The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Assessing the energy implications of political intervention

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This is a guest post from Robin Lovelace, a PhD student in energy research at the University of Sheffield, UK.

Energy is back in the public consciousness and perhaps higher up political priority lists than at any time since the summer of 2008. Disruptions in Libya, leaked cables about Saudi Arabia's creative accounting, and rapid growth in worldwide understandings of resource depletion make dodging future energy supply problems increasingly difficult. A few symptoms of this are:

- Hype about "getting off the oil hook" from the UK's energy secretary
- Spain limiting speed limit to "combat" rising oil prices
- Talk of releasing some of IEA members' 1.6 bbl of reserves as a "last resort"

People in power seem to be waking up to the importance of oil and talking about it in public in ways that they never have before. But this raises some questions: Do they (or we) have any idea about the likely impacts of different interventions proposed to deal with energy problems? and how can the energy implications of different interventions be assessed?

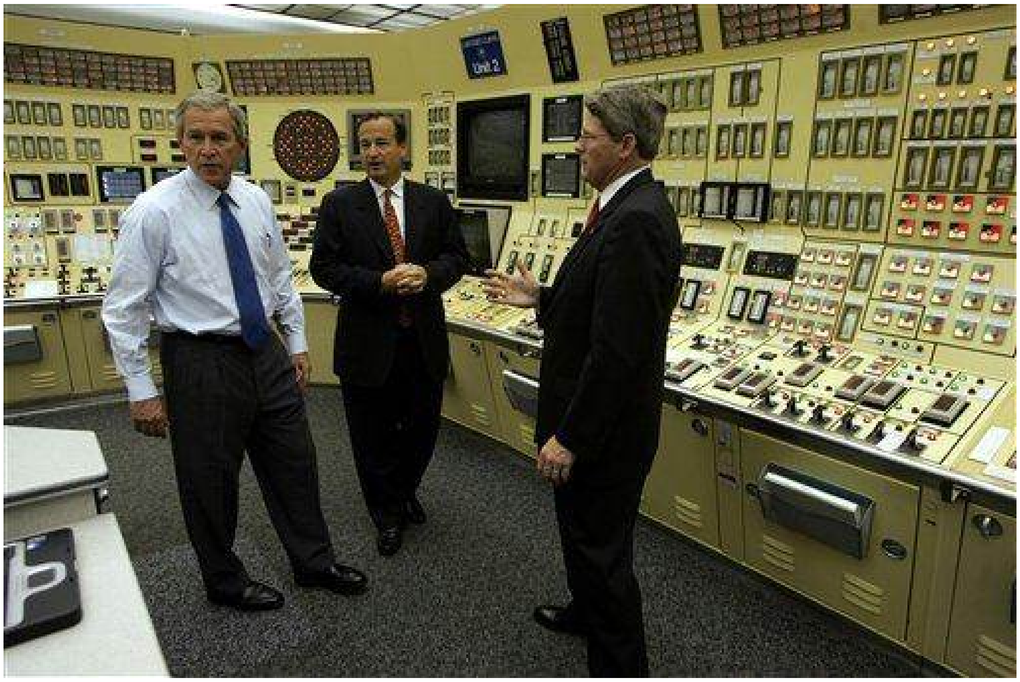
In this essay I aim to answer these questions with reference to a paper published in Energy Policy titled "The energy implications of replacing car trips with bicycle trips in Sheffield, UK". A preprint is available for those without institutional access.

Interventions

The idea of intervention relies on the assumption that some people or institutions have the ability (or 'power') to alter the outcome of certain events and, if the intervention is big enough, change history. The term precludes fate as the sole player in life and encourages the world-view that you can make things change. This is, as John Michael Greer will tell you, is a dangerous thing. Subjected to intractable problems and a global predicament with no single solution, we are ill advised to try single handedly to change the course of history. History, according to Greer, is largely guided by the narrow train-tracks of natural resources and human ecology.

Such a belief may be labelled as fatalistic. Considering the fundamentals (ballooning populations, declining resources) and the history of civilisation-level collapse, it is belief that is difficult to challenge. This essay does not deny such limitations. It does, however, see the looming space of declining net energy production as a bounded field of possibilities rather than a black hole. By intervening with available policies, technologies and free will, it may be possible to smooth rocky descents to future low-energy societies.

