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Strategic analysis adaptation assessment: An alternative to the storyline scenario

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Keywords

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Title: Strategic Analysis Adaptation Assessment: An Alternative to the Storyline Scenario

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Abstract

Scenarios of future trends are widely used by government and international agencies to inform decision-making. While story line scenarios may be useful for business or government thinking, they are not effective at informing engineering research, innovation and design, and add very little to the understanding of sustainability. This paper presents a strategic analysis approach to complex systems, which relies on identification of risks to important activities and wellbeing. This method mimics the actual processes of anthropogenic continuity, where people explore, experiment, learn from success and mistakes, and adapt and evolve. The method is applied to the case study of transportation fuel supply in New Zealand. Directions for immediate strategic engineering research and innovation are clear outcomes of the analysis.

Keywords: Sustainable Development; Strategic Analysis; Transportation, Scenarios

Introduction and Background

Some 20 years have passed since the publication of "Our Common Future" by the World Commission on Environment and Development in 1987, where the concept of sustainable development was formally stated [1]. However, a functional definition of sustainable development which informs and directs decision making is still illusive. Societies grapple with subjective decisions concerning development of remaining remnants of natural areas. Although the negative effects of anthropogenic atmospheric alteration are becoming more alarming, accepted practice of sustainable development and definition of the acceptable limits to development are still illusive [2].

Scenarios are often constructed from historical data to forecast future trends. Future energy scenarios have been developed by a wide range of industry groups, government agencies, and researchers [3-5]. However, scenarios are not strategy and often do not inform decision making for sustainability. Scenarios are commonly based on fundamental assumptions of economic growth, and present future situations which would be environmentally disastrous or physically impossible. Clem [6] has argued that economics is but one of many bottom lines for sustainable development.

Energy issues are interconnected with economy, society and environment [7]. Many of these elements are often difficult to quantify. Multi-Criteria Decision Making (MCDM) techniques emerged to address quantifiable and unquantifiable issues. MCDM is gaining popularity in energy management and planning with sustainability goals. A comprehensive review of various MCDM techniques has been conducted by Pohekar and Ramchandran [8]. A recent development in regional planning is SWOT (strengths, weaknesses, opportunities and threats). SWOT was originally devised for corporate decision makers and has several examples of successful application [9]. SWOT is not accepted as the definitive sustainable development approach and has particular limitations of not providing analysis or a robust plan for engineering projects [10].

Dr. Susan Krumdieck and researchers at the Advanced Energy and Material Systems Laboratory, have developed a method known as Strategic Analysis (SA) of Complex Energy/Environment Systems [11]. The first step in the SA approach is similar to SWOT, but it is much more pragmatic in the context of sustainable energy engineering. Strategic Analysis relies on identification of risks to important activities and wellbeing. The relatively simple method offers a much more realistic approach to issue identification and decision making for risk mitigation than is offered by the usual economic-based demand scenario. The SA project also results in an action strategy which is one of the shortcomings of the SWOT exercise. The SA approach is described in the following section, followed by an example of the method results for the private motor transportation system in New Zealand.

Strategic Analysis of Complex Energy/Environment Systems

As with all other system analysis methods, the SA method requires that a particular system be defined, as well as the context and surroundings in which the system operates. The SA method seeks to identify actions that should be taken at the present time in order to meet strategic energy/environment goals. This is accomplished by undertaking two projects and a prioritization analysis. The SA method is illustrated in the flow chart in Figure 1.

The first exercise is the identification of *Adaptation Issues*. The current system must be defined and characterized, and then a multidisciplinary team should enunciate the problems which threaten wellbeing of people and the environment. The analyst will then compile and prioritize these issues and analyze the risks through probability horizons and estimation of impacts. This step has a component similar to the SWOT approach, in that it involves making a list of issues which could cause the system to fail to provide the intended services.

The second exercise is to generate a *Transformation Concept*. This is a very creative project that must include technical and economic feasibility. A systems engineering team will

