076.aspx

Exactly what the international price of greenhouse gas emissions might be in the future is the subject of a large amount of speculation and conjecture. By its very nature, the future price of emissions is a great unknown, due to profound uncertainties about the international regulatory regime, technology developments and global economic growth and income distribution. The current market price estimate used by the New Zealand Treasury in the government's 2007 financial statements is US$ 11.90 per tonne $CO_2$ equivalent.

*Item 18 –The long term cost of GHG emissions is expected to reach or just exceed the cost of abatement.*

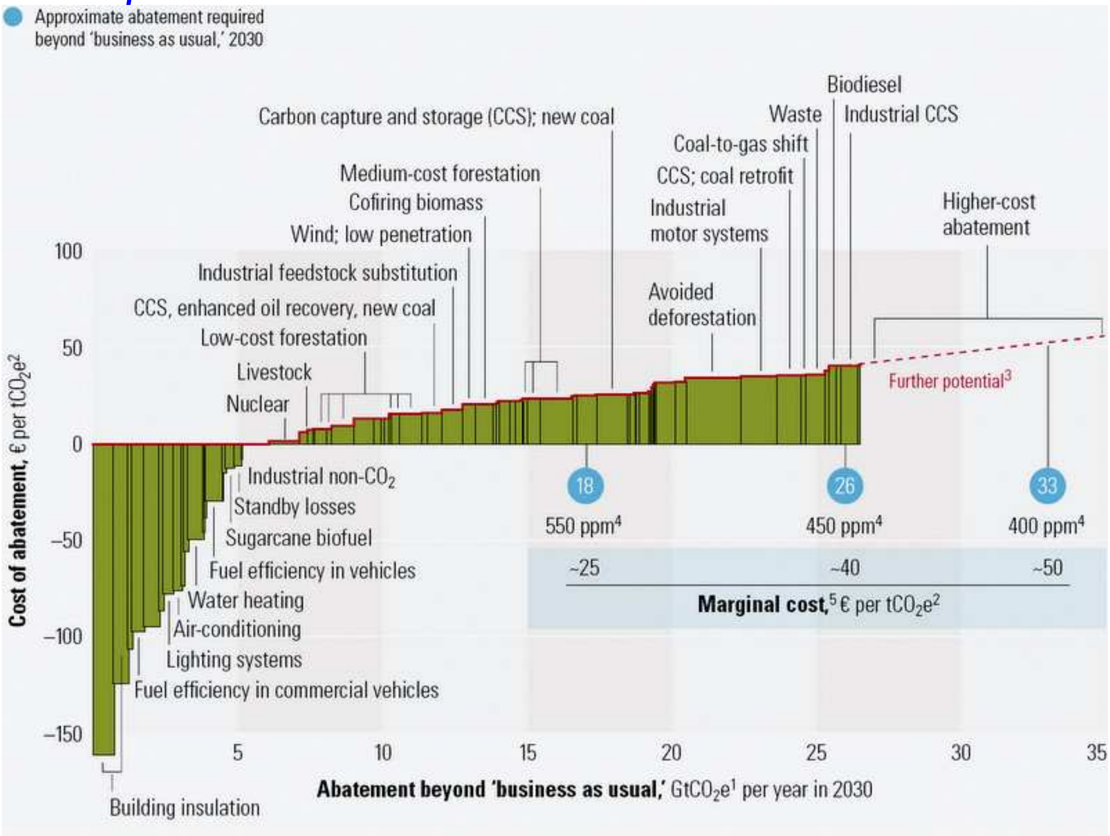



**Figure AB: Global cost curve for greenhouse gas abatement measures beyond "business as usual".**

Source: Enkvist et al., McKinsey & Company, 2007

Notes:
(1) $GtCO_2e$ = gigaton of carbon dioxide equivalent;
"business as usual" based on emissions growth driven mainly by increasing demand for energy and transport around the world and by tropical deforestation.
(2) Marginal cost of avoiding emissions of 1 ton $CO_2$ equivalents in each abatement demand scenario.
(3) The annual abatement needed to achieve stable atmospheric greenhouse gas concentrations of 500 ppm (parts per million), 450 ppm and 400 ppm of CO2-equivalents.

A number of means of estimating longer-term emissions prices have been employed by various bodies. For example, Vattenfall and McKinsey have inferred future emissions prices on the basis of derived global carbon abatement cost curves. Estimates of US$30 per tonne for 2030 were produced.

The Intergovernmental Panel on Climate Change Working Group, in its draft fourth assessment report, estimates the emissions prices associated with various atmospheric greenhouse gas stabilisation scenarios. The stabilisation scenario consistent with a maximum global temperature increase of 2ºC produced a price of US$ 100 in 2030.

