Energy policy: complex?

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Abstract

- Energy generation is comparatively simple, energy policy is not.
- Can complex systems science help us to understand the national and international policies past and present?
- Can it contribute to a sensible resolution of the problems caused by our low cost energy economies and resulting carbon emissions?
- If so, how? If not, why not?

Energy Policy from an economic perspective

- The problem of energy is by now well known – how to create energy without:
  - affecting the climate to such an extent that it damages the ability of people to live in a style to which they have grown accustomed;
  - changing the climate irreversibly;
  - being exposed to unacceptable political or military threats.

- Energy policy should take care of this. It should determine:
  - how much to invest in the development of alternative energy sources,
  - where the investment should come from and
  - how it should be distributed between different energy sources
- Energy policy should be determined by standard economic criteria.

Standard economic perspective

- Let the market decide

  The use of carbon has been priced at zero.

  But this is incorrect as the creation of carbon-dioxide has financial consequences. But what should be the level of this tax? $30/ton? Possible answers; sufficient:

  - for the market to switch to non-carbon technology
  - to develop and install non-carbon technologies
  - to compensate for the future damage of continuing to use carbon energy

- # Net Present Value?

What percentage of GDP should be invested over the next 12 years to avoid a collapse of 50% of today's GDP for a period of 10 years, beginning 50 years from now?

Value To Be Discounted	Year (n)	Discount Rate (%)	Present Value
$ (0,04)	0	1,05	$ -0,040
$ (0,04)	1	1,05	$ -0,038
$ (0,04)	2	1,05	$ -0,036
$ (0,04)	3	1,05	$ -0,035
$ (0,04)	4	1,05	$ -0,033
$ (0,04)	5	1,05	$ -0,031
$ (0,04)	6	1,05	$ -0,030
$ (0,04)	7	1,05	$ -0,028
$ (0,04)	8	1,05	$ -0,027
$ (0,04)	9	1,05	$ -0,026
$ (0,04)	10	1,05	$ -0,025
$ (0,04)	11	1,05	$ -0,023
$ -	13	1,05	$ -
$ -	14	1,05	$ -
$ -	15	1,05	$ -
$ 0,50	50	1,05	$ 0,044
$ 0,50	51	1,05	$ 0,042
$ 0,50	52	1,05	$ 0,040
$ 0,50	53	1,05	$ 0,038
$ 0,50	54	1,05	$ 0,036
$ 0,50	55	1,05	$ 0,034
$ 0,50	56	1,05	$ 0,033
$ 0,50	57	1,05	$ 0,031
$ 0,50	58	1,05	$ 0,030
$ 0,50	59	1,05	$ 0,028
		Total Discounted Value	$ -0,019

But what should be the discount rate?
The UK Stern report versus Nordhaus.
See the interchange in the New York Review of Books, 25 September, 2008.[1]

- market rate based on return from competing use of funds
- comparative ability to pay for the investment at different times

[1] http://www.nybooks.com/articles/21811.

The New York Review of Books

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'The Question of Global Warming': An Exchange

By William D. Nordhaus, Leigh Sullivan, Dimitri Zenghelis, Reply by Freeman Dyson

In response to The Question of Global Warming (JUNE 12, 2008)

The New York Review *received many letters concerning "The Question of Global Warming" by Freeman Dyson [*NYR*, June 12]. Following are comments by William D. Nordhaus, whose book* A Question of Balance: Weighing the Options on Global Warming Policies*, was reviewed in the article, as well as letters from two other readers, along with a reply by Freeman Dyson.*

—The Editors

I have little to quarrel with in Freeman Dyson's review of my study *A Question of Balance: Weighing the Options on Global Warming Policies*. However, his review provoked a small eruption of letters that complained in equal measure about my study and his review, and these comments provide an opportunity to revisit some of the major controversies.

1.