In the absence of tools to evaluate the relative merit of such well-meaning acts, however, we are stuck. Our current situation is like being in a nuclear reactor control room in melt-down without a clue about which button does what. In this metaphor the Earth is the reactor control room, climate change and resource depletion are the melt-down, and the buttons are the various interventions available to us. Instead of frantically running around pressing as many buttons as possible, this essay proposes firstly categorising the buttons that are available to us and secondly thinking about ways of assessing which button does what.



Imagine being inside a nuclear plant in melt-down. What do you do?

Fortunately we do not live in a nuclear plant in meltdown: each of us has a range of buttons available that we can choose to push or merely consider at our leisure. The buttons differ considerably from one person to the next, but we all have at least some options that will affect energy use. Although this essay is aimed primarily at assessing energy policies, it is hoped that it will be of use to people trying to figure out which buttons to press. What's the best course of action in a world of physical constraints?

Before diving into assessment methods it's worth taking a step back to think about what 'interventions' actually are. The Oxford Dictionary definition of the verb 'to intervene' is "to take part in something so as to prevent or alter a result or course of events." This means interventions result in some kind of *change* that causes the future to be different than what it would have otherwise been: interventions implicitly set up at least a couple of scenarios of the future: a baseline, or default scenario and a parallel reality; the scenario in which the intervention takes place. An example that has received a lot of press coverage is speculation about what would have happened in Benghazi without air-strikes from Western forces. One article says a "bloodbath" would have ensued, while another suggests there may have been *fewer* civilian casualties in the absence of intervention. Both illustrate how the concept of intervention sets up imaginary future scenarios to inform discussion.

To assess *energy* implications, however, a narrower definition of 'intervention' is needed. Interventions that can be assessed using the methods outlined here must be discrete events with predictable outcomes. The installation of a solar panel can therefore be treated as an intervention while diffuse movements such as Transition Towns cannot. Ideally, the intended effects of intervention should be verifiable and not purely speculative so they can be evaluated in subsequent studies. In the paper mentioned above, the testability of our assumptions about how the cycling rate would respond to different policies is an example of this: will the data follow the sigmoidal form projected on page 8? We'll have a pretty good idea later this decade, when the data can feed-back into future policy guidance. Energy assessment, like all science, should strive to create falsifiable hypotheses.

Testing our result that increased cycling rates result in net energy savings is a taller order: We lack good data on the extent to which bicycle trips replace car trips (*RR*), the influence of modal shift on energy inputs to road maintenance (*Lg*), and the embodied energy of food inputs for hungry cyclists (*Ef*). Each of these parameters (described on page 9) could in theory be verified, given the right data.

The energy hierarchy

Knowing the types of intervention suited to energy assessment, the next problem is the sheer range of interventions that affect energy use. Voluntary lifestyle changes, electric cars, algal biofuels, carbon rationing and modal shift policies are just some of the 'solutions' proposed. Each will require slightly different techniques for assessment. To categorise and understand this variety, the energy hierarchy can be used:

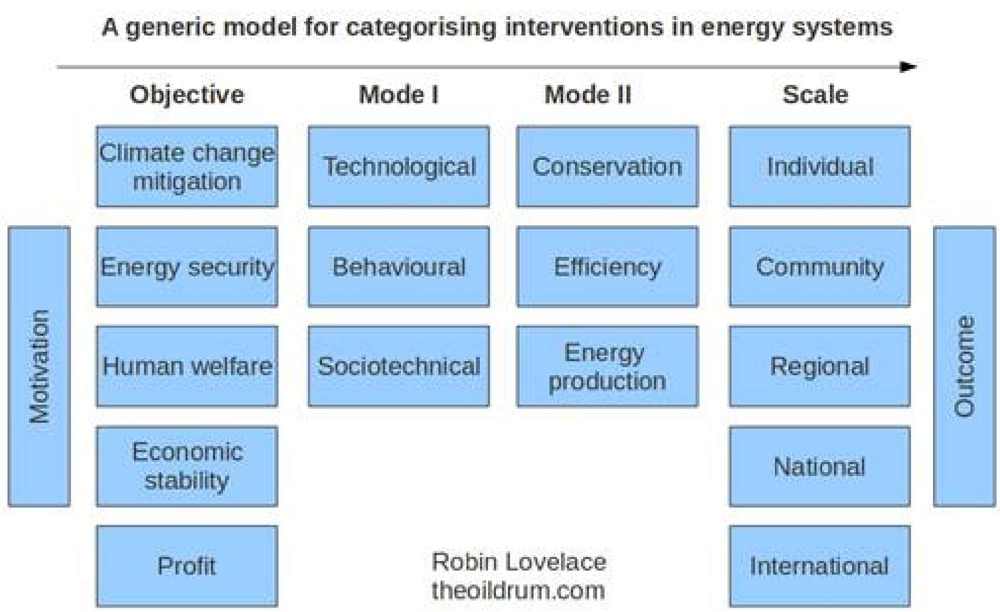
The energy hierarchy, according the Institute of Mechanical Engineers (ImechE, 2009)