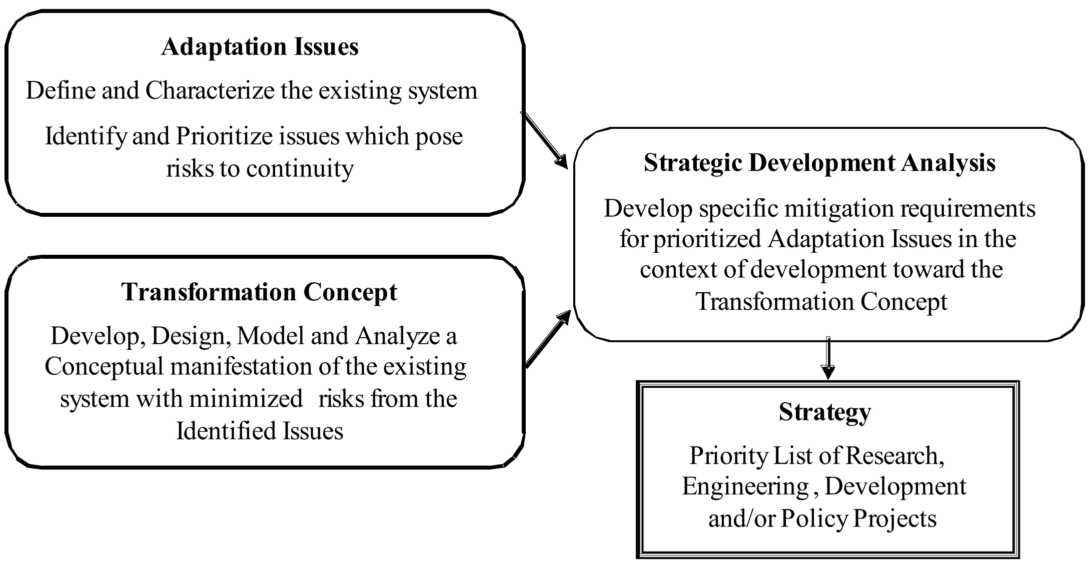

Figure 1. Strategic Analysis method for Complex Energy and Environment Systems

develop a "design space" model system that could satisfy the system requirements, needs and desires, that could be economically realized, and that is technically feasible. The primary objective of this concept generation mission is that the concept system must have minimal exposure to the risks which face the current system.

The final stage of the SA effort is the *Strategic Development Analysis.* The development analysis process is based on proposing possible risk remediation actions, then determining feasibility and the effectiveness for managing the identified risks. The Adaptation Risks were previously identified, and the Transition Concept is used as a benchmark for the effectiveness of the remediation actions being explored. The outcome of the analysis is a prioritized set of actions and projects which form an adaptation and transformation strategy which leads toward sustainability for the particular system. The strategy may involve research in areas where the mitigation measures are not yet developed. The strategy may consist of specific technologies, or of certain policies that would mitigate the risks. The list below gives a synopsis of the method for carrying out the Strategic Development Analysis.

a. For each of the identified risks estimate the cumulative probability horizon.
b. For each risk, estimate the impact on wellbeing if the risk event occurs.
c. For each risk, postulate mitigation measures which would reduce either the probability of occurrence or reduce the impact of the event.
d. Evaluate the feasibility and lifecycle analysis of the postulated mitigation measure.
e. If the measure is feasible, and the cost is commensurate with the value of the service provided and with the avoided impact cost, then place the measure into the characteristic description of the modified system.
f. Continue until the risks have been reduced to acceptable levels by the most feasible and cost-effective mitigation measures.

This process mimics the real process of exploration, research, learning, and trial and error that takes place as human societies adapt and evolve. Changes in the way people behave and in the infrastructure and technology they use are made in response to problems or to new opportunities. Once new technologies enter the market, they increase in efficiency through continuous research and improvement. The exception to this process is when there are no resource constraints apparent to the people in the society. In this latter case, increasingly higher consumptive development may continue until environmental systems are exhausted, and the system collapses.

Strategic Analysis Applied to Private Vehicle Transportation in New Zealand

Global climate change, energy supply, and wellbeing of people and the environment are the big problems facing the world. In this section, the Strategic Analysis method is applied to these imperatives to develop a Motor Transportation Strategy for New Zealand. This paper gives most detail to the first step of the SA project, i.e. identifying and prioritizing the Adaptation Issues, but we also present the results of a long-running project in the AMES Lab around long range energy strategy.

Identification of the Transport Fuel System and Adaptation Issues

The current transportation fuel system for New Zealand relies nearly exclusively on imported fossil fuel oil and finished products, as characterized by Ministry of Economic Development (MED) data [12]. Risks identified for the wellbeing of New Zealand society include commercial and residential sectors and relate to the wellbeing of the environment, both local and global. Social wellbeing is interpreted as affordable, reliable, secure, safe and sustainable access to goods and services. Environmental wellbeing is interpreted as stable resource, climate and ecological cycles. Risks that are impending or eminent in near future (10-20 years) were taken for this study.