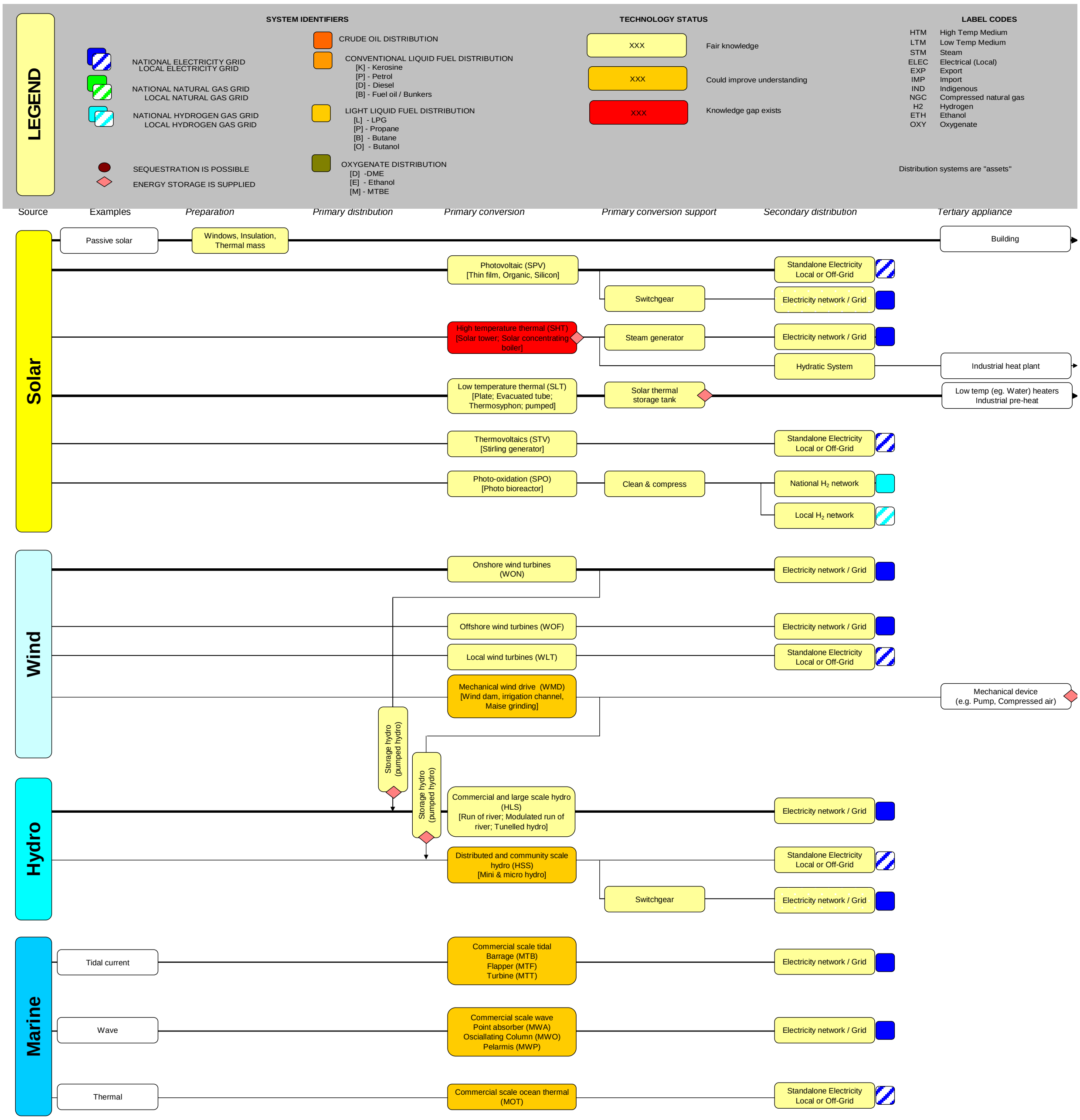
Various modelling simulations and comparative analyses have also been undertaken by universities and think tanks, producing a wide range of estimates. Generally, these techniques have produced estimates with very large standard errors.

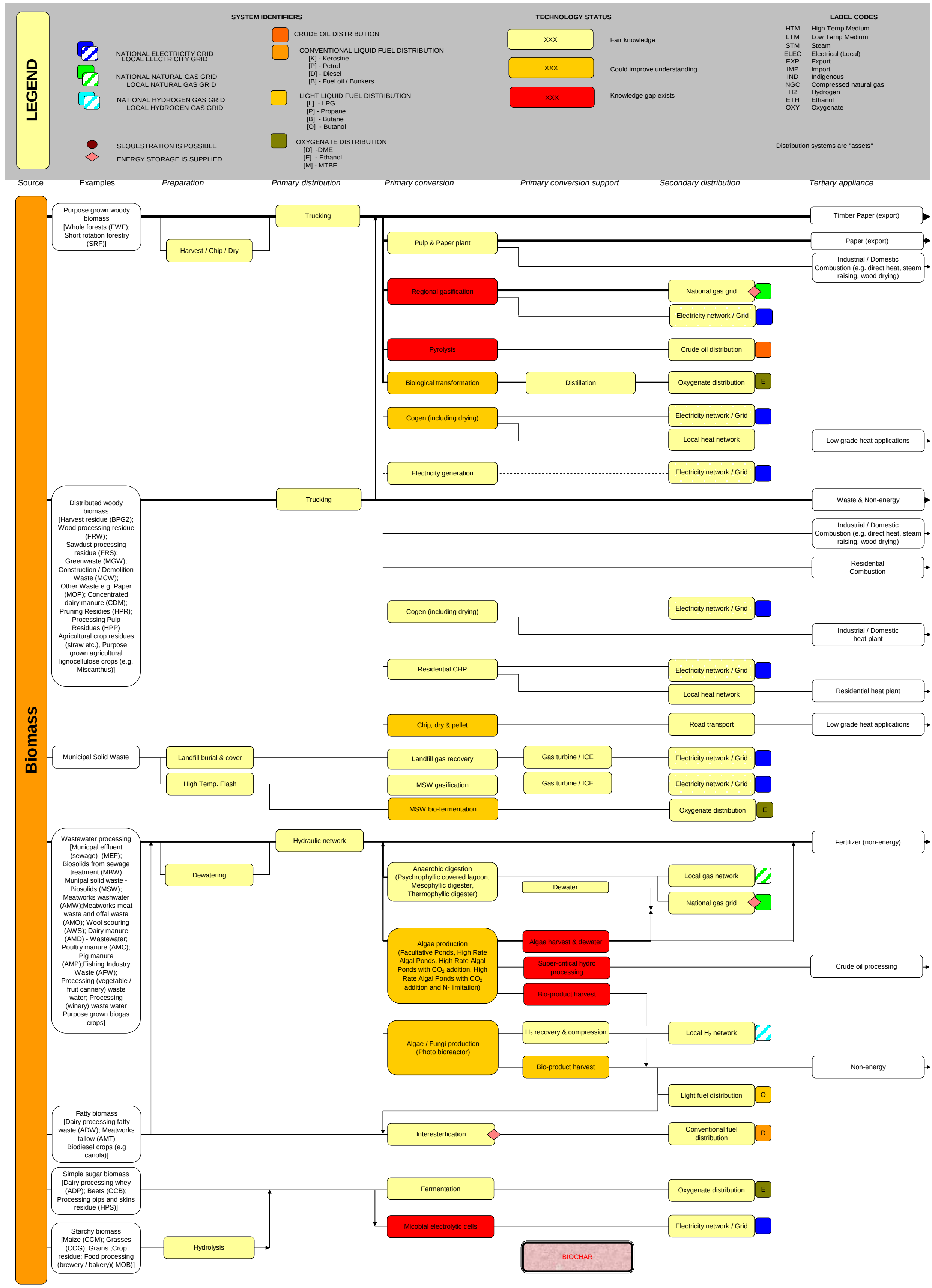
The diversity in estimates of future greenhouse gas emissions prices reflects the profound uncertainty of related factors. However, most commentators in this area broadly seem to expect the price of emissions to rise over time.

