The First Rule and why it would work

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The scientific evidence is unequivocal: immediate, drastic and substantial reductions in fossil fuel combustion must be achieved to avert catastrophic climate disruptions. The geologic evidence is conclusive: oil is finite. Politics and economics have had more than twenty years to respond to these imperatives. What would an engineering solution look like? This paper examines a hypothetical strategic policy derived by applying the first rule of engineering. The resulting analysis demonstrates that the most efficient and cost effective way to reduce transport fuel combustion is to reduce the quantity of fuel used directly through an upstream instrument, an import restriction quota. The *First Rule* calls for a 10% import quota reduction in transport fuel imports in 2009, and a further 10% reduction in 2011.

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Engineering Problem Solving

Engineering problem solving works pretty well. There's something about the creative practicality of engineering that has resulted in amazing technological and infrastructure development over the past few centuries. Many of the routine problems engineers work on are complex and very hard, and they always have conflicting requirements and constraints. Engineering is the art of applying known and inviolate laws of physics, scientific facts, properties of materials, and mathematical models to solve problems or take advantage of opportunities. While scientific curiosity and creativity are essential to engineering research, it differs from the pure sciences in that the research is always aimed at an application, a goal, a benefit to society or a money making proposition. If you Google™ "The first rule of engineering" you will get a sense of what the profession considers good rules of practice:

- Always know what problem you are working on
- Don't do something stupid
- If it ain't broke don't fix it (also means "know what needs doing")
- Avoid needless complexity (usually expressed "**K**eep **I**t **S**imple **S**tupid")
- Don't reinvent the wheel (meaning "if there's a good solution, copy it")
- Every decision is a compromise
- There are no free features
- Make a drawing (which means "understand the whole picture")
- Don't Panic! (which means "reactionary decisions must be avoided")

Although safety and environmental impacts are always considerations, engineers are rarely asked to solve social, economic or political problems. So, how would an engineering approach be applied to the complex problem of sustainable transport? The first thing would be to re-brand the basic engineering approach so it sounds interesting, like *Strategic Analysis of Complex Energy and Environment Systems*.[1] Non-engineers wouldn't be impressed with just "engineering", and you would want to avoid any unfortunate references to social engineering. After the re-branding, I would apply the rigorous methods of engineering and the rules of practice above, including my own first rule:

- If an obvious solution exists, try that first

This paper presents the results of a thought experiment: What would an engineer do? What if a Mechanical Engineer with expertise in energy and systems engineering (myself) were asked to devise one act of Parliament that would solve all of New Zealand's sustainable transport problems? What would that one law be and how would it work? Of course, I hold no expectations that the arguments presented will be considered seriously. But the results do show us a good deal about our current assumptions and the real barriers to beginning the transition to sustainable transport.

The following section will address the key task of defining the problem that we are trying to solve. The proposed policy, *The First Rule*, will then be explained,

and in the final section I will provide an analysis of how it would work and discuss the impacts, outcomes, and benefits.

The Problem of Sustainable Transport

The obvious problem is that we don't have a sustainable transport system. Actually achieving anything remotely sustainable by any definition is a long term problem which will require evolution of all aspects of land use, vehicle and energy technology. I work on this problem a lot, but it is not the problem at hand. The problem addressed here is what should be done *now* to solve the immediate sustainability issues. These immediate sustainability issues stem from the risk to existing transport systems.

If our transport system doesn't work, then the impact would be high. The transport system works by providing people with affordable access to activities and markets, and movement of goods and services from production to markets. Risks to the transport system stem from three issues: (1) inherent growth issues– pollution, congestion, safety, and inefficient land use; (2) accelerating climate issues – CO_2 emissions from fuel use and embedded energy investment; and (3) imminent resource depletion issues – escalating cost of fuel and materials, and shortages of fuel, materials and land.

I can distil these issues down into two characteristics of our transport system that are at the heart of the trouble: (a) travel demand is too high and growing, and (b) fuel consumption is too high and growing. This continued growth in congestion and fuel use does not generate increased benefit to wellbeing. The fact that there are no effective, economically viable mechanisms yet known to stop or reduce these two growth problems is a dynamic characteristic of our socio-economic-transport system which represents the real root of the problem.

The First Rule: Always know what problem you are working on

Fuel consumption and travel demand must decline, and we must become a people with the capability to maintain our wellbeing and our environment even as we reduce fuel consumption to a required level.

It should be noted that from the engineering point of view I have not included travel behaviour as one of the sustainability issues. This is because behaviour is responsive not deterministic. For example, people living in a city with an un-sustainable transport system (e.g. Auckland) will behave logically today, and use that system in ways that work to meet their needs, even if it is unsustainable in the long term. People living in a "more" sustainable city (e.g. Amsterdam) would also behave in logical ways to use that city's tram and bike facilities to meet their needs, not because they have better behaviour, but because their transport system is different. And people living in a sustainable city (e.g. Xi'an 1046 BC –

1920 AD) likewise would behave rationally and use the infrastructure and technology that works to meet their needs. Behaviour is locally rational even if it is not globally sustainable. This means that the sustainability of an urban or regional transport system must be approached as a system design and operation problem. Thus, I humbly present Krumdieck's law of transport behaviour: *Behaviour in personal transport and goods movement will adapt to use what ever works*.