Transition Concept of Low Risk Transport Fuel System

The postulated low-risk Transport Fuel system would afford the access of all members of society to goods and services without the use of imported fossil fuels. If New Zealand carried out its activities without using imported fossil fuels, the transport system would be stable and sustainable. If the built environment was constructed within the requirements for primary production of food and for wellbeing of ecosystems, then the static system would be sustainable. The AEMS Lab has been exploring non-fossil fuel transport systems for several years, and there is no real reason not to explore these concepts [13].

Strategic Development Analysis

The strategy to achieve a low risk transport system can be developed by proposing mitigation measures for both the near term and long term risks. The logical development path is to develop the mitigation measures and to implement them in the most cost-effective way possible. These measures may include up-taking existing technologies in the New Zealand context, adapting emerging technologies into the New Zealand system, innovation through research for the New Zealand energy system including new management and communication systems, and through changing the energy demand structure.

As mentioned previously, most of the adaptation issues can be identified and analyzed to some degree, but mitigation measures do not currently exist. The SA method represents a turning point in approach, from the "fossil era" thinking about solutions to problems, to a "constrained energy era" thinking, New Zealand scientists and engineers could be among the first in the world to work on developing the systems and technologies and engineering processes which allow development toward the low risk strategic target through adaptive research programs. Society will adapt to the new energy and resource constrained era, but only if it chooses to.

The results of a strategic analysis of the domestic and commercial transportation sectors are displayed in Table 1. The specific issues and the concepts identified for mitigation are further described in the following sections.

<u>Descriptions of Risk Events and Issues</u>:

1. Failure of delivery-on-demand supply system –
    - Shipments of petroleum products and refinery feedstock are not available to New Zealand. The reserves in the country are depleted as demand is not managed or controlled, and fuel runs out at filling stations in random locations. This risk event is modelled on previous events, in particular the 2000 UK shortage due to fuel worker protests [14].
    - Lack of compliance with energy savings measures (eg. speed reduction).
    - Panic buying exacerbates shortage for unlucky customers. For the commercial sector, reduction in fuel supply means products do not get delivered, and commerce does not take place. Follow-on economic impacts are profound, including shortages of products for consumers and loss of employment. In the UK in 2000, even soccer matches were cancelled due to transport fuel shortages.

Table 1. Risks to Transportation Access and Wellbeing Due to Oil Shortage
Oil shortage defined as supply ≤85% of current use within a short time frame, e.g. 3 months.

Risk Event	Adaptation Issue	Mitigating Concept
Domestic Sector		
Failure of delivery-on-demand supply system	People randomly unable to purchase fuel, thus loose access to essential activities	Supply distribution and allocation management system
	Panic and uncertainty lead to anti-social actions	Supply information system
Fuel Price Increase	Lower income people loose access to activities	Increased availability of low cost public transport
	Increased current account deficit, lowered wellbeing for low-income people, reduced consumption overall	Reduced fuel consumption necessary to achieve essential activities (reduce fuel demand)
Traffic Demand Growth	Loss of access and activities due to absence of low energy transport options and behaviours	Alternative shorter distance destinations, trip combining, ride sharing
Fuel Demand Growth	Higher CO_2 emissions	Reduced Fuel Demand
Commercial Sector		
Failure of Product Delivery	Trade lost, products delayed or not delivered, shortages of goods, safety problems, reduced sanitation, employment	Low energy delivery and shipping transport alternatives.
	Loss of essential and emergency services	Stockpiling of fuel for emergency, government, and priority use
Fuel Price Increase	Product price increase – Inflation, economic recession	Local production of goods for local markets is competitive
Fuel Demand Growth	Just-in-time shipping, road shipping by trucks, and destruction of rail networks	Low energy delivery systems, local production and markets of essential goods

2. Fuel Price Increase -
Carbon price added to the price at the pump.
Oil production and supply shortfall causes price escalation.
Alternative liquid fuels costly and don't fill the demand gap.
Oil supplies mainly from the Middle East by 2010 – politically unstable.
Oil price volatility has negative impacts on households and anti-government sentiment.

3. Traffic Demand Growth -
The risk is manifest because the transport mode, frequency, and distance profiles for New Zealand are energy intensive, e.g. urban sprawl and single mode transport systems relying on personal vehicles. As shown by Krumdieck *et al.* [15] energy risk to essential activities is a very strong function of urban form. If transport infrastructure investments are focused on individual mobility rather than access to goods, services and activities, then the resulting high mobility systems can become dysfunctional with even modest fuel shortfalls.

Even if higher efficiency vehicles are substituted, high traffic demand growth will negate the efficiency gains, as has been the case in the USA and Europe.
For the commercial sector, a considerable growth in demand since the late 1980's has been due to a large increase in road shipping. The commercial transport system in New Zealand depends on long haul trucking.