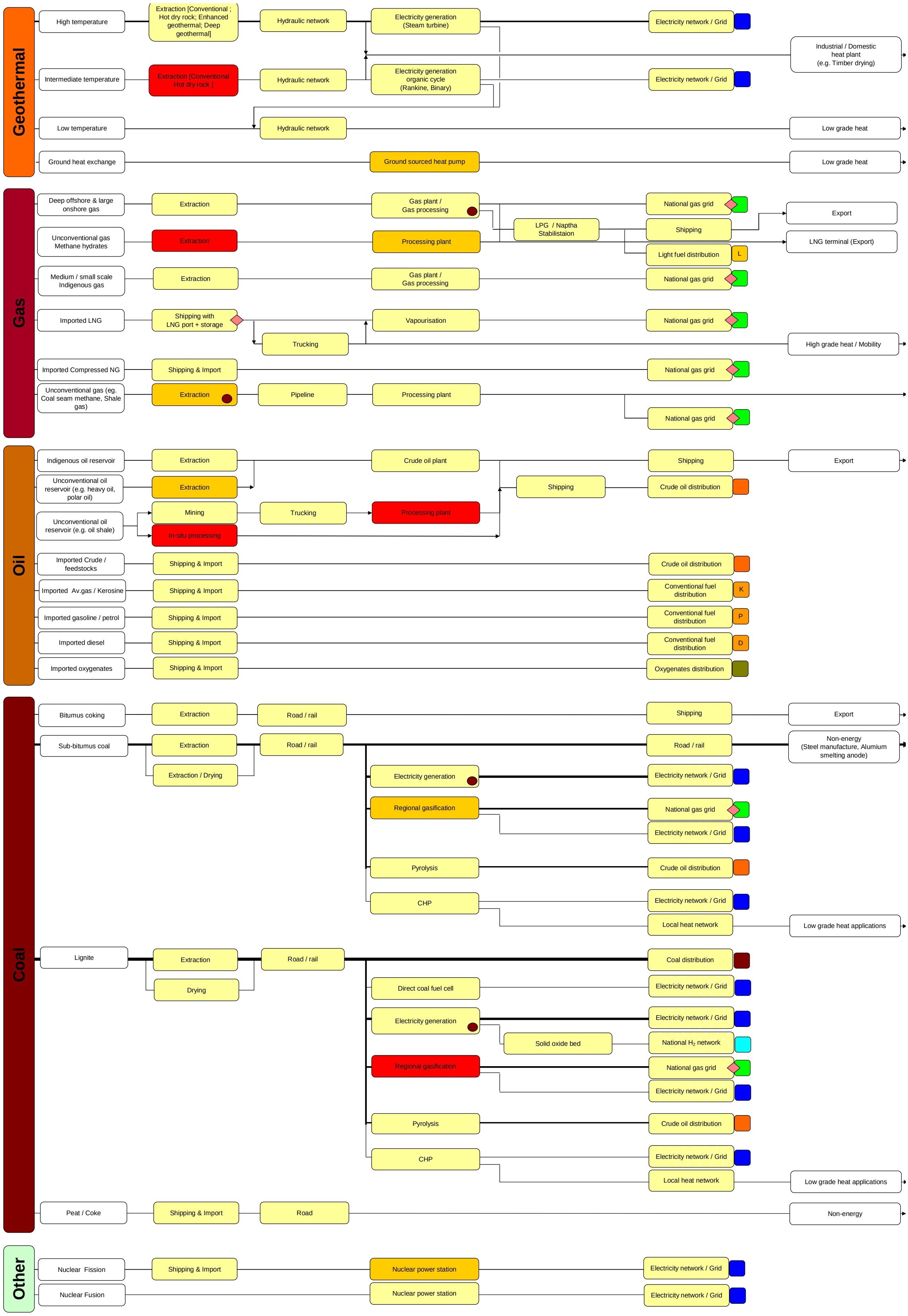
## Acknowledgement

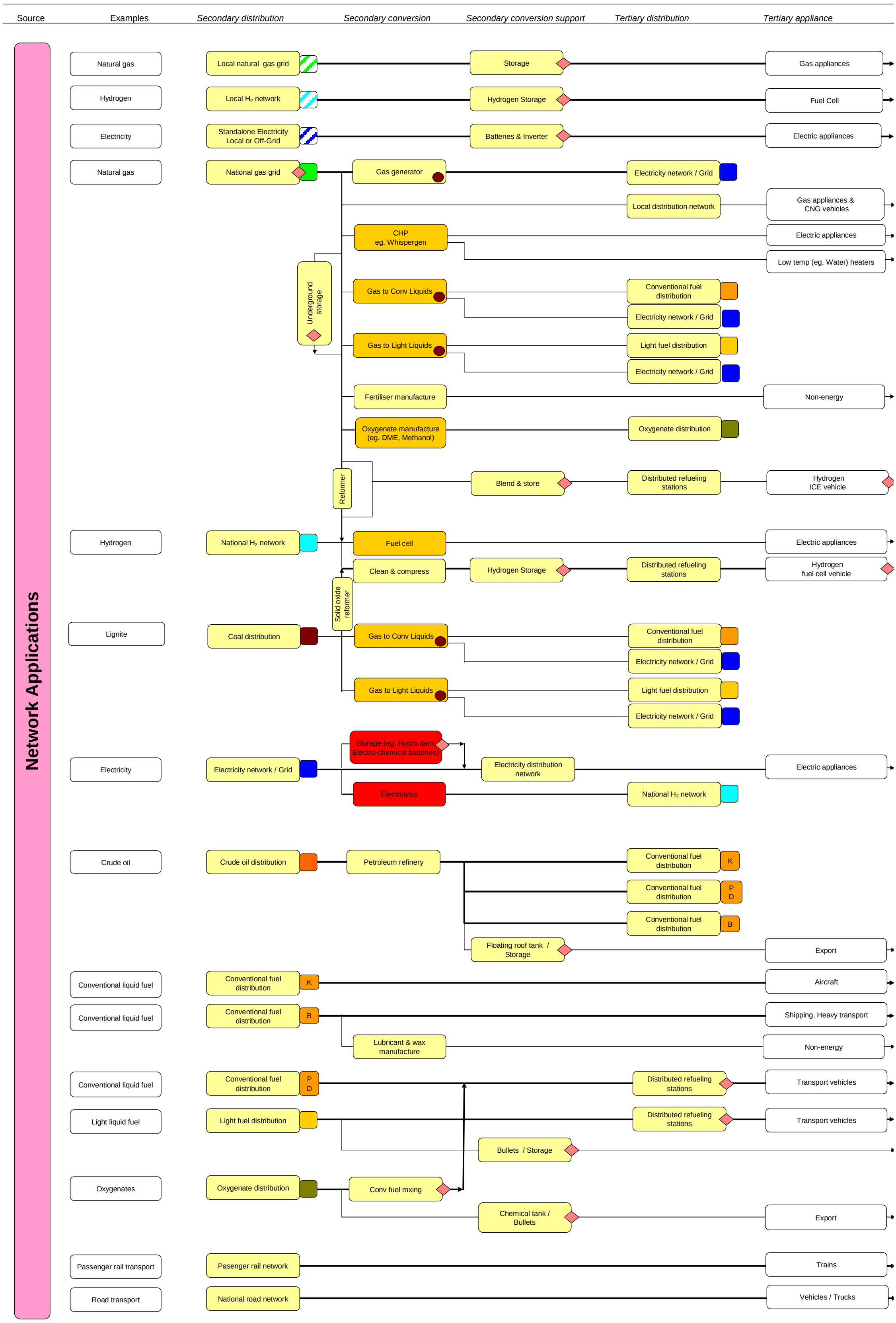
NIWA wish to acknowledge Magnus Hindsberger of Transpower, for allowing EnergyScape to adapt the questionnaire concept that he developed for the T2040 project. We found the probability questionnaire approach to be a very useful mechanism for stimulating discussion and channelling consensus.

# APPENDIX B: KNOWLEDGE GAP IDENTIFICATION BY PATHWAY MAPPING




LEGEND
SYSTEM IDENTIFIERS
NATIONAL ELECTRICITY GRID
LOCAL ELECTRICITY GRID
NATIONAL NATURAL GAS GRID
LOCAL NATURAL GAS GRID
NATIONAL HYDROGEN GAS GRID
LOCAL HYDROGEN GAS GRID
SEQUESTRATION IS POSSIBLE
ENERGY STORAGE IS SUPPLIED
CRUDE OIL DISTRIBUTION
CONVENTIONAL LIQUID FUEL DISTRIBUTION
[K] - Kerosine
[P] - Petrol
[D] - Diesel
[B] - Fuel oil / Bunkers
LIGHT LIQUID FUEL DISTRIBUTION
[L] - LPG
[P] - Propane
[B] - Butane
[O] - Butanol
OXYGENATE DISTRIBUTION
[D] -DME
[E] - Ethanol
[M] - MTBE
TECHNOLOGY STATUS
XXX
Fair knowledge
XXX
Could improve understanding
XXX
Knowledge gap exists
LABEL CODES
HTM High Temp Medium
LTM Low Temp Medium
STM Steam
ELEC Electrical (Local)
EXP Export
IMP Import
IND Indigenous
NGC Compressed natural gas
H2 Hydrogen
ETH Ethanol
OXY Oxygenate
Distribution systems are "assets"
Source
Examples
Preparation
Primary distribution
Primary conversion
Primary conversion support
Secondary distribution
Tertiary appliance
Biomass
Purpose grown woody biomass [Whole forests (FWF); Short rotation forestry (SRF)]
Harvest / Chip / Dry
Trucking
Timber Paper (export)
Pulp & Paper plant
Paper (export)
Industrial / Domestic Combustion (e.g. direct heat, steam raising, wood drying)
Regional gasification
National gas grid
Electricity network / Grid
Pyrolysis
Crude oil distribution
Biological transformation
Distillation
Oxygenate distribution
E
Cogen (including drying)
Electricity network / Grid
Local heat network
Low grade heat applications
Electricity generation
Electricity network / Grid
Distributed woody biomass [Harvest residue (BPG2); Wood processing residue (FRW); Sawdust processing residue (FRS); Greenwaste (MGW); Construction / Demolition Waste (MCW); Other Waste e.g. Paper (MOP); Concentrated dairy manure (CDM); Pruning Residies (HPR); Processing Pulp Residues (HPP) Agricultural crop residues (straw etc.), Purpose grown agricultural lignocellulose crops (e.g. Miscanthus)]