Sustainable transport has been a focus for many years from a range of perspectives; safety, travel demand reduction, fuel supply security, congestion reduction, vehicle technology, public transport and air pollution. Safety and security are more immediate aspects of sustainability which are important, regardless of the energy resources used or environmental impacts. Very large public and private investments have been made in current transport systems that are not sustainable, and will therefore change over time. The problem is then one of change management, optimisation of future investments, and leveraging of stranded investments. The problem is complex and complicated, with considerations in behaviour, technology, energy and governance to name a few.

Hard, Cold Facts and Constraints

The current transport system produces unsafe levels of emissions and impacts, damages and kills too many people, will continue to escalate in operating and maintenance cost, and has no way to manage a 2-6% annual reduction in fuel supply over the next 50 years.[2] There is no renewable energy resource that can substitute for fossil fuel to maintain current levels of fuel demand. There are no vehicle technologies that can be purchased and substituted for existing petrol and diesel vehicles to simultaneously maintain current travel demand and reduce transport's contribution to carbon emissions to the IPCC target. The price of fuel will continue to be more expensive, and world oil production will not increase.

The complicating aspect of the sustainable transport problem is perception of the participants in the system. Wide-spread public perception is counter to the cold, hard facts and constraints listed above. This final layer of the problem brings me to another first rule:

- People will believe a lie either because they want to believe it's true or because they are afraid it might be true.[3]

Laws of Nature for Human Travel Behaviour

It is obvious that people can easily learn and adapt to different transport systems, for example when we travel to Paris or Manhattan we don't travel like we do in Christchurch. The problem is the assumption that we have all heard, in so many forms, that people won't change (e.g. "people won't give up their cars"). This is a persistent and inhibitory lie that pervades our society and stifles progress toward working on the problem of sustainable transport. I just stated that it is a lie that people won't change, and I think that is obvious. Travel behaviour and fuel

consumption have been changing continuously for centuries, and they change instantly for individuals every time we shift to another city. I stated earlier that people are rational in that they don't change travel behaviour that works. The conclusion of the combined logic of these two statements is the key to the solution of the problem of sustainable transport.

The Krumdieck Law of Travel Behaviour

People and businesses change and adapt to use what ever transport works

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People and businesses won't change travel behaviour that works

The Obvious Solution: The First Rule

There is one obvious solution to the complex problem of changing and adapting New Zealand's transport system to reduce travel demand and reduce fossil fuel combustion: Reduce fossil fuel consumption. The following policy is a supply-side cap which is easily accomplished and fundamentally un-thinkable for economists and politicians.

The First Rule: 20 by 12

Phase I	Import quota restriction on oil in 2008. Total oil and refined fuel products not to exceed 2007 levels, or a total of 260 PJ. One new government job created to oversee the import planning and enforcement of import plan.
Phase II	Import quota restriction set on oil and refined fuel products in 2009 to represent 10% reduction from 2007 levels, or a total of 234 PJ.
Phase III	Import quota restriction oil and refined product imports in 2010 to represent 0% growth from 2009 levels, or 234 PJ.
Phase IV	Import quota restriction set on oil and refined fuel products in 2011 to represent 10% reduction from 2010 levels, or 208 PJ.
Phase V	Freeze on imports of oil and refined products in 2012 to represent 0% growth from 2011 levels, or 208 PJ.

Unlike the oil demand reduction policies during the oil shocks in the late 1970's, the "20 by 12" proposition would not include any domestic market or behaviour intrusions such as rationing or car-less days or other additional cost measures like gas-guzzler taxes or carbon emissions cap and trade schemes. The policy would be announced for the nation as a whole, no exempt sectors, no late entrants, no added costs, no bureaucracy. The free market in New Zealand, and the creativity and problem solving ability of the people would work out the most efficient responses to this reality.

National Response

People can adapt to use less fuel, but they need to know with certainty that using more fuel will not work. The only way to change the whole transport system in New Zealand to use less fuel is to make it absolutely clear that less fuel will be available. People and businesses can reduce their fuel consumption by 10%-20%. However, adaptation is nearly always in response to changed circumstances not intentions.

It is not efficient to go through the assessment, analysis, decision-making, and investments needed for change if change is not really required. It is widely acknowledged that the car-less days of 1979 failed to reduce travel demand and fuel consumption. People perceived an attempt to restrict their behaviour and they adapted to that attempt largely by circumventing it. They did perceive a fuel price shock but did not change their behaviour. They did not perceive a fuel shortage. Alternatively, in the USA there were no car-less days or behaviour restrictions. There were shortages widely publicised in the media, and people took immediate and dramatic action to maintain their activity systems while reducing their need for fuel.

Under the 20 by 12 action, the government would support new enterprises in systemic fuel reduction, such as advancing improved freight management. Local councils and communities would develop initiatives aimed at re-organising activities and urban landscapes to reduce fuel use. The most important government support mechanism would be in regulatory flexibility and removal of barriers. For example, many local action groups have already identified regulatory barriers that make local food production and farmers markets difficult.