Type of intervention – promotion of:	**Examples**
Energy conservation	Modal shift policies, “turn off your lights” type campaigns, lifestyle changes
Energy efficiency	Policies encouraging electric cars, insulation, energy certificates
Renewable energy	Subsidies for algal biofuels, wind, solar, wave etc.
Alternative energy technologies	Nuclear power subsidies, CCS demonstration plants

Fossil fuel dependence	Cut fossil fuel taxes and freeze air passenger duty (see Monbiot's section here), subsidies for fossil fuel industries (IEA, 2010)

Categorising some of the 'buttons' (interventions) available

A further categorisation of interventions in energy systems would include the aims, mode, and scale of the intervention at hand. To meet this need, I have developed the following schematic. Think of some examples, and trace their route through the diagram.



A schema of further categorisation of energy interventions. Trace the trajectory of your favoured energy policies from left to right and imagine alternatives.

Examples

With an idea of which interventions are suitable for assessment, and a generic way of conceptualising and categorising them, the next step is to estimate their energy implications. How you go about doing this depends to a large extent on what kind of intervention you're looking at. Let's take a look at some examples ranging from national scale to single installation assessments.

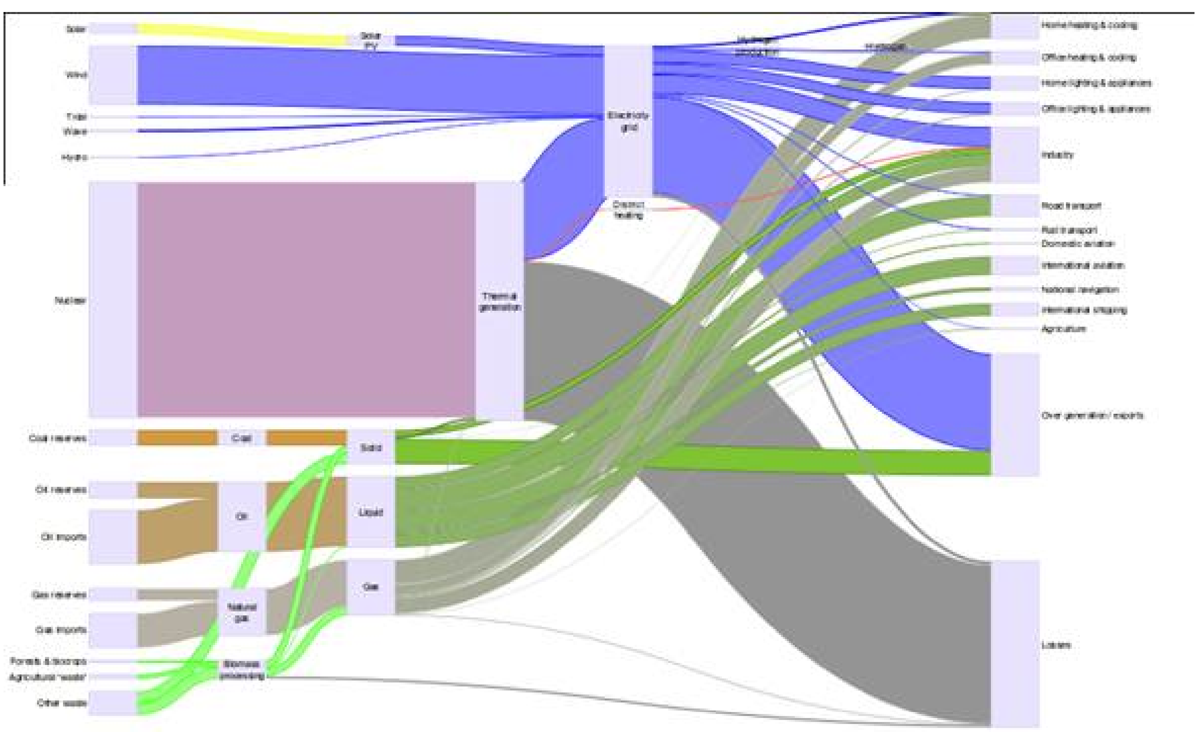
DECC's 2050 pathways tool

The UK's Department of Energy and Climate Change (DECC) hired David MacKay as their chief scientific advisor in September 2009 following the publication of *Sustainable Energy* Without the Hot Air. MacKay advocates simple models of big energy systems as the basis for informed energy policy discussion. His approach has clearly rubbed off on the government department when you look at the 2050 tool.

The tool takes realistic assumptions about the build-rate and implementation times of various national scale energy policies. Amazingly, it allows you to adjust both demand-side and supply-side factors, using effort levels ranging from 1 to 4. Based on your preferences, the tool creates graphs, area plots, and even Sankey diagrams. It provides a comprehensive yet bite-sized overview of change in the UK's energy system to 2050.

Not only that, but you can create your own preferred policies. You can see mine [here]() and in the images below. If you don't like it, create your own!