Trucking
Waste & Non-energy
Industrial / Domestic Combustion (e.g. direct heat, steam raising, wood drying)
Residential Combustion
Cogen (including drying)
Electricity network / Grid
Industrial / Domestic heat plant
Residential CHP
Electricity network / Grid
Local heat network
Residential heat plant
Chip, dry & pellet
Road transport
Low grade heat applications
Municipal Solid Waste
Landfill burial & cover
Landfill gas recovery
Gas turbine / ICE
Electricity network / Grid
High Temp. Flash
MSW gasification
Gas turbine / ICE
Electricity network / Grid
MSW bio-fermentation
Oxygenate distribution
E
Wastewater processing [Municpal effluent (sewage) (MEF); Biosolids from sewage treatment (MBW) Munipal solid waste - Biosolids (MSW); Meatworks washwater (AMW);Meatworks meat waste and offal waste (AMO); Wool scouring (AWS); Dairy manure (AMD) - Wastewater; Poultry manure (AMC); Pig manure (AMP);Fishing Industry Waste (AFW); Processing (vegetable / fruit cannery) waste water; Processing (winery) waste water Purpose grown biogas crops]
Hydraulic network
Fertilizer (non-energy)
Dewatering
Anaerobic digestion (Psychrophyllic covered lagoon, Mesophyllic digester, Thermophyllic digester)
Dewater
Local gas network
National gas grid
Algae production (Facultative Ponds, High Rate Algal Ponds, High Rate Algal Ponds with $CO_2$ addition, High Rate Algal Ponds with $CO_2$ addition and N- limitation)
Algae harvest & dewater
Super-critical hydro processing
Bio-product harvest
Crude oil processing
Algae / Fungi production (Photo bioreactor)
$H_2$ recovery & compression
Local $H_2$ network
Bio-product harvest
Non-energy
Light fuel distribution
O
Fatty biomass [Dairy processing fatty waste (ADW); Meatworks tallow (AMT) Biodiesel crops (e.g canola)]
Interesterification
Conventional fuel distribution
D
Simple sugar biomass [Dairy processing whey (ADP); Beets (CCB); Processing pips and skins residue (HPS)]
Fermentation
Oxygenate distribution
E
Starchy biomass [Maize (CCM); Grasses (CCG); Grains ;Crop residue; Food processing (brewery / bakery)( MOB)]
Hydrolysis
Micobial electrolytic cells
Electricity network / Grid
BIOCHAR