My recommendation for government initiative would be facilitating and establishing several key new technologies. It won't be surprising that several of these new technologies were invented by my research group in anticipation of involuntary fuel supply constraints after post-peak oil. The fuel retail management system (FRMS©)[4] is a *First Rule* technology that handles all of the allocation and distribution aspects of a worry-free, fuel-constrained society. FRMS would be deployed nation-wide through all fuel retailers with the MED providing the oversight.

The TACA Sim© program[5] is another *First Rule* technology that would be deployed over web-based systems for every urban and rural area so people could manage their transport and fuel risk. TACA Sim© also allows local and regional councils to monitor travel behaviour and assess the most efficient transport investments. The RECATS© (risk assessment for energy constrained activities[6]) analysis would be carried out for all urban areas to identify and address high risk areas. RECATS© would also be used to develop new priorities in transport network investments for the 20 by 12 situation. The *TransitionScape* design and modelling process[7] would be taught at Canterbury University and practiced throughout the country by engineering consultancies like Opus, Beca and MWH as they facilitate continuity planning and sustainability re-organisation by local communities.

Impact Analysis

The 20 by 12 policy would change everything. Firstly, it would directly address the problem, as it would ensure that fuel consumption and travel demand were reduced. Secondly, it would stimulate exactly the response that is critical to managing carbon (and fuel) reduction: every fuel user, private, business, farmer, and government services, must evaluate their own activities and determine how to reduce their consumption in the best way for them. Other unexpected benefits would be reduced congestion on roads, better fitness as people cycle and walk more, better road safety as drivers reduce speed and become more appreciative of bikers freeing up fuel for them to use. Imagine the benefits of new local production and services, and improved community social capital. Investment in new roads and even bike lanes could be freed up for other transition measures.

20 by 12 would end the stalemate between Climate Change and Peak Oil and it would solve both problems at the same time. The rational response to Climate Change is to reduce oil consumption, but we are rightly afraid of reduced oil supply because we have only a few bad experiences of that condition, and we haven't learned how to deal with it. However, 20 by 12 forces all sectors of society to face a reality, to prepare for it, and to deal with it.

Preparing for reduced fuel supply is not a bad thing. In fact, it is similar to the exercise of retirement planning. We might all like to think about having the same salary we earned at our career peak when we retire, but that is not reality. Most people are capable of understanding the situation of reduced income in retirement, and they firstly plan and invest for it, and then as the time comes they change their spending habits. People who do not change their spending when their income goes into the post-retirement decline could loose their assets and end up destitute and dependant.

Conclusion: can we really afford NOT to do this?

20 by 12 would serve as a national planning exercise because it would communicate a direct, unavoidable reality, and people would respond. Local councils would audit their essential services and businesses would audit their transport systems and set priorities. People would figure out how much fuel they use, and what they will change to use 20% less. My research group's analysis of travel demand behaviour and goods and services movements in New Zealand indicates that this 20% reduction would be possible without any new fuels or transport technologies, so it could be accomplished in this short timeframe. 20% fuel import reduction would not mean disaster to the economy. Rather, it would result in new efficiencies that would free up oil money ($1.6 billion per year @ US$140/bl) to use for new businesses and new ideas. If biofuels and electric vehicles are efficient and feasible responses to reduced imports of fossil fuels, then companies will bring them to the local market without encouragement from government.

The 10% reduction target represents the fuel demand in 2004, and the 20% target was the consumption rate in 1995. If our current creativity and problem

solving escape us, we can always examine what people were doing in the recent past, and learn from them how to use a bit less fuel without collapsing civilization as we know it. However, because my research group has been working on this problem for a while, we believe that that the country would move forward rather than backward. There are many new technologies, businesses and local products and services that would be stimulated by the clear 20 by 12 signal. In fact, because New Zealand would be the first country in the world to develop these new fuel-reduction assets and capabilities, we would be well placed to sell these solutions to the rest of the world.

Comments of an Average Kiwi

Male, age 43, Aircraft Engine Engineer

I met him in a café and started up a conversation about the paper I was writing

"That really makes sense, and it would be fair to everyone. I'd rather just know what I need to do than keep mucking around. We really do need to do something instead of just talking about it. I think the airlines could cut out 20% of flights and shift people onto the others, there are a lot of empty seats. How do you plan to get the government to do this? It needs to be done pretty soon."

Peak Oil is definitely something to fear if we do nothing but fear it so much that we do not even speak of it. Global Climate Change is the most irresponsible thing that one generation has ever done to a hundred future generations (ok, besides extracting and refining nuclear materials). Setting and achieving 20 by 12 would have the cultural benefit of shared achievement and leadership. There would be real, measurable carbon reduction and exciting innovations in the span of just four years. The country as a whole would be over its fear of peak oil.

Granted, New Zealand's 20% oil reduction would not change the climate impacts of 70 years of exponential growth of global carbon emissions. On the other hand, it would change everything. A world where there is a developed country that takes on the reality of reducing fuel consumption is a world with some hope. Maybe I'll pitch my *First Rule: 20 by 12* policy idea to Sweden…

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