My favourite energy policy scenario allowed within the constraints of [DECC's 2050 tool]()



Sankey diagram of the UK's energy system in 2050 according to my preferences, within the bounds of the assumptions behind DECC's 2050 tool.

You can see the area consumed in my scenario here, and the (high resolution) Sankey diagram here.

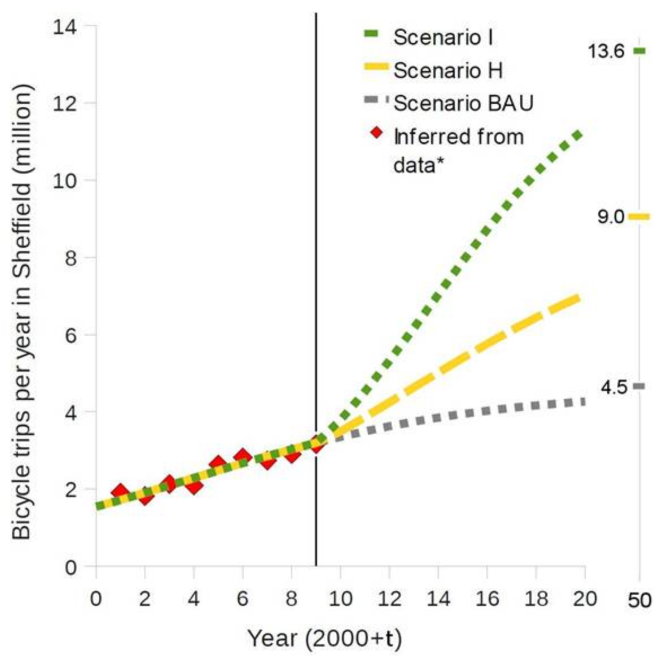
Like all things, the tool does have its faults:

- Scenarios of demand reduction are far too tame. Level 4 on transport, for example, says individuals will travel the same distance in 2050 as they do now! MacKay and his team have clearly not read, or disagree with the findings of a paper that suggests we are approaching "peak travel" (Millard-Ball and Schipper, 2011).
- It appears to take little account of peak oil. When I asked David MacKay at a recent conference in Leeds about the impact it may have on his scenarios he shrugged it off.
- It takes little account of the resource requirements of each scenario and the global implications of all countries following the same path.

These are not fatal flaws, and, as MacKay said to an indignant question about population at a talk in Leeds, "if you don't like the assumptions we've made, feel free to change them; this is all open source stuff". Anyone up for making a version of DECC's 2050 tool which takes resource depletion into account? The software and assumptions driving it are free to download and modify. This transparency illustrates a vital step in energy assessments: state your assumptions.

The energy implications of cycling not driving

The energy assessment of replacing car trips with bicycle trips in Sheffield is an interventionencouraging energy conservation (see above categories). To create scenarios of the futureat the city level, we looked at available data from other cities which had implemented pro-cycling policies, fitted a population model to time-series data in Sheffield, and adjusted the parameters to reflect plausible rates of change, given different levels of political intervention(.



Scenarios of the cycling rate to 2020 based on different policies

Armed with these three scenarios (business as usual, hard, and integrated pro-cycling policies), we could then calculate energy impacts, based on evidence of how many additional bicycle trips are required to replace a single car trip, the length of average trips, the fuel consumption of an average car, and the energy costs of read maintenance (see page 9 for details).

