THE APPLICATION OF SOCIAL SCIENCE RESEARCH TO PROBLEMS OF ENERGY SUSTAINABILITY IN NEW ZEALAND

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> *"To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies"*
> (Principle 8 of the Rio Convention on Environment & Development , 1992)

In addition to this agreed principle, the UN General Assembly Special Session on Agenda 21 (UNGASS/ Rio plus 5) noted that one of the priorities for the 2001 meeting would be energy. At this forthcoming session the Convention on Sustainable Development is to examine *"sustainable patterns of production, distribution and use of energy".* (from MFAT debriefing paper, 1997).

Whether we or our leaders like it or not, energy sustainability is on the international and New Zealand's agenda. Furthermore, according to Morgan Williams, the Parliamentary Commissioner for the Environment, in a recent address at Lincoln University – energy efficiency and sustainability is one of the main environmental issues facing the country. However moving towards increased energy sustainability will present a major challenge to New Zealanders.

In this paper I present some of the keys issues, and outline some examples of how social science research is currently helping to answer the key questions of

- how we currently use energy?
- what needs to change to bring about increased sustainability?
- how can we bring about such change? and
- what is stopping us from developing technologies, and adopting existing technologies, which are cleaner, more efficient, and sustainable.

Rather than catalogue the outcomes of this research, I have chosen to present some background on the purpose of the work, and the way in which it was carried out. But first I'd like to review some features of the NZ energy sector, and identify some of the sustainability challenges before us.

Key issues in NZ Energy Sustainability

In terms of moving towards increased energy sustainability, New Zealand faces four sets of issues.

1. A high proportion of NZ's primary energy requirements (approximately 71%) are being met from non-renewable sources (Figure 1). This particularly applies to
   - Road, rail, air and sea transport – (apart from parts of the railway system, and some city bus services), where we rely heavily on imported hydro-carbon fuels (figure 2)
   - Electricity generation – where natural gas and coal burning make up approximately 28 % of all generation. (figure 3)
   - The use of our own natural gas supplies for industrial, commercial and residential purposes (figure 4).

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Figure 1

Figure 2

Figure 3

Figure 4
Gas consumption by sector

2. New Zealand gets 65% of its total electricity supply from hydro generation and 6% from geothermal sources. We tend to consider hydro power as "renewable" in that we expect to have sufficient ongoing supply of water in our river systems (derived from snow melt and rainfall) to go on producing power indefinitely. However hydro generation has limits that need to be acknowledged due to
   - eventual siltation of existing hydro dams
   - competing demands for available water
   - the limited number of potential sites for new hydro power stations
   - the potential effects of global warming on our climate
   - the high capital and environmental costs of establishing new power stations.

3. Our ongoing use of domestic stocks of natural gas, which we burn for electricity generation and other purposes, is limited – particularly due to
   - the limited life of the Maui field, which supplies over 75 % of our gas demand, which is expected to be exhausted around 2006.
   - the burning of fossil fuels is changing the worlds climate, and we have international commitments to reducing our greenhouse gas emissions.

4. On top of these problems, we have an increasing demand for energy – especially transport fuels and electricity. For example, according to EECA statistics, between 1991 and 1998 energy use by the transport sector increased by 28%, or an overage of 3.6% per annum (figure 5). While there are encouraging signs that non-transport energy use is declining slightly, and that economic growth is being achieved without increases in overall energy consumption (i.e is becoming increasingly more energy-efficient), per capita energy use has been increasing at about 0.6% per annum over the past 10 years (figure 6).

   It could be said that, compared with other developed countries, we are relatively inefficient, even wasteful, energy users. For example, the 1997 NZ Yearbook noted that "New Zealand's energy intensity (measured as energy use per dollar of GDP) is amongst the highest in the OECD" (figure 7).

   Particular issues include
   - The lack of incentives or requirements to save energy while the supply is good. This is compounded by power prices which are artificially low because we fail to build in the environmental costs of establishing and running generating stations.
   - Recent NZ governments have backed off from taking strategic responsibility for energy supply and demand, and have failed to foster a culture of energy sustainability or even efficiency.
   - Public awareness of sustainability might be high, but our behaviours, including purchasing choices, show little sign of changing towards more efficient use of energy.
   - There is relatively little R&D effort going into to understanding patterns of consumption; to investigating and developing clean sustainable energy supplies and energy- using technologies; and how were might be able to move towards increased sustainability.

Figure 5
Consumer energy use by sector

(source: EECA, 1999)

Figure 6
Total Consumer Energy Use per capita IEA Countries

figure 7
Total Consumer Energy to GDP Ratios for IEA Countries, 1995

Social Research and Energy Sustainability

For the rest of this paper, I'd like to focus on three sets of energy related work that I have been involved with as a research scientist since 1994, and which have attempted to address the key questions outlined above. All of these efforts have been supported by the Public Good Science Fund. In each case my formal role has been as a sub-contractor, though in practise I functioned as a member of an interdisciplinary team ranging from two to six members and contributed to the development of the research proposals and the research designs.