Geothermal
High temperature
Extraction [Conventional ; Hot dry rock; Enhanced geothermal; Deep geothermal]
Hydraulic network
Electricity generation (Steam turbine)
Electricity network / Grid
Industrial / Domestic heat plant (e.g. Timber drying)
Intermediate temperature
Extraction [Conventional Hot dry rock ]
Hydraulic network
Electricity generation organic cycle (Rankine, Binary)
Electricity network / Grid
Low temperature
Hydraulic network
Low grade heat
Ground heat exchange
Ground sourced heat pump
Low grade heat
Gas
Deep offshore & large onshore gas
Extraction
Gas plant / Gas processing
National gas grid
Export
LPG / Naptha Stabilistaion
Shipping
Unconventional gas Methane hydrates
Extraction
Processing plant
LNG terminal (Export)
Light fuel distribution
L
Medium / small scale Indigenous gas
Extraction
Gas plant / Gas processing
National gas grid
Imported LNG
Shipping with LNG port + storage
Vapourisation
National gas grid
Trucking
High grade heat / Mobility
Imported Compressed NG
Shipping & Import
National gas grid
Unconventional gas (eg. Coal seam methane, Shale gas)
Extraction
Pipeline
Processing plant
National gas grid
Oil
Indigenous oil reservoir
Extraction
Crude oil plant
Shipping
Export
Unconventional oil reservoir (e.g. heavy oil, polar oil)
Extraction
Shipping
Crude oil distribution
Unconventional oil reservoir (e.g. oil shale)
Mining
Trucking
Processing plant
In-situ processing
Imported Crude / feedstocks
Shipping & Import
Crude oil distribution
Imported Av.gas / Kerosine
Shipping & Import
Conventional fuel distribution
K
Imported gasoline / petrol
Shipping & Import
Conventional fuel distribution
P
Imported diesel
Shipping & Import
Conventional fuel distribution
D
Imported oxygenates
Shipping & Import
Oxygenates distribution
Coal
Bitumus coking
Extraction
Road / rail
Shipping
Export
Sub-bitumus coal
Extraction
Road / rail
Road / rail
Non-energy (Steel manufacture, Alumium smelting anode)
Extraction / Drying
Electricity generation
Electricity network / Grid
Regional gasification
National gas grid
Electricity network / Grid
Pyrolysis
Crude oil distribution
CHP
Electricity network / Grid
Local heat network
Low grade heat applications
Lignite
Extraction
Road / rail
Coal distribution
Drying
Direct coal fuel cell
Electricity network / Grid
Electricity generation
Electricity network / Grid
Solid oxide bed
National H₂ network
Regional gasification
National gas grid
Electricity network / Grid
Pyrolysis
Crude oil distribution
CHP
Electricity network / Grid
Local heat network
Low grade heat applications
Peat / Coke
Shipping & Import
Road
Non-energy
Other
Nuclear Fission
Shipping & Import
Nuclear power station
Electricity network / Grid
Nuclear Fusion
Nuclear power station
Electricity network / Grid


Source
Examples
Secondary distribution
Secondary conversion
Secondary conversion support
Tertiary distribution
Tertiary appliance
Network Applications
Natural gas
Local natural gas grid
Storage
Gas appliances
Hydrogen
Local H2 network
Hydrogen Storage
Fuel Cell
Electricity
Standalone Electricity Local or Off-Grid
Batteries & Inverter
Electric appliances
Natural gas
National gas grid
Gas generator
Electricity network / Grid
Local distribution network
Gas appliances & CNG vehicles
CHP eg. Whispergen
Electric appliances
Low temp (eg. Water) heaters
Underground storage
Gas to Conv Liquids
Conventional fuel distribution
Electricity network / Grid
Gas to Light Liquids
Light fuel distribution
Electricity network / Grid
Fertiliser manufacture
Non-energy
Oxygenate manufacture (eg. DME, Methanol)
Oxygenate distribution
Reformer
Blend & store
Distributed refueling stations
Hydrogen ICE vehicle
Hydrogen
National H2 network
Fuel cell
Electric appliances
Clean & compress
Hydrogen Storage
Distributed refueling stations
Hydrogen fuel cell vehicle
Solid oxide reformer
Lignite
Coal distribution
Gas to Conv Liquids
Conventional fuel distribution
Electricity network / Grid
Gas to Light Liquids
Light fuel distribution
Electricity network / Grid
Storage (eg. Hydro dam, Electro-chemical batteries)
Electricity
Electricity network / Grid
Electricity distribution network
Electric appliances
Electrolysis
National H2 network
Crude oil
Crude oil distribution
Petroleum refinery
Conventional fuel distribution
K
Conventional fuel distribution
P
D
Conventional fuel distribution
B
Floating roof tank / Storage
Export
Conventional liquid fuel
Conventional fuel distribution
K
Aircraft
Conventional liquid fuel
Conventional fuel distribution
B
Shipping, Heavy transport
Lubricant & wax manufacture
Non-energy
Conventional liquid fuel
Conventional fuel distribution
P
D
Distributed refueling stations
Transport vehicles
Light liquid fuel
Light fuel distribution
Distributed refueling stations
Transport vehicles
Bullets / Storage
Oxygenates
Oxygenate distribution
Conv fuel mxing
Chemical tank / Bullets
Export
Passenger rail transport
Pasenger rail network
Trains
Road transport
National road network
Vehicles / Trucks