The economics of climate change is straightforward. Virtually every activity directly or indirectly involves combustion of fossil fuels, producing emissions of carbon dioxide into the atmosphere. The carbon dioxide accumulates over many decades and leads to surface warming along with many other potentially harmful geophysical changes. Emissions of carbon dioxide represent "externalities," i.e., social consequences not accounted for by the workings of the market. They are market failures because people do not pay for the current and future costs of their actions.

- Leontief Input-Output model of the economy, by sector?

Monetary transactions in a Three Sector Economy

Economic Activities:

columns show the input required by each sector

rows show destination of the output from each sector

	Inputs to			Final	Total
	Agriculture	Manufacturing	Transport	Demand	Output
Agriculture	5	15	2	68	90
Manufacturing	10	20	10	40	80
Transportation	10	15	5	0	30
Labour	25	30	5	0	60

Missing are the environmental inputs that are forecast to be affected by climate change, such as:

– water supply
– climate suitability for crops, particularly long lead time crops, e.g. trees
– labour migration as the result of water shortage and crop failures
– time required to adapt machine, techniques and skills to changed circumstances

Complex Systems Models

- Best when numbers are critical, e.g. preditor-prey models
- Big advantage is in predicting size distributions, e.g. power law fits to numbers/sizes
- Ideal for handling non-linear effects, in particular phase transitions and discreteness in numbers and locations.

Two examples from ISI, Torino

- Nannen's model for predicting the effect of various policies for encouraging the adoption of carbon-neutral methods of production:[2]
  - network of firms each choosing standard or green energy
  - imitation: firms imitate the energy policy of those network network neighbours that are more financially successful
  - government policies: tax standard energy use and either use the taxes to:
    - reward the greener users
    - advertise the green users so that they are visible to more firms
  - simulation shows which policies are most effective under different conditions

[2] http://www.cs.vu.nl/ volker/

- Cantono's model for predicting the effect of various subsidies to encourage hydrogen as a fuel source:[3]
  - geographic network of builders who decide on what fuel source to install in new buildings
  - imitation: builders will only switch to new fuel source if one of their neighbours has
  - learning: cost of new fuel source is initially high, but decreases as more units are produced
  - a number of scattered builders are chosen as the first adopters
  - government has a total subsidy which it uses to reduce the cost of early adopters, spread over a number of years
  - simulation shows the effect of different ways of distributing the subsidy over time on speed and total number of adopters

[3]Environmental Input-Output Analysis and Life Cycle Assessment Applied to the Case of Hydrogen and Fuel Cells Buses. May 25, 2008. U. of Torino Department of Economics Research Paper No. 5/2008-GE

- Critique:
  - Neither model has been empirically verified against past technology changes
  - Rather both are aids for thinking through the likely consequences of various policy decisions.

Tidal energy: an anecdotal case

Energy from tides is captured by placing turbines in the sea (bed) in areas of high tidal streams ($>$ 4 knots)