These three sets of work have been:

1. A ongoing systematic attempt to gather information on, and understanding the end use of energy, particularly electricity, in New Zealand homes, in order to identify how we can change demand and increase energy efficiency in the residential sector.

2. An investigation of the kinds of energy efficiency technologies and practises that NZ householders have adopted, or might adopt, and under what circumstances.

3. An investigation of the impediments to the uptake of new, sustainable energy technologies in New Zealand.

Understanding and Modelling Residential Energy Use

To move to increased sustainability in the residential sector we need good information on how and when energy is used in our homes, who uses it, and how efficient this use is. However for some years energy managers have faced the problem of a lack of detailed information on energy end-use in NZ homes. The last comprehensive information gathering was done in 1972 by the Department of Statistics[2]. Historically energy use in houses was considered to be mainly related to the thermal performance of the building, the efficiency of the space heating system, the hot water system and other appliances (Stoecklein et al, 1996). However international studies have shown that only about a half of energy use in homes can be accounted for by physical factors – so logically, energy use has a lot to do with the householders and their behaviours.

In 1994, Industrial Research initiated a new study of the end use and time of use of electricity in homes in Christchurch. This was intended to begin to plug the information gap noted above, and to provide data for the design of energy conservation and efficiency measures for the domestic sector, and other demand-management interventions. In other words, to assist in moving towards increased sustainability.

My involvement began with a search of the literature on the social aspects of domestic energy use. It revealed that there was (and still is) very little published research based on actual measured household consumption, and the social factors affecting this consumption. It also confirmed the historic concentration on describing and modelling the physical and technology factors. Around the same the Energy Efficiency and Conservation Authority (EECA) convened a national workshop to examine the development of a national database on household energy end use. This workshop identified that there were potentially five interacting sets of variables making up the household energy use "jigsaw":

- energy supply factors, such as: availability of different types of fuels, market characteristics, tariffs, institutional arrangements, and system load profiles;
- energy end uses in the house– and the available opportunities to consume energy including, for example: appliance inventories, appliance characteristics, actual measured use, duration and pattern of use;

[2] Department of Statistics (1973). Report on the Survey of Household electricity Consumption 1971-72. Department of Statistics, Wellington.

- the physical environmental factors , including: location, climate, characteristics of the house itself, immediate environment of the house, insulation and physical energy properties of the house;
- social, cultural and economic factors, such as: number and characteristics of the occupants (age, ethnicity, education, gender, life stage), income and expenditure, health status, lifestyle, and patterns of occupancy;
- attitudes, perceptions and behaviours of the occupant- consumers, including: expectations of comfort and service, attitudes to energy use and conservation etc, awareness and perceptions of energy issues, skills and knowledge, relevant life patterns, and energy management and related behaviours.

(Taylor Baines, 1994)

This "jigsaw" of potential factors, along with the small amount of previous research in New Zealand, was used as the basis for designing the data gathering for our study. Data was collected in two ways:

- Non-intrusive continuous metering of total electricity use for a sample of 34 houses in Christchurch, using small computers or data loggers which recorded consumption for each half hour of every day – over 1994/95.
- Completion of a face to face questionnaire covering the many factors listed above, accompanied by physical observations of the property.

The consumption data was subsequently consolidated for seasons, weekdays and weekends, and three periods through the day. Detailed daily patterns of consumption were pictured as "load profiles". The questionnaire data provided a comprehensive picture of the houses, fittings and appliances, the occupants, their living patterns and energy-using and managing practises and behaviours, their opportunities to consume, and their attitudes. These various characteristics and patterns were then examined in relation to the actual recorded energy use and the time of use in order to identify significant relationships. From this analysis attempts were made to develop statistical models of the key factors in consumption .

This work was complemented by a programme of measuring electricity use at the neighbourhood level (using loggers attached to a sample of local feeder substations) and relating this to the characteristics of the neighbourhood as recorded in the Census of Population & Dwellings.

Subsequent household-level end-use studies in the IRL programme involved analysis of household questionnaire and household-level consumption data for approximately 100 houses gathered by Southpower over the 1995/96 period. Southpower had initially collected this data, using the IRL methodology and questionnaire, for marketing and energy management purposes. At the same time IRL began the continuous logging, in 10 houses, of electricity consumption for each of the main end-uses (i.e. circuits and appliances – such as water heating, laundry appliances, refrigeration, lighting, and space heating,) along with indoor and outdoor temperature – enabling a more detailed picture of end uses to be built up. The patterns and levels of consumption for each major use were examined according the social and physical characteristics of the householders and the dwelling.

Because of the high cost of installing and reading the sophisticated meter-loggers it was only ever possible to have a small sample of households being studied at the detailed "circuit and appliance level" at any one time. In 1996/97, BRANZ also became involved in household energy use studies, with the research effort co-ordinated through EECA's Household Energy End-use Project. From 1998 BRANZ took over the overall research effort, and the number of households being studied in varying locations increased. These recent efforts have been examining gas and solid-fuel use, along with electricity.

