Engineering of Emergence for a Low Carbon Economy

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