# APPENDIX C: SAMPLE SHEET FROM WEIGHTED-SCORING METHODOLOGY MATRIX

**Energy Research Prioritisation Matrix**

Priority level

| Research area | Status: International | Status: New Zealand | Relevant science providers | Research description | Justification for research | Form of research | Justification category | Current funding ($million p.a) | Cost range ($million) | Duration (yrs) | Latest start | Knowledge gap | Innovation | Timing | Environ. | Strategic fit: Economic & Resilience | Social | NZ strength | Research value | Priority level | Concluding comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | 2 | 2 | 1 | 2 | 4 | 2 | 1 | 1 | | |
| **Energy end-use cont.** | | | | | | | | | | | | | | | | | | | | | |
| **Transport** | | | | | | | | 0.246 | $5 - 12.5 mill | 5 | 2008 | 7.0 | 6.4 | 7.8 | 6.7 | 8.3 | 8.2 | 6.0 | 6.9 | A | |
| Petrol Fuel Retail Management System | Evolving | Evolving | UC AEMS Lab | Innovation in fuel retail management system will need national government support for development and coordination of the oil, software, ICT players involved for public good and economic benefit. | MED fuel supply disruption strategy still requires solutions for fuel shortages and demand reduction for CO2 emissions. Fuel shortages highly costly and disruptive. An ICT system concept to eliminate the need for rationing has been explored and modelled. The government supported research will bring together the necessary players - oil suppy, fuel retail, software, consumer products, and regulation. Development of the ICT FRMS technology could be exported. | NZ lead (Ongoing) | | 0.001 | $0.5 - 2.5 mill | 2 | 2008 | | | | | | | | | A | Critical need for market-ordinary fuel system to avoid economically and socially destructive rationing. |
| Energy-use data (Petrol, Diesel, CNG, LNG) | Evolving | Immature | Stats NZ, MED, MOT | Develop and implement plan for improving fuel demand data collection. | Energy use measurement and statistical energy end use survey information is lacking. Trends in "absolutes" need better capture. | New Zealand lead | | | <$0.5 mill | 1 | 2008 | | | | | | | | | B | |
| + Price Effects (ETS, Volatility, Fuel Poverty) | Evolving | Immature | UC, AEMS Lab | Develop and implement improved monitoring of the elasticity between different types of price increase/decrease in different transport modes and infrastructure costs and travel demand/congestion. Develop survey method to understand transport poverty and impacts in NZ | The oil price shock of 2008 illustrated how unprepared transport is for volatility. Many experts suggest that this kind of volatility may be more common in the future. Research is needed to understand the short term mode shift and other adaptations that people and businesses make when prices rise, the lag-time in recovery when prices fall again, and the possible lasting impact on trends. This research is urgent in that councils and business need to be able to respond quickly to these price swings, and the recent price shock provides a possibility for research. | New Zealand lead | | 0.14 | <$0.5 mill | 2 | 2008 | | | | | | | | | A | |
| Transport adapability | Evolving | Immature | UC AEMS Lab | Develop survey methods and fundamental principles for assessing adaptability in a given urban form or urban-rurla network. Develop modelling methods and tools that allow transport planners to concieve of adaptable transport systems. | Reaction to 'oil shock'/peak oil. Analysis of alternatives, flexibility, etc. and impact on economy. If regional and city planners and business were able to include price shocks and fuel disruptions in their modelling, they could better plan ahead in developing policy, regulation, and adaptive transport system plans. For example, a very rapid up-take in 2-stroke scooters (as in Asia) could be an adaptive response for personal transport that would be better if anticipated and regulations put in place to regulate pollution and noise standards of imports and trafic safety regulations. | New Zealand lead | | | <$0.5 mill | 2 | 2008 | | | | | | | | | B | |
| + Freight, goods movements, Primary Production | | | UC AEMS Lab | Develop survey and assessment methods for freight. Develop technology and database management systems. Develop modelling and optimisation technology for energy efficient goods movements and primary production. Develop a freight contract transfer system (essentially "just in time" but with fuel optimisation included) the nationally manages freight movements for optimal energy efficiency. | Data and monitoring of the freight and goods movements in New Zealand is lacking. Freight hauling has been growing rapidly and is susceptible to oil price shocks. Freight has adopted "just in time" shipping from overseas. It is thought that this dispatch model is responsible for much of the increase in fuel consumption, speed, accidents, and number of trucks. Research is needed to measure these factors and to develop an improved dispatch system that can ensure energy efficiency, road safety, and economic delivery. | New Zealand lead | | 0.025 | $0.5 - 2.5 mill | 5 | 2008 | | | | | | | | | A | |
| Urban planning (Walkable developments) - Re | Evolving | Immature | UC, Sustainable Cities, OPUS, MWH… | Develop fundamental metrics and measures of "human activity and human power mode (HAHPM) capability" for urban forms. Target: implement in software that evaluates existing urban forms and proposed urban development plans. Develop transitional modelling tools to evaluate changes to existing urban forms for impact on HAHPM capability. | Urban planning choices. Are at the root of transport energy demand patterns. This reduces demand significantly. Improves resillience, improves health. Transport, Urban Design, Land Use Planning research have each been independently seeking the holy grail of "human centered" urban forms with high-speed un-congested freight and commuter flows. This line of research could use an infusion of new thinking including methods to integrate the disciplines and public/business activites. | New Zealand lead | | | $0.5 - 2.5 mill | 5 | 2008 | | | | | | | | | A | |
| Ride share systems and technologies (urban) | | | UC | Business models, social network research, and development of ICT systems to facilitate ride share coordination and implemetation. | Examples exist overseas. With some start-up research this idea could provide community-based transport resillience | Niche / commercial opportunity | | | <$0.5 mill | 4 | 2009 | | | | | | | | | C | |