From this patchwork of generally complementary data gathering, various preliminary statistical models incorporating the key pieces of the "jigsaw" have been developed. These confirmed that the social characteristics and behaviours of households are often the most important factors in determining different types of household energy consumption. In addition, these studies have provided considerable insight into opportunities for energy conservation and efficiency in New Zealand homes.

The Potential for Implementation of Demand Management Within NZ homes

In order to move towards increased energy sustainability in the residential sector - where literally millions of people make regular and apparently insignificant, but cumulative, resource consumption

choices – we need to understand what might cause people to voluntarily adopt practises and technologies which would bring about greater efficiency in their consumption, or enable them to reduce consumption. Effecting such change – voluntarily, through pricing mechanisms, or involuntary regulation of consumption and appliance use - is generally referred to as demand-side energy management. This research, conducted in 1998, therefore aimed to assess the likely adoption of, or reaction to, a range of electricity demand management strategies by New Zealand householders.

In formulating the research we were anticipating changes in the electricity supply sector designed to bring about increased market competition, and the eventual introduction of new metering systems which, among other things, might enable consumers to purchase their power from a range of suppliers depending on the tariff at any particular time of day or year. The study also sought to build on and complement previous and ongoing research into energy use in the residential sector and the social determinants of use (outlined above).

Using a geographically representative sample survey (413) of Christchurch households, the study specifically aimed to identified which types of incentive, motivation, or education would be required among domestic consumers to modify their demand for electricity services, the energy technologies and products/services they used, and the time of their use/energy usage.

The survey covered

- household profile, including size, composition, household and family type, income, dwelling tenure, length of occupancy of the current dwelling, and main means of home heating, as well as the occupation, age, and education of the person completing the questionnaire;
- perceived and actual household electricity consumption;
- current electricity saving practises and reasons for their adoption;
- likelihood of adoption of electricity saving practises under various scenarios of power price increase, incentives, and information provision;
- likelihood of shifting time of use under peak time price increase scenarios;
- suitability and perceived credibility of information sources on electricity saving, including perceptions of appliance labelling; and
- appliance-purchase decision making.

Some of the findings

Figure 8 Potential Uptake of energy Saving Chnages with Power Price Increases
-

Figure 8 indicates that there is already a high level of adoption of commonly understood efficiency and conservation measures, and little is to be gained by trying to broadly promote or induce uptake of measures which achieve apparently trivial energy savings, or which require the householder to compromise their general comfort, or which entail considerable capital outlay (but which might save considerable amounts of energy). However there is scope for bringing about or promoting the adoption of lower cost measures (such as additional insulation of hot water cylinders).

Figure 9 indicates that significant changes in the price of power at peak demand times could bring about a considerable change in the timing of use (away from the peaks) – especially activities which are not time-of-day dependent.

Figure 9 Potential Uptake of Load-Shifting Measures etc

Figure 10 relates to trust in sources of information about how to save electricity. As can be seen, tradespersons, manufacturers, and retailers (those most likely to be at hand and offering advice) are the least trusted, while consumer organisations enjoy a high degree of credibility. This is consistent with the findings on the best places to receive information on energy saving (figure 11)

Figure 10 Proportion of Households Indicating A great Deal of Trust etc

Figure 11 – Proportion of Households Considering Means of Supplying Information etc

Finally, an interesting finding from the study was that the much advocated "star rating" of appliance energy performance (found as labels on some appliances) was very poorly understood by the population – only 4%, and 15%, respectively, demonstrated a full or general understanding of these types of labels, and their purpose.

Overall this work has helped understand what kind of energy efficiency/saving practises might be adopted in NZ households and under what conditions, and how to target the promotion of increased sustainability.

Barriers to the Uptake of New Energy Technologies

This research was commissioned by the Foundation for Research Science & Technology to address an apparent problem of lack of uptake of new and emerging energy technologies in New Zealand. It sought to answer, from a range of perspectives, the following:

- What are the impediments to uptake?
- Why are they viewed as impediments?
- In what decision-making contexts and at what levels of decision-making are they viewed as impediments?
- Which evaluation methods and decision-making tools might be useful, and how can existing tools be made more relevant to the needs of various stakeholders?

In attempting to answer these questions the research sought to provide a better understanding of the issues, barriers and opportunities surrounding new energy technologies; to enhance planning and risk management for future energy delivery in the context of local, regional and national groups, agencies and organisations; and in terms of likely developments in the patterns of supply and demand, to facilitate the entry of such technologies where appropriate.

The research was conducted by a multidisciplinary team of six scientists –from engineering, energy physics, resource management, and myself as a sociologist/anthropologist. Overall the work was seen as a social research exercise. In addition, a multidisciplinary reference group was established to guide the research, with members drawn from government agencies, universities, energy companies, and the private sector.

Contrary to the assertions of some fundamentalist dry economists in government agencies that there was no problem and that the market was simply doing its thing, the team and the reference group felt that the issue of slow adoption of the new technologies was significantly more complex, and needed to be understood systemically. A soft systems methodology[3] provided a possible way to move through and understand the complexity, while involving the various stakeholders. We also believed that that the knowledge about impediments already existed within the industry and our job was to collate and organise it in a meaningful way (Sanders et al, 1998).