4. Fuel Demand Growth –
If a city or a country increases fossil fuel use, then the CO_2 emissions also increase. The risks associated with atmospheric CO_2 pollution are not specific to transport activities, but rather are shared risks to viability of environmental resource systems. Variability in weather and climate have always been important risks to civilizations. Cultivation in all of its forms relies on matching local weather and climate conditions to the growing conditions of certain crops and livestock. If the weather is variable, then the risk to food production is high.
Variability in regional climate and weather has always represented a risk to transportation of goods. The commercial sector will have a higher probability of loos of ships and delay of trucks if weather patterns are unpredictable due to CO_2 pollution of the atmosphere.

<u>Description of Mitigating Concepts:</u>

1. Supply distribution and allocation system-
This type of system would provide known quantities of fuel to customers so that they could plan their activities accordingly. Such a system would reduce or eliminate panic and could reduce anti-social and anti-government sentiment. The allocation system would improve individual analysis, allowing adaptation to continue participation in activities through alternative means if it also provided advanced information about fuel availability. *This type of system does not yet exist and should be a priority for research and development.*

2. Supply information system-
This type of system would provide information about supply availability and locations and timing of supplies. With this information, individuals could plan their activities and transport modes accordingly to use the available fuel and not run-out. Such a system would reduce or eliminate panic and could reduce anti-social and anti-government sentiment. *This type of system does not yet exist and should be a priority for research and development.*

3. Reduced Demand for Transport and for Fuel-
If activities could be carried out using less fuel, then there would be lower risk. Different societies have a proportion of activities that are accomplished using mechanized transport. Local transport systems have evolved according to local opportunities and constraints. There is currently no model, method, or theory for development and adaptation of transport systems with reduced energy and reduced transport demand. *This type of transport system engineering capability does not exist and should be a priority for research and development.*

4. Low Energy Transport System-
The technological options for low energy consumption are well understood. For example, scooters, motorcycles and three-cylinder motor cars are low energy personal transport options. Trains consume much less fuel per tonne of cargo delivered than road trucks. However, a low energy urban form, urban-rural system, and national transport system is not known. *This type of low energy transport system engineering capability does not yet exist and should be a priority for research and development.*

5. Commercial Fuel Shortages-
No mitigation factors can be conceived for fuel shortages in the commercial hauling and shipping sector that do not reduce the level of service. The mitigation concepts thus involve

reduced services according to product origin, delivery time and schedule, rather than curtailing of goods movement. The first concept would be to prioritize fuel for shipping, thus increasing the fuel shortage in the personal transport sector. Another concept is a variation on the "just in time" shipping and "lowest cost product" goods sourcing systems to reflect the lowest fuel delivery and possibly the most local source. *These types of system does not yet exist and should be a priority for research and development.*

6. Stockpiling Fuel for Essential and Emergency Services-
As with other plans for dealing with disasters, fuel allocation plans could be developed to ensure that essential goods and emergency services are not curtailed due to energy shortages. *This type of system exists to some degree for natural disaster planning, but does not currently exist for fuel shortages and should be a priority for research and development.*

7. Local Production for Local Markets-
Food in particular could be produced locally for local markets, thus reducing transport fuel inputs. With new information networks, "nearest to market" provision of goods and services could replace "just in time" transport systems. Susan Krumdieck just invented "nearest to market" shipping, so it doesn't really exist as yet. *This type of system does not yet exist and should be a priority for research and development.*

<u>Environmental and Health Risks:</u>

What are the environmental risks of transport fuel shortages? This is a tricky question. From the environmental perspective, reduced consumption of fossil fuel is a MITIGATING factor for climate disruption, erosion, deforestation, urbanization, and globalization.

For humans, the environmental risks of fuel shortages would include the failure of sanitation systems. Waste removal and processing (e.g. land filling) is important to health of modern urban areas. A transition concept for non-fossil fuel waste removal systems includes ideas for waste reduction and for recycling and organic treatment of other wastes locally for re-use in local agriculture and production. A further concept is to direct part of the waste stream into energy production. Many of these types of systems have been developed for the purpose of waste management, and so could be implemented for reducing waste removal transportation requirements as well.

Energy Strategy for Transportation

The energy strategy proposal focuses on solutions that would facilitate economic activities and ensure wellbeing of people and the environment by managing the use of existing fuels and developing lower energy intensity transport technologies and infrastructure. Priority number is an indication of urgency as determined by the risk analysis.

