The Development of a Long-Term Energy Model for New Zealand

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Abstract

Long-term planning is often required for energy developments, however changes to energy markets over the last decade in New Zealand have left a large gap, which emphasis on short-term market issues. This paper outlines the preliminary steps that have been taken to develop a long-term planning model that will be useful not only to industry but also to regulators. This is especially important, for example, with the signing of the Kyoto Protocol to reduce greenhouse gasses and the transition from gas to coal as the marginal fuel for electricity generation.

The MARKAL model being developed is a general equilibrium model, and has been successfully used overseas, thus minimising the cost of development. It is hoped that its use can lead to better planning within the energy industry and more appropriate regulation. Such a model can look about 50 years ahead.

The main requirements for development of the New Zealand model are to collect data for both the supply and demand side. Forecasts of demand, (broken down by fuel type), and possible supply side developments need to be costed.

This paper describes this work in progress, outlines the problems in obtaining appropriate data, and discusses potential applications.

Introduction

Many decisions in energy planning require long time horizons, particularly for the development of resources This is especially in an isolated environment such as New Zealand where (other than oil and coal), import or export of energy is almost impossible. There is therefore a need for models which consider the energy economy as a whole over a long period, often several decades.

Models of this sort were developed in New Zealand in the 1970s, but with the demise of Government energy planning, little has been publicly available. This model is an attempt to redress the situation by the development of a model that can be used both by government agencies and private companies. The framework of the model is sufficiently open for different users to insert their own data and assumptions into the model, and run their own version without compromising confidentiality.

Many countries have adapted the MARKAL (market allocation) modelling approach for their analysis. Indeed New Zealand is one of the few countries which does not have a MARKAL model. The adoption of this approach has enabled a rapid development of the model framework, to which data can be added as available. As is so often the case, obtaining data is the most difficult part of the exercise.

This paper describes work in progress. Much of the input data is only approximate and will require further development. The extent to which the model can be improved will very much depend on funding.

Applications of the Model

Considerable overseas experience suggests that the model could be of use in answering questions such as:

- Mitigation of CO_2 emissions with a carbon tax at different levels.
- Investment requirement in the energy sector to 2050.
- Estimate of the contribution of renewable technologies.
- The cost to the economy of the Kyoto Protocol.
- Timing of major energy developments, such as a new gas field.
- In the case of an abrupt climate change requiring immediate action, what is the best course of action to take?

New Zealand's need for integrated energy modelling

New Zealand is currently in a similar situation to 1975, facing an uncertain energy future with a need to implement new technologies. Now uncertainty arises from the unknown future course of Kyoto commitments, from Maui depletion, and from the insecurity of oil supplies; and different technologies are needed because new gas supplies are more costly, and because the role of renewable energy and increased energy efficiency (which date have not been a major component of energy planning) need to be carefully investigated. New Zealand has not suffered since the mid-1980's from its lack of appropriate modelling capability, because the surplus of supply capacity that was the legacy of 'think big', left major economic burdens but few investment decisions needing to be taken. New Zealand cannot risk getting it wrong again with the decisions that need to be taken this decade, and which will have long-term impacts, e.g. on the cost of Kyoto, such as policy choices to influence energy sector investments in long-lived assets, and the balance of energy and land use sustainability in the Kyoto response.

Currently, policy decisions are mainly based on 'top down' models, which rely on data derived from econometric analysis of the past and present performance of the economy, and of the energy sector. Of its nature, this cannot take account of specific resources and technologies that are available but not currently used in New Zealand. If environmental constraints or other factors make it desirable to use such resources and

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technologies, or to envision a future in which they will be used, 'top down' modelling is methodologically wrong since it does not (cannot) make use of data related to them.

Additionally, there exist in New Zealand several engineering style models of different sub-sectors of the emissions-sensitive sectors, including models for scheduling generating capacity, of the transport fleet, of the potential for energy efficiency, etc., along with forestry and farming models. However these models, while they can, in principle (and, in some cases, in practice) take account of currently unused technologies in the relevant sub-sectors, they cannot look at the interactions of sub-sector decisions across the emissions-sensitive sectors as a whole.

In tracing out medium and long term prospects, both top-down modelling and engineering calculations become increasingly misleading – the first, obviously, as the past and present that provide its data base become more out of date; the second because prospects for one technology depend on those of other technologies: small hydro will save less CO_2 further down the track if the system then also uses more wind-power; and increased efficiency reduces the scope for both, especially if the low running costs of existing plant keeps it from early scrapping.

Analysing these complex inter-actions requires 'bottom up' modelling across all emitting sectors to enable engineering data, embodied in the various sub-sector models, to be factored into the analysis of the cost minimizing pattern of development needed to meet forecast demands. However, even such sector-wide modelling cannot give a complete picture, since the costs of Kyoto impact on the growth of the economy as a whole, which in turn 'feeds-back' into the demand for energy and other emissions intensive products. Thus an integrated model is needed which combines the econometric information embodied in 'top down' models with the engineering data embodied in 'bottom up' modelling.

Of course, New Zealand is not alone in facing such problems and many countries have developed their own modelling capability in this area. But such modelling is costly and, New Zealand withdrew from an international collaboration engaged in such work. This was the International Energy Agency's Energy Technology Systems Analysis Programme (ETSAP), which meanwhile has continued in being, with its MARKAL (market allocation) suite of models now the international best practice approach to the problem. Accordingly, there is no need for New Zealand to re-invent the wheel in order to access the best analytic capability available – all that is needed is to re-join ETSAP and to load into the appropriate MARKAL model a data-base that captures the detail of New Zealand's situation.

This model follows the usual General Equilibrium approach, using Linear Programming to minimise total discounted costs. Extensions, such as the ability to handle price sensitive demand and stochastic constraints require more non-linear techniques.