Through workshops, the team scoped the new technology problem situation as it saw it, and the range of potential stakeholders. This lead to the organising and conducting of a series of focus groups in different parts of the country – drawing together a range of people with experience of dealing with new technologies – spit into innovators/inventors & researchers, financiers, commercialisers/marketers and retailers, small-scale users, large-scale users, policy-makers, and advocates. The questions put to these discussion groups varied according to the focus – but generally covered experience with new energy technologies, people involved and the nature of the interactions, motivations and perspectives, and issues and problems faced. These discussions were written up in detail then analysed by the team together. From the focus groups it was recognised that new energy technologies included supply or demand energy technologies, particularly renewables and energy efficiency technologies that are close to full

[3] See Checkland, P. (1981) Systems Thinking, Systems Practise; and Checkland, P. & Scholes, J. (1990) Soft Systems Methodology In Action. Both published by John Wiley & Sons, Chichester.

commercialisation, and that technology also included management systems and software, and was not limited to hardware alone.

The team then subjected the focus group proceedings to a soft systems analysis, identifying, through a series of iterations, seven interacting "human activity systems" associated with technology adoption (figure 12). Note that human activity systems are not organisational descriptions - actual organisations in the real world (individuals, groups, businesses) often operate across several of these activity systems. (Baines et al, 1998).

Figure 12: Human Activity Systems in Technology Adoption

Each of the activity systems was then defined and described according to the CATWOE categories used in the soft systems methodology, that is in terms of

- Customers (direct beneficiaries or victims),
- Actors (people/organisations carrying out the activities),
- Transformations being affected,
- World view prevailing (roles, norms, values at work),
- Owners (those likely to gain from changes or improvements), and
- Environmental constraints.

This analysis, when compared against the experiences of the focus group participants and the reference group, immediately threw up points and areas of conflict, mismatch of understandings, expectations and knowledge, institutional and organisational purposes and procedures, and resources – and provided pointers of what changes were needed to enable new energy technologies to be successfully adopted in New Zealand.

The issues were then explored further through personal interviews. These were complemented by detailed case studies (involving interviews with stakeholders within each of the human activity systems) of six new energy technologies, including: a water heating innovation, a heat pump system, a wind turbine development, energy performance contracting (a management technology), an electric mobility scooter, and compact fluorescent lamps. The case studies provided additional insights into the human activity systems and the various types of impediments to new technology uptake, resulting in refinement of the overall model. The work produced a range of immediately useable outputs, including a series of "helps" for those attempting to progress a technology through to successful uptake. The challenge now remains for government and its agencies, providing they see a strategic role for themselves, to take on board the findings, and find means for dealing with the impediments to the adoption of those new energy technologies which could move us towards greater sustainability.

Concluding thoughts

The examples of the research outlined above illustrate how social science perspectives and methods can be brought to bear on problems of energy sustainability in New Zealand. Each of these efforts occurred because the Foundation for Research Science & Technology recognised, in the funding provided, the need for research on energy sustainability issues and resource management. They also occurred because the research providers recognised the need to have social science input to their research projects, and through a multidisciplinary approach, to integrate this with other efforts. Such multidisciplinary research is essential to solving the complex problems inherent in moving towards greater environmental sustainability, while maintaining and enhancing opportunities for human development. However greater efforts are required by science providers to disseminate and use the findings from the work – one of the weaknesses of the projects described.

Unfortunately, scientists, and even many social scientists, seem unable or unwilling to grasp that environmental and resource sustainability issues are social issues – that people generate demands on our natural environment through need, want or greed, and in so doing generate consequences for themselves and others around them that have to be understood, managed and remedied. Disciplinary bunkering, combined with meta-ignorance, means that there is insufficient attention paid to, and resources provided for, social research on environmental and natural resource issues. Greater effort is required to understand the demand-side of our environment and resources and the implications and impacts of these demands. If we are to be serious about applying science to enable New Zealand to move towards greater environmental sustainability, we must therefore also begin to address the institutional and intellectual barriers which prevent science from adopting cross and multidisciplinary modes of research, and which relegate social science to a tack-on support or "market research" role.