Although the magnitudes of the energy savings are subject to uncertainty, the results led to 4 main conclusions about the energy implications of pro-cycling interventions in Sheffield:

- Plausible increases in the cycling rate would yield net energy savings.
- Reduced fuel consumption would be the largest single energy impact.
- If the rate of car purchase declines with the rate of car use, the resulting energy savings would be large.
- The additional food requirements of hungry cyclists could entail a large energy cost.

The first two conclusions may seem obvious from common sense, but our study provides evidence to support cycling from an energy perspective. The latter two are less obvious, and indicate the merits of a systems approach to energy analysis: changes in one sector can have knock-on effects in another.

Net energy from a solar panel installation

A similar approach can be taken when assessing the energy implications of a single energy conversion device. In this case, the analysis is simpler as there fewer unknowns, and performance can be measured accurately.

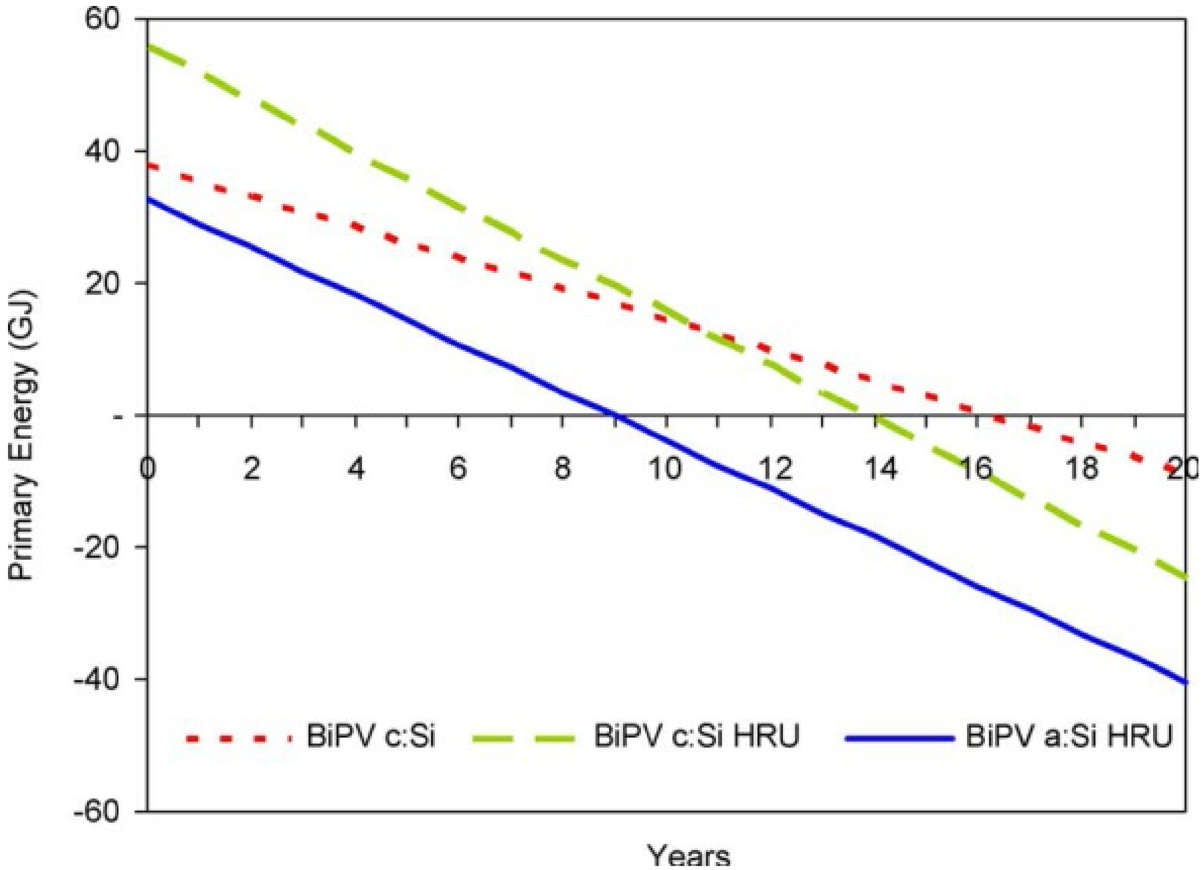
There is still considerable uncertainty in energy return on investment (EROI), however, as embodied energy estimates vary greatly from study to study:

Estimate (GJ/m^2)	Source	Comments
27.8 to 30	Crawford et al. (2006)	Wide boundary energy analysis including all aforementioned components as well as upstream materials, and the embodied energy of capital costs and machinery. Small c-Si panel installation (1.26 m^2).
4,61	Garcia-Valverde et el. (2009)	Small (0.86 m^2) installation of off-grid mc-Si array. Energy calculation excludes embodied energy of batteries.
8.99	Hagedorn (1989)	Mc-Si array produced using old technology. Seen by (Wilson 1996) as comprehensive, may be outdated.
4.45	(Lu & Yang 2010)	System-wide analysis of medium-scale (166 m^2) installation of mc-Si panels in Hong Kong. Includes inverters, transport and installation materials.
5.18	Muneer et al (2006)	Includes inverters, installation and operating energy costs. Similar scale installation (160 m^2).
4.75 (2.59 to 8.64)	Inventory of Energy and Carbon (ICE) v2.0	Panel-wide costs of Mc-Si panel. Excludes installation energy costs, transport, and inverter.

Embodied energy estimates for photo-voltaic panels range

The analysis by Crawford et al. (2006) is unusually comprehensive in its inclusion of indirect energy costs such as labour, the machinery used to build the panels, and the carbon costs of capital investment. As the above table shows, their embodied energy estimates are almost a factor of 10 higher than those of other studies.

Based on the motto “plan for the worst, hope for the best”, let’s assume that Crawford’s study is correct. This means that PV panels struggle to pay back their embodied energy over the cell's lifetime, even in sunny Australia, where the solar resource (~1800 kWh/m2/yr) is double that of the UK and much of western Europe (~900 kWh/m2/yr). See pvgis for European solar resources; Australia's solar resource was inferred from data showing 1.8 MJ/d fall on Adelaide.



Net primary energy impact of a PV panel installed in New South Wales, according to Crawford et al's (2006) wide boundary life-cycle analysis

Because of uncertainty, energy assessments should generally include a range of scenarios that in include best and worst cases, as is the case in the graphic above. Note that in the UK's climate the installation investigated by Crawford et al. (2006) would be unlikely to ever pay back the energy invested, especially given evidence that the government's feed-in-tariff scheme is deemed to do little to reduce electricity demand, instead subsidizing the electricity industry (Tamas et al., 2010).

Conclusion: putting the methods into practice

As you can see from the above examples, energy assessment is not an exact science. It is often messy and complex. When energy assessments of political intervention project energy use in the future, it is important to create alternative scenarios to illustrate that there is a range of possibilities. It is essential to state the assumptions on which the assessment is based so these can be criticised and updated with new evidence. The transport demand settings in DECC's 2050 tool is one example of this where new evidence (Millard-Ball and Schipper, 2011) suggests distance travelled could actually drop, rather than growing or levelling off. There is nothing stopping me (or anyone else) writing to DECC asking them to include more realistic assumptions.

While it is easy to criticise such models of the future as speculative, it is often only slightly less easy (but a lot more productive) to change them to incorporate more realistic assumptions in order to inform debate. Energy assessments encourage evidence based energy policy, rather than a series of knee-jerk decisions driven by emotion and rhetoric.

The range of examples illustrates how energy assessment methods are applicable to “political intervention” in the broadest sense. You can even assess the energy implications of your own life. Do you use more or less primary energy than an average citizen in your own country? What would it take to use less than the global average? All these questions can be answered with a combination of energy bills, a few reasonable assumptions, and some applied mathematics. A year ago I wrote about bicycle touring holidays as a proactive response to peak oil. The vision was largely speculative, but I could back-up my gut feeling with an analysis of the energy costs of doing it by car instead, strengthening the arguments.

In conclusion, the energy implications of a wide range of interventions can be assessed, as long as the changes are discrete, bounded and predictable. That is not to say more diffuse strategies are not worthy of consideration – indeed movements such as Transition Towns may hold the key to a successful low-energy future – simply that debates about certain energy policies can be enlightened by energy assessment.

Returning to the two questions posed at the beginning of the essay, yes we can have some idea of the likely energy impacts of political intervention by careful application of scenario driven energy analysis. The challenge now is to put these methods into practice.