The current version of the program consists of a straightforward implementation, using deterministic demands. Much of the data, especially cost data are, approximate at this stage. Collection of improved data and more sophisticated modelling will depend on funding!

Some Preliminary Results

This is work is still under development, so the conclusions are indicative only. No attempt has been made at this stage to 'steer' the solution in any particular direction (such as towards a sustainable energy future), or to include externalities such as the Kyoto Protocol. The results should therefore be treated with considerable caution.

Some significant changes are likely to take place over the next 50 years. The reduced availability of natural gas will make oil and coal the marginal fuel for many uses, particularly in industry, and in electricity generation. This could lead to significant increases in fuel imports and costs, particularly as many of the fuels may need to be oil based.

The model does not currently include any consequences of the Kyoto, such as a carbon charge. This will clearly have a significant influence on costs.

As shown in Figure 1, energy demand increases at a moderate rate over the period (about 1% per annum), but an increasing proportion of energy may need to be imported.

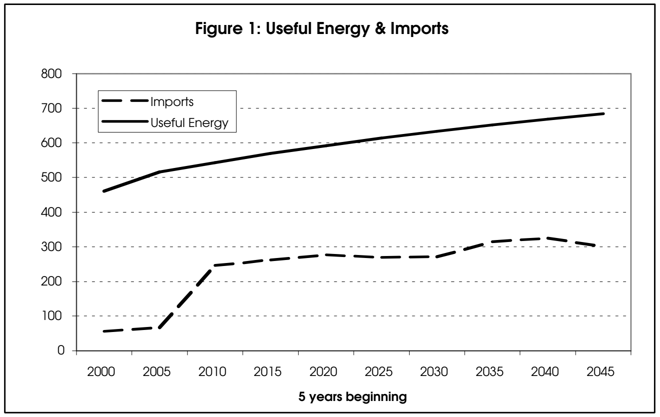

Figure 2 indicates the increasing cost of imported fuel, as imports replace local natural gas.

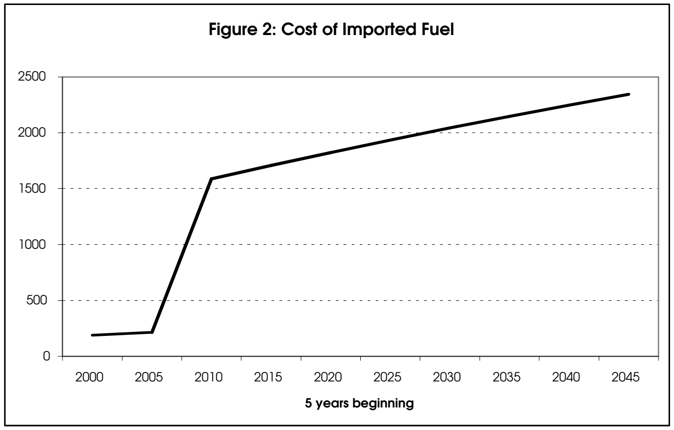

Figure 2: Cost of Imported Fuel

As shown in Figure 3, the mix of electricity generation is likely to change, some new hydro developments are possible, but most further developments may need to be for thermal plant, although some of this could be geo-thermal development.

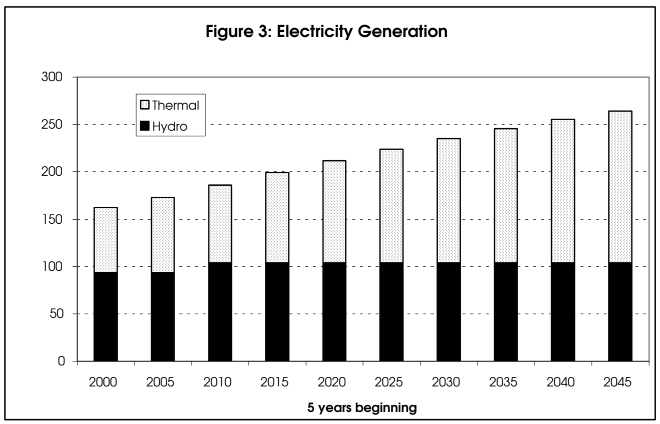

Figure 3: Electricity Generation

The replacement of natural gas (assuming there are no major new discoveries) will require a mixture of fuels. Coal can be used for electricity generation, and for some industries. This can be either local or imported. Other uses may need imported oil fuels.

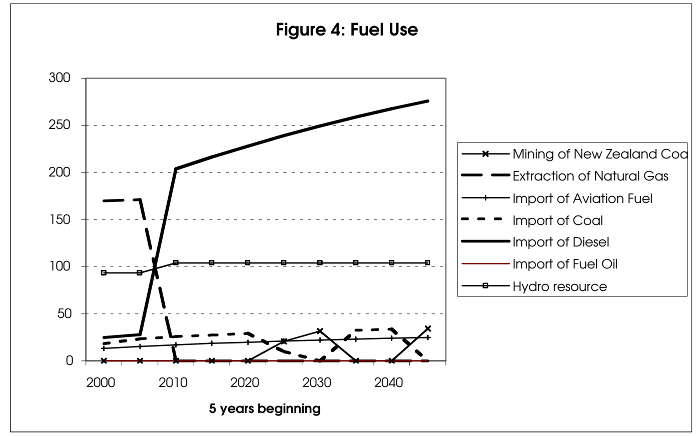

Figure 4: Fuel Use

Conclusion

There is a need for indicative energy planning over the long-term, despite the development of sophisticated energy markets. Models such as MARKAL can play a useful part, both for Government agencies and industry. The issues that energy development will have to face in the 21st century are expensive and complicated, and a wide range of tools will be needed. As always, the collection of adequate data is by far the most difficult task.