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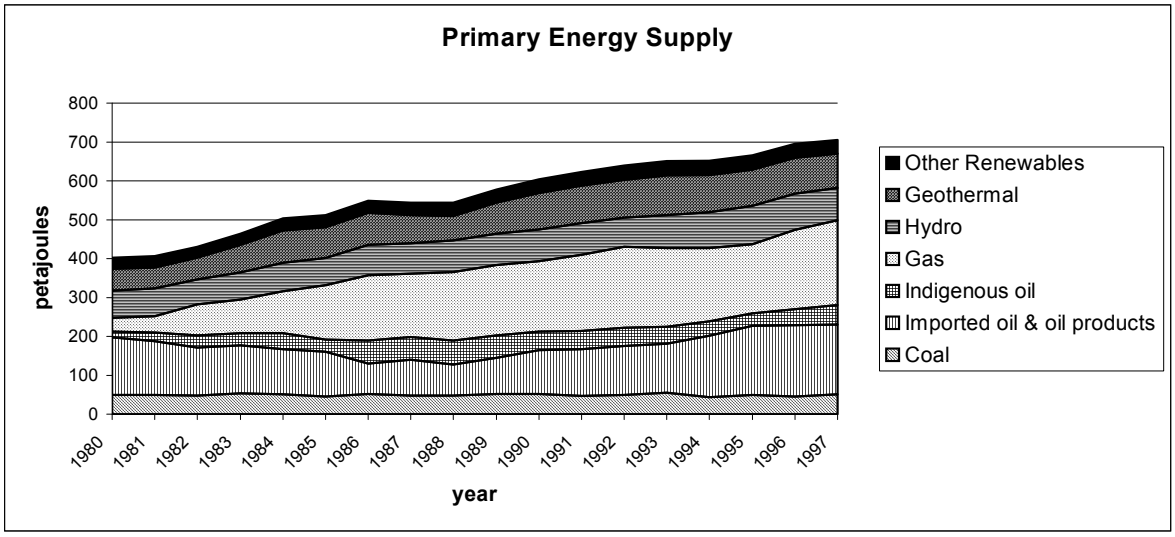
Figure 1



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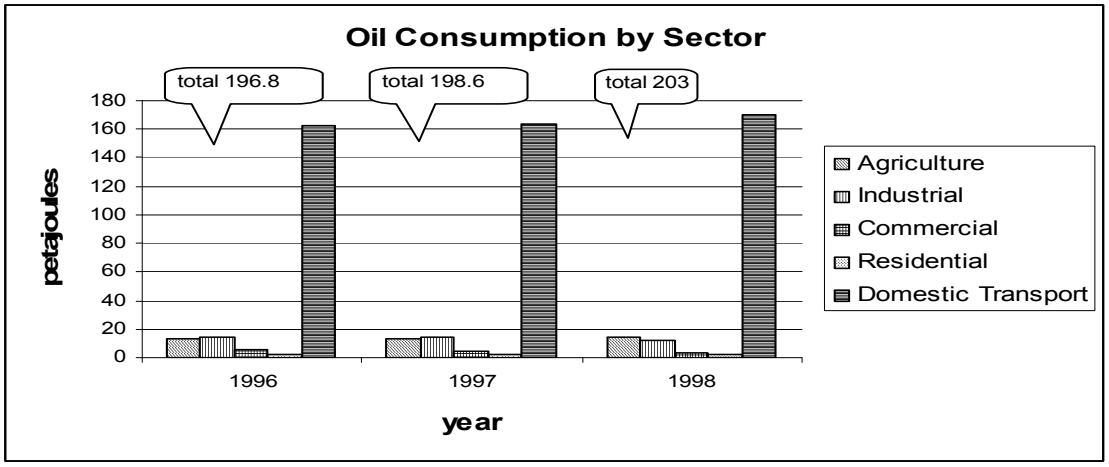

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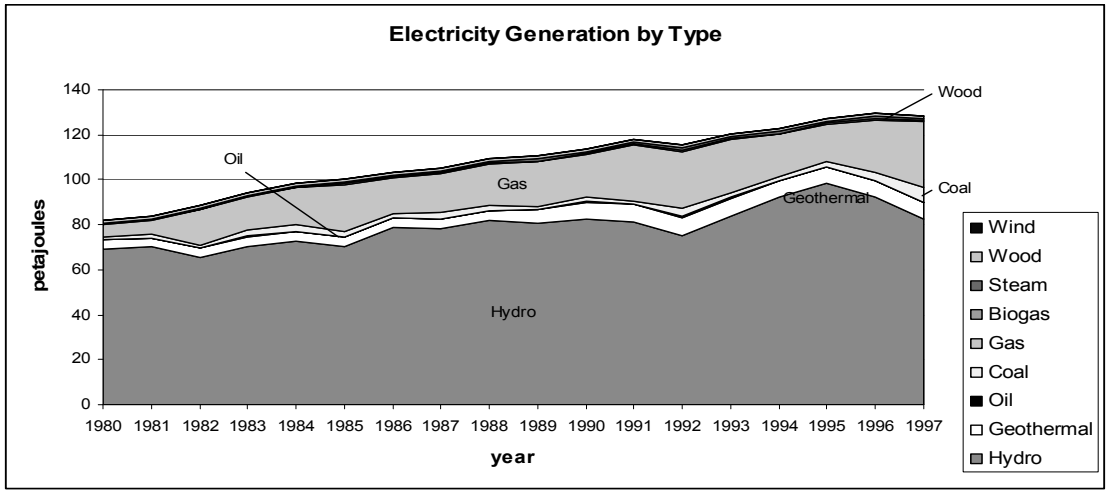