Priority #1
Research and development of fuel distribution and management systems for private motor transport. Research and development of information networks for fuel availability and public and shared transportation availability. Rapid deployment and up-take of these systems.

Priority #2
Research and development of "nearest available" low energy transport information and modelling system. Demonstration projects in major urban areas. Rapid implementation.

Priority #3

Research and development of modelling and engineering tools for developing current urban and urban/rural infrastructure into low energy transportation networks and urban forms. Local councils undertake planning exercises for low energy and negative fuel demand growth development. Research and development of commercial systems for local production for local markets. Demonstration and pilot projects in all major urban areas.

Priority #4
Implementation of low-energy transport options, information systems, and infrastructure change through competitive bid process, construction of pilot projects, and assessment of effectiveness through research.

Conclusion of Strategic Analysis

Reducing fuel demand is the highest priority response for New Zealand as it is a strong mitigation factor for peak oil price and shortage risk management and for meeting global obligations for reducing CO_2 emissions.

Discussion and Comparison with Current New Zealand Government Strategy

Like rest of the world, New Zealand's transport system is vulnerable to fuel shortages. Like the rest of the developed world, individuals and corporations in New Zealand are responsible for environmentally damaging emissions from fossil fuels.

Current Fuel Shortage Management Methods

The Ministry of Economic Development (MED) generates economics-based scenarios of future energy demand. Recently, a discussion paper, "Options for Government Response to an Oil Supply Disruption" has been released for public comment [16]. This new document deals with the measures to respond to an emergency oil supply disruption. These fall into two categories:

Measures to Improve Supply –

- Release stocks form NZ petroleum reserve to the market
- Domestic production increased
- Petroleum product specifications relaxed

Measures to Restrain Demand –

- Appeals made to the public via public information campaign to voluntarily save fuel
- Government compulsion used to restrain demand, prevent hoarding and distribute a limited amount of fuel
- Substitute alternative fuels

There is a marked difference between the risk management approach of the current New Zealand government and the SA method. In particular, the SA method produces a list of immediate projects and directions for research with specific desired outcomes. It only suggests a particular mitigation measure if it currently known to be feasible. This is a major issue for ideas such as substituting alternative fuels.

MED Scenario Approach

According to the recently updated MED report, "Energy Outlook 2030", the transportation system in 2030 would be at even greater risk than the current system. [17]. Three scenarios were considered by MED and summarized below:

Business as Usual Case

> "Oil remains the largest energy source for New Zealand, and its supply grows by about 35% between 2005 and 2030. Rising oil use reflects increasing transport demand, especially road transport. The bulk of this oil will be imported, as it is now."
>
> "National transport is the sector with the largest energy demand and the largest growth in absolute terms. It grows by about 35%. Road transport accounts for about 75% of the growth in national transport."

High GDP Growth Case

> "Overall energy use is about 7.5% higher by 2030 than it would be in the Base Case. The results show that coal, oil, and gas would be the major sources of this additional energy. Not surprisingly, given that there are no real alternatives under 'business as usual' assumptions, oil absorbs the growth in transport demand."

Low GDP Growth Case

> "Overall energy demand in the Low GDP Growth Case is about 6% lower in 2030 than in the Base Case."

The MED scenarios all depict significant increase in oil imports for New Zealand over the next twenty years. This long range target is vastly different from the zero fossil import transformation concept discussed above from the Strategic Analysis project. Neither the MED scenarios nor the SA concept are actual "predictions". Nor are they meant to represent desired or obtainable targets. However, they do highlight the vastly different thinking between the approaches of economic projection used by MED and risk analysis and mitigation employed in the SA project.

There is no evidence that energy sustainability in New Zealand can simply be purchased through technology from overseas. The salient case for relevant research in constrained energy systems is that neither the fundamental understanding nor any enabling technologies currently exits. Research funding must be targeted at critical enabling technologies to address New Zealand's most critical issues.

Future work

The strategic analysis method has been proposed, but is in the early stages of applications research. The AEMS Lab is giving high priority to research and development of risk mitigation measures and the strategic development capability. For example, we are working on a fuel supply management system which could be implemented *before* a fuel supply disruption and used to manage demand response in a rational manner. A project recently completed has developed an analysis method and software implementation package for analysis of energy risk to essential transportation activities as related to urban form [18-20]. We are also working on renewable energy transportation technologies and on modelling of fossil fuel free urban forms and urban/rural integration. Finally, we are working on adaptation technologies and information systems that can help people adjust their fuel consumption and make choices about low fuel use destinations, and that can organize shipping activities for minimum fuel consumption.

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