Figure 6. MCT Experimental SeaFlow

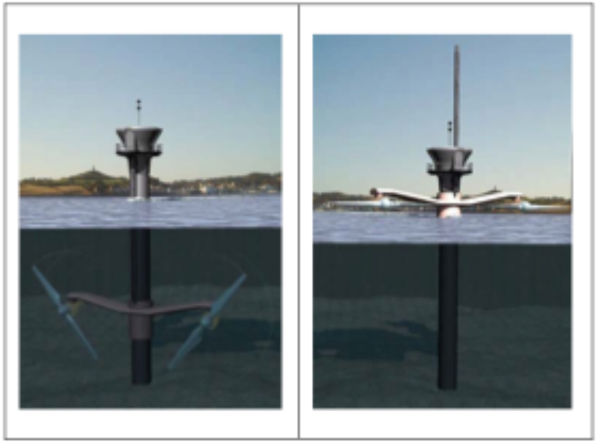

Figure 7. MCT SeaGen Prototype

Turbine types

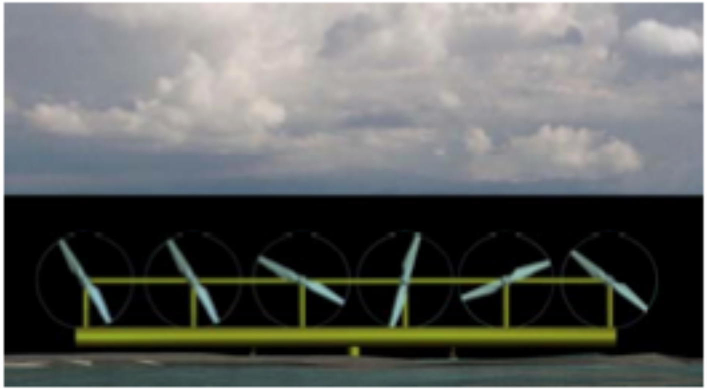

Figure 13. MCT Next Generation Concept

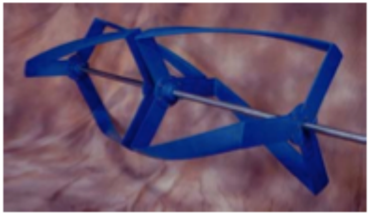

Figure 4. Gorlov Helical Turbine

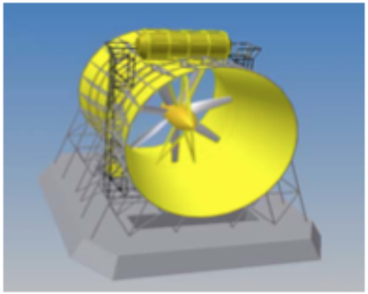

Figure 5. Lunar Energy RTT Turbine

Figure 8. Open Hydo Rim Drive Turbine

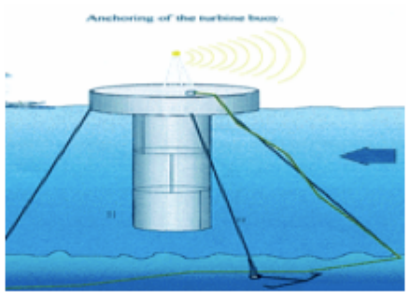

Figure 9. Seapower Vertival Axis Turbine

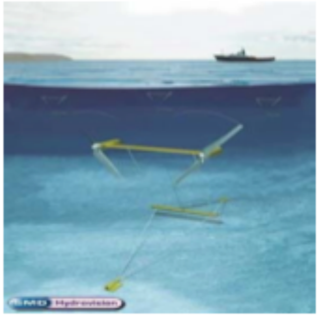

Figure 10. SMD Hydrovision

Figure 110. UEK Shrouded Turbine

Figure 121. Verdant Power RITE Turbines

What proportion of the energy of a stream can be extracted?

- The theoretical maximum amount of energy that can be extract from a smooth flow by a single turbine is 60% (Betz Law)
- The currently figure used in both the UK (by the Carbon Trust from a report they commissioned from Black and Veatch) and the USA (by he EPRI: Electric Power Research Institute) studies of tidal energy is 15-20%
- This is based on an *assumption* used by Ian Bryden (now at Edinburg University) in a series of papers from the 1990s onwards
- However, it is now an accepted 'fact'.

- In reality, the limitation is neither 20% nor even 60%, as even a single turbine with a shrowd can theoretically be more effective and a collection of turbines is not limited by Betz Law.
- It is going to be hard to change this misperception in the heads of policy makers

Towards a complex systems model for energy policy

So what is one looking for in a complex systems model suitable for guiding energy policy? Starting from a form of model already recognised in the economic community, e.g. the Leontief I-O model, but extending it it various ways, mainly to model aspects of bounded rationality

- a lag time between the creation of knowledge and its acceptance
- the birth of new firms specialising in the build of the new technology
- an influence network linking potential adopters
- learning that reduces costs both in build and use
- competition leading to standarisation of product, e.g. the three bladed wind turbine
- firms that are heterogenious, in particular of different sizes

- AND, most important, data on adoption of new techniques with which to verify the model, e.g. the development and spread of wind turbines

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