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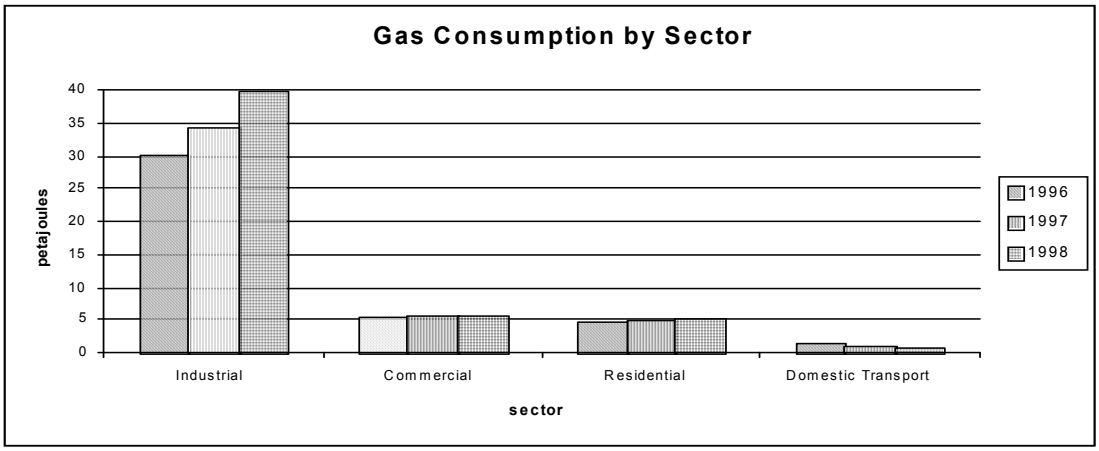

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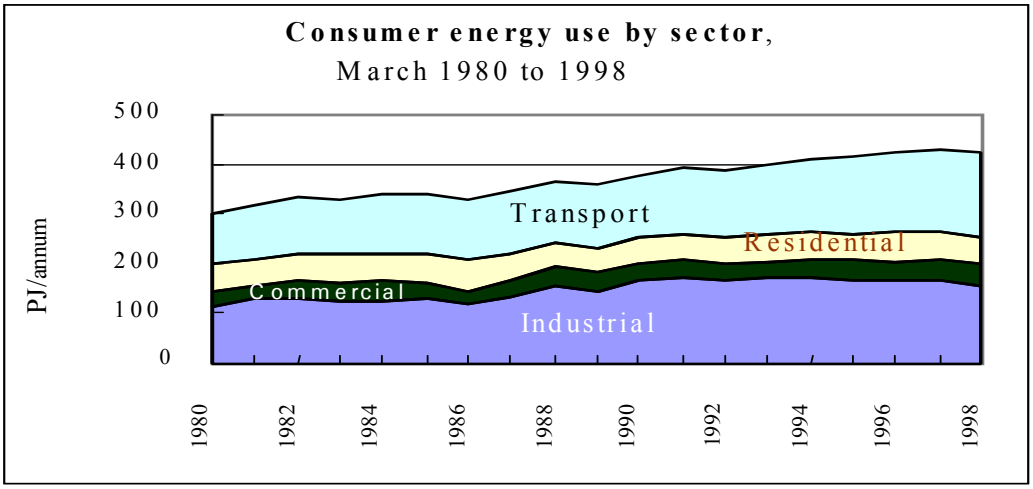

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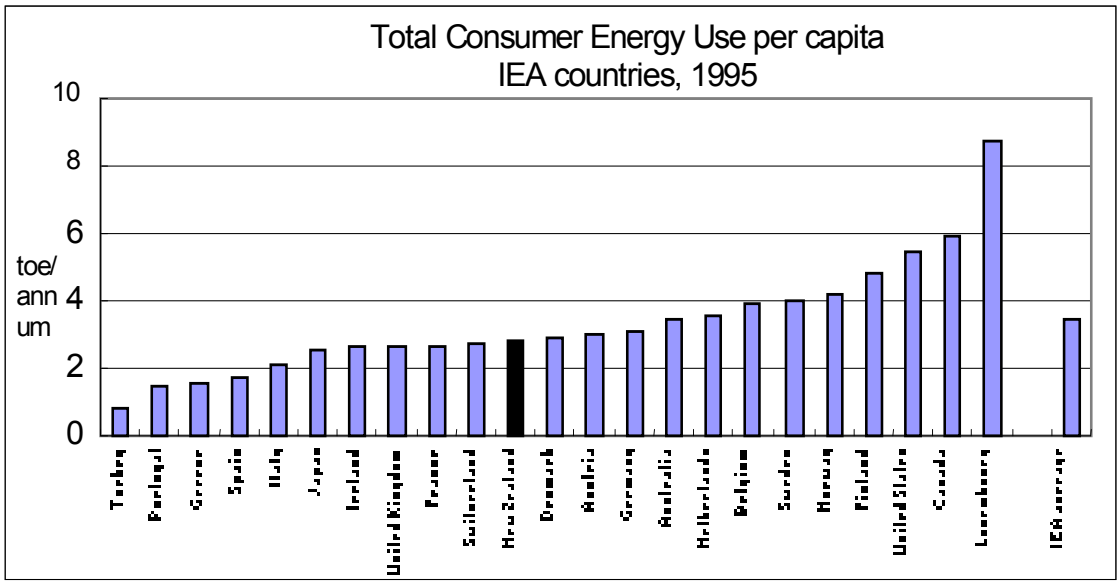