| + Ride share networks for rural communities | | | | Business development research | | | | | | | | | | | | | | | | | |
| Transport future scenario development | Immature | Immature | UC | Develop scenarios for different transport development paths. Broad investigation of implications fo a wide range of possibilities is needed for public debate. Scenarios include electric vehicles, rail, electric train and tram, urban form change, 2-stroke scooters, etc. | Major use of Electric vehicles will have new and major barriers, limitations implications on electricity grid. | Applied | Focus now | 0.02 | <$0.5 mill | 3 | 2008 | | | | | | | | | A | |
| Major transport mode change drivers and polic | Immature | Immature | UC | Transport researchers have been trying to figure out what would "get people out of their cars" for 30 years. This research would focus on new ideas of system transition taking systems view, and developing methodologies that integrate transport, energy, social disciplines. | Understanding of change drivers for changes that have long lead times planning. - RECATS - long term energy risk as a function of urban form. (on-going UC research) | Fundamental enabling | Critical capacities | 0.06 | <$0.5 mill | 3 | 2009 | | | | | | | | | A | |
| **Electric Vehicles** | | | | | | | | 0 | $0.5 - 2.5 mill | 2 | 2008 | 5.8 | 6.1 | 5.9 | 5.6 | 5.8 | 5.8 | 5.2 | 5.3 | C | |
| Demand requirements from electric vehicles | Immature | Immature | UC - EPECentre, NERI | | Major use of Electric vehicles will have new and major barriers, limitations implications on electricity grid. | New Zealand lead | | | <$0.5 mill | 2 | 2010 | | | | | | | | | B | |
| Market regulation Electric vehicles | Evolving | Evolving | VUW, EECA, MED, UC | | How will electric cars, home recharging deal with road-user charges? Etc. | New Zealand lead | | | <$0.5 mill | 2 | 2011 | | | | | | | | | C | |
| Electric Vehicle Development | Mature | Immature | UC, AEMS Lab | Technology review, market analysis, survey of other countries, survey of potential manufacturers and manufacturing/product capabilities | Deep Dive needed to determine the probabilities of different scenarios for developments overseas leading to affordable electric vehicles being available in New Zealand and the timeframe. This research would include investigation of the different electricity demand requirements and technologies. May also include NZ manufacturing route Development Vector Analysis. | Fast adaptor | | | <$0.5 mill | 1 | 2009 | | | | | | | | | B | |
| Influence of battery recharge storage capacity ( | Immature | Immature | UC - EPECentre | | Major use of Electric vehicles will have new and major barriers, limitations implications on electricity grid. | New Zealand lead | | | <$0.5 mill | 2 | 2010 | | | | | | | | | B | |
| Electric Vehicle retrofit | Immature | Immature | UC, Waikato | Regulation, standards, safety, certification! Review of experience overseas, then set up a testing, safety and certification lab where training can also be established for certified converters. | Vehicles have long life times and large investment involved. Retrifit has the potential to extend/recover some of the cost . | Fast adaptor | | | <$0.5 mill | 1 | 2008 | | | | | | | | | C | |
| Electric vehicle barriers to uptake | Evolving | Immature | Govt? | This is irrelevant. Why would the government interfere in the market anymore than they would look at the barriers to uptake of fuel efficient cars? It's especially irrelevant when we don't have any electric vehicles in the market. | A change in vehicle fuels requires significant adaptation (soc./econ./env.) - no it doesn't - why are we not studying the impact and uptake of SUV's over the past 8 years? | | | | <$0.5 mill | 1 | 2012 | | | | | | | | | B | |
| Electic vehicle technologies (electric motors an | Evolving | Immature | Waikato Uni? | | Determine what is needed for skills, infrastructure, technologies etc. SK: Products are needed, that's what! If Ford wants to manufacture and sell and service electric cars, then why would the government have anything to do with their service capabilities? | | | | <$0.5 mill | 2 | 2013 | | | | | | | | | B | |
| Battery technologies | Evolving | Non-existing | | There is very low probability that NZ will become a battery developer and manufacturer of miracle new batteries. Rather, NZ will have to deal with batteries that are brought into the country in new large numbers if electric personal vehicles are imported. How will these batteries be handeled and recycled? That is the question. | Lifecycle assessment of batteries in New Zealand and Islands. What local collection and reycling systems will need to be put in place to ensure environmental impacts of greatly increased number of batteries is managed? | | | | <$0.5 mill | 1 | 2013 | | | | | | | | | C | |
| Energy and recharge (electric) infrastructure re | Evolving | Non-existing | UC - EpeCentre | Survey of charging technologies for private EV's and assessment of impact on power quality, network management, etc. | | | | | <$0.5 mill | 1 | 2009 | | | | | | | | | A | |
| Opportunities for New Zealand Businesses fror | Evolving | Non-existing | | Assessment | Lack of knowledge and good advice | New Zealand lead | | | $0.5 - 2.5 mill | 2 | 2008 | | | | | | | | | B | |
| Parts manufacture | | | | Assessment | Lack of knowledge and good advice | | | | <$0.5 mill | 1 | 2008 | | | | | | | | | C | |
| Part recycling | | | | Assessment | Lack of knowledge and good advice | | | | <$0.5 mill | 1 | 2008 | | | | | | | | | C | |
| Methanol / CNG | Evolving | Evolving | | | Domestic supplies can provide some of the demend. | New Zealand lead | | | <$0.5 mill | 2 | 2009 | | | | | | | | | A | |
| **Road network** | | | | | | | | 0 | $0.5 - 2.5 mill | 5 | 2008 | 6.5 | 8.0 | 8.5 | 6.5 | 7.0 | 7.0 | 7.0 | 6.5 | A | |
| Low carbon transport systems | Maturing rapidly, Major manufactures | Following international trend | U Canterbury | Survey and study of overseas progress, assessment of adaptation to New Zealand | Low Carbon, Low Energy Transport systems are of high interest as a quick technical fix. What is the real story? What are the time frames for new technologies? What are the probabilities of success? | Fast adaptor | | | $0.5 - 2.5 mill | 2 | 2008 | | | | | | | | | C | |