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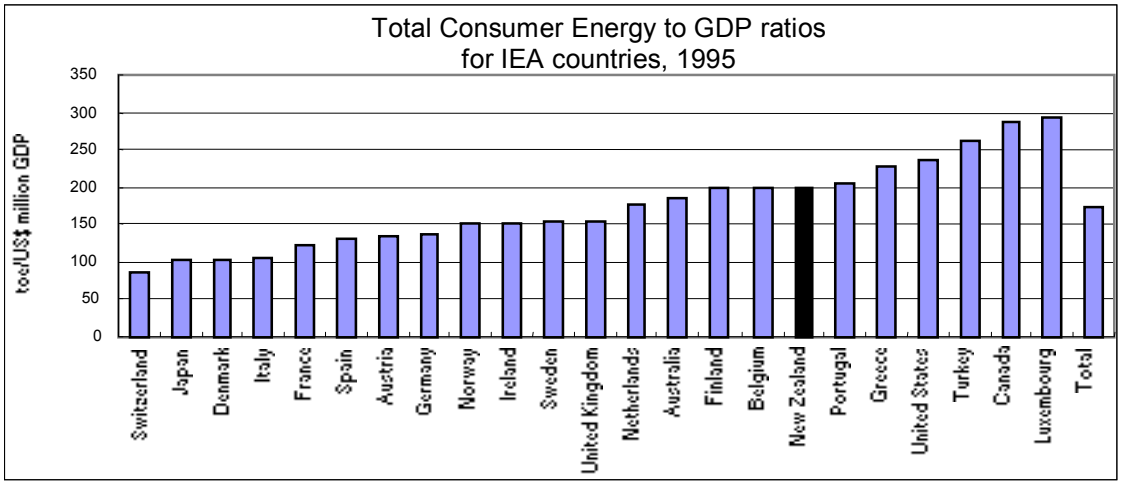

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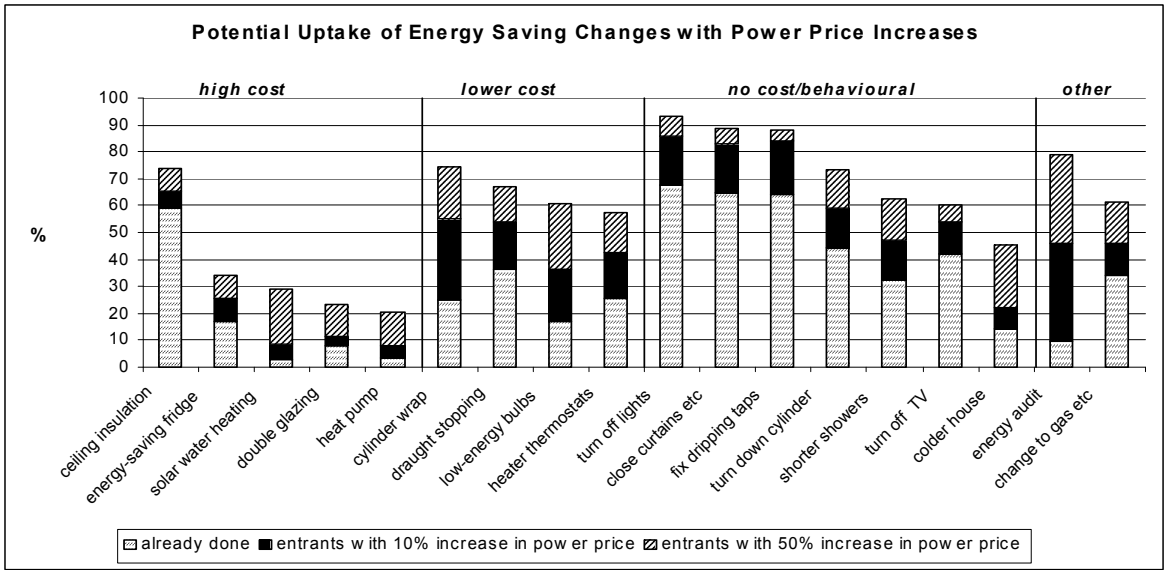

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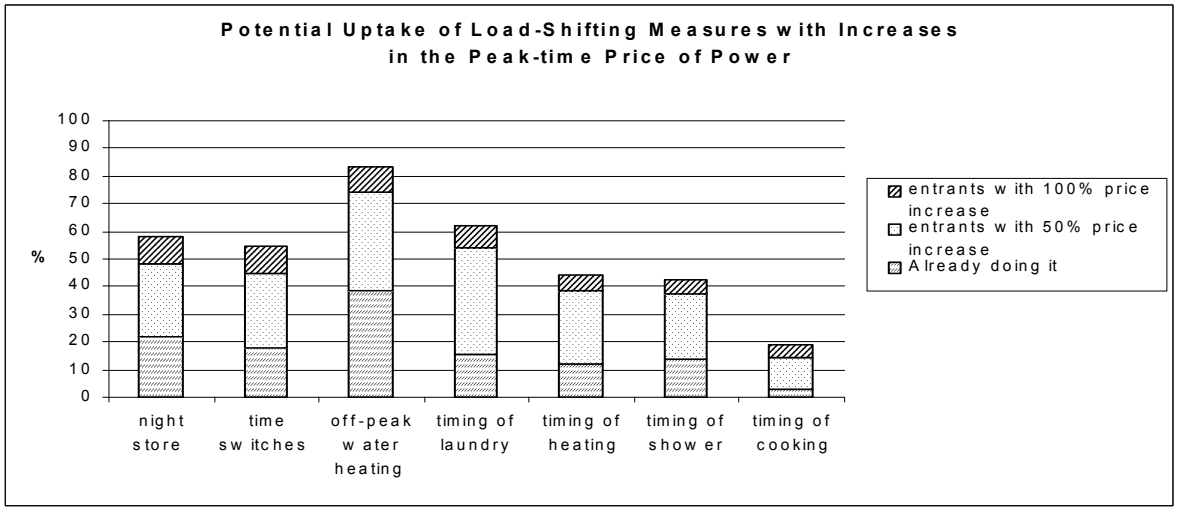

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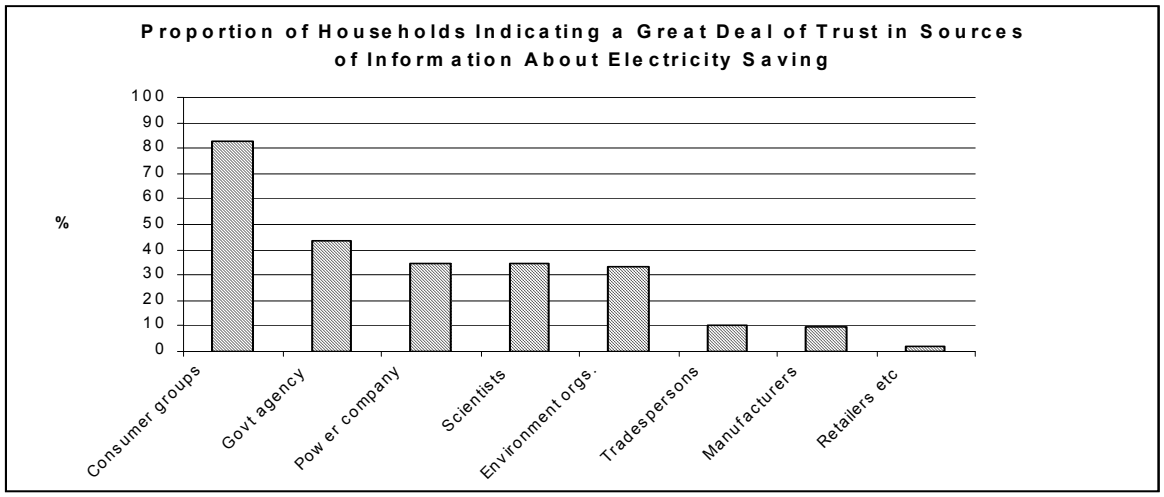

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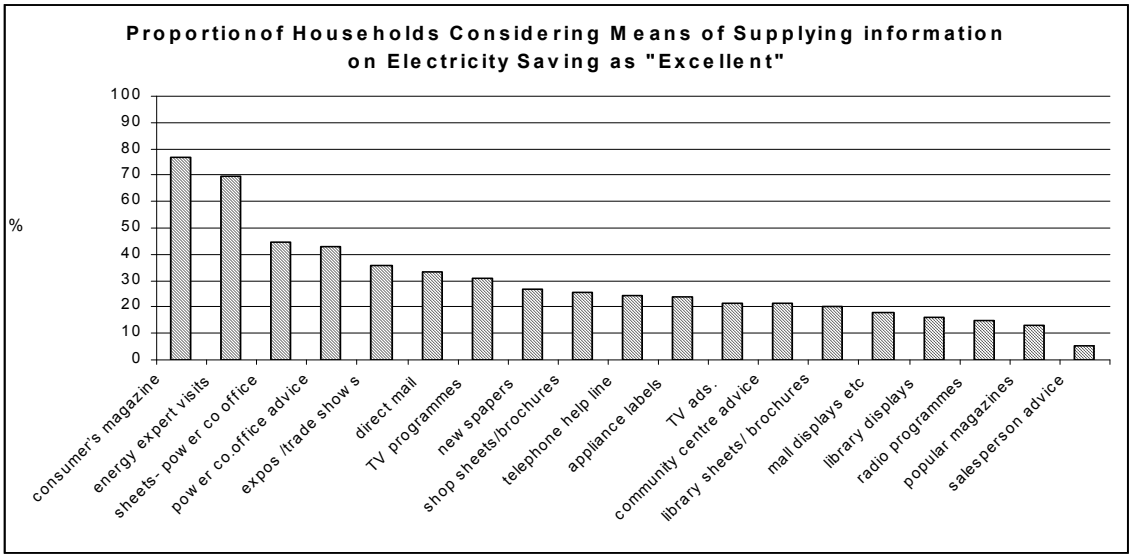

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