| De-Congestion | immature | Immature | Canterbury University | Development of new transportation planning modeling that handles de-congestion factors. | The recent oil price spike has resulted in de-congestion in New Zealand's major urban centres. Traditional transport planning is focused on keeping ahead of the growth in congestion through building of new roads and transport networks. If the future instability in oil supply will mean that congestion will stay the same or reduce, then transportation engineering needs an innovation in modelling and planning methods. Given the potential savings in "not" building un-needed roads, this research is vital. | Fast adaptor | | 0 | $0.5 - 2.5 mill | 5 | 2009 | | | | | | | | | A | millions potentially saved in new road build. Reduced risk exposure to peak oil effects |
| **Rail network** | | | | | | | | 0 | >$12.5 mill | 15 | 2008 | 6.0 | 5.8 | 6.8 | 6.2 | 7.6 | 7.2 | 6.0 | 7.0 | A | |
| Vulnerability to & roll in peak oil mitigation | Immature | Mature | UC | Set up data collection and monitoring systems and conduct risk assessment of rail movements | The rail system runs on Diesel. Data for energy use should be available. The UC developed method for assessing risk to energy transport systems should be used to identify the mose essential rail services and the most oil-vulnerable services. | New Zealand lead | | | <$0.5 mill | 1 | 2008 | | | | | | | | | B | |
| Re-building of the rail system | Mature | on-going | RailNewZealand, UC | R&D support for re-building of rolling stock, track, tunnels, monitoring, safety… | The NZ rail system has been run down. There are innumerable small, medium, and large problems needing a range of engineering research to find solutions. FRST could greatly accelerate the return to high performance of the national rail system if R&D support were consistently available. | NZ lead (Ongoing) | | | >$12.5 mill | 15 | 2009 | | | | | | | | | A | |
| Development of the national rail system | Mature | on-going | UC, RailNewZealand | Develop models of different future development scenarios. | Per kg-km rail is vastly more energy efficient that road and air. What are the barriers to mode shift to rail? What would the country's goods movements be like if NZ had a fully re-developed rail system with access to most urban and regional areas? What would it be like if just the main NS line was re-developed? Research is needed to examine the costs and benefits and model the freight movements that are possible, and energy demand for different development scenarios. | New Zealand lead | | | $0.5 - 2.5 mill | 2 | 2009 | | | | | | | | | A | |
| Prospects for Electric Rail Development | Mature | Immature | UC, RailNewZealand, EPECentre | Develop models of different future development scenarios. | electric rail systems are mature in Europe and Asia. They used to be more common in New Zealand. Research is needed to consider and model future scenarios for development of electrical rail transport systems in New Zealand. Overseas electric rail systems are usually on separate grid, so this research would need to dovetail with electric power research | Fast adaptor | | | $2.5 - 5 mill | 5 | 2009 | | | | | | | | | A | |
| Rail Freight Security | Immature | Immature | UC, RailNewZealand | Develop new security technology and operation methods to increase the security of freight. | One of the most common reasons cited for why freight is put on trucks rather than rail is security. When a company hires a truck company to move their goods, they are also hiring a security guard: the driver. This research will seek to find solutions, both technology and operational, to this barrier to greater rail transport | Fast adaptor | | | $2.5 - 5 mill | 4 | 2008 | | | | | | | | | A | |
| **Shipping network** | | | | | | | | 0 | <$0.5 mill | 1 | 2008 | 7.0 | 5.0 | 7.0 | 5.0 | 8.0 | 8.0 | 7.0 | 5.0 | B | |
| Vulnerability to & roll in peak oil mitigation | Immature | Mature | UC | Set up data collection and monitoring systems and conduct risk assessment of rail movements | The shipping system runs on Diesel. Data for energy use should be available. The UC developed method for assessing risk to energy transport systems should be used to identify the mose essential rail services and the most oil-vulnerable services. | New Zealand lead | | | <$0.5 mill | 1 | 2008 | | | | | | | | | B | |
| Research issues are very much related to economics of ports and shipping over other transportation methods. This is likely to be influenced strongly by new government policy in the energy area, and the instruments which are applied to encourage greater use of coastal shipping. No substantial technology developments are likely in the medium term. | | | | | | | | | <$0.5 mill | | | | | | | | | | | | |
| | | | | | | | | | <$0.5 mill | | | | | | | | | | | | |
| | | | | | | | | | <$0.5 mill | | | | | | | | | | | | |
| **Air Transport Infrastructure** | | | | | | | | 0 | $0.5 - 2.5 mill | 5 | 2008 | 8.3 | 6.7 | 8.0 | 5.3 | 8.0 | 7.3 | 7.3 | 6.3 | A | |
| Vulnerability to & roll in peak oil mitigation | Immature | Mature | UC , ANZ | Set up data collection and monitoring systems and conduct risk assessment of rail movements | The air transport system runs on jet fuel. Data for energy use should be made available. The UC developed method for assessing risk to energy transport systems should be used to identify the mose essential rail services and the most oil-vulnerable services. | New Zealand lead | | | <$0.5 mill | 1 | 2008 | | | | | | | | | B | |
| De-Congestion, or contraction | Immature | Immature | UC, ANZ, regional and city airports | Modelling of investment and operation strategy for reducing air travle demand | The recent decline in tourist numbers ends a decade of steady growth. Airports have been planning and innitating expansion plans based on projectd continued growth. A rapid re-think and re-evaluation of these decisions could be facilitated by resarch of guture oil supply and travel demand from the AEMS Lab group at UC. | NZ lead (Ongoing) | | | <$0.5 mill | 2 | 2008 | | | | | | | | | A | |
| Essentiality | Immature | Developing | UC | Develop assessement, data collection, and survey methods and analyse NZ air transport for essentiality to economy, production, health, safety | Air travel has grown steadily. What is the essentiality of the range of air trips? As prices rise, how elastic is demand for different kinds of travel? As demand reduces, how vulnerable is the continuation of enough flights to keep essential travel going? This is a unique type of research pioneered by UC which could be exported to other countries. | NZ lead (Ongoing) | | | $0.5 - 2.5 mill | 5 | 2008 | | | | | | | | | A | |
| | | | | | | | | | <$0.5 mill | | | | | | | | | | | | |
| **TOTAL FOR SECTOR** | | | | | | | | 0.2 | >$40 mill | 15.0 | 2008 | 6.8 | 6.3 | 7.3 | 5.9 | 7.5 | 7.3 | 6.4 | 6.2 | B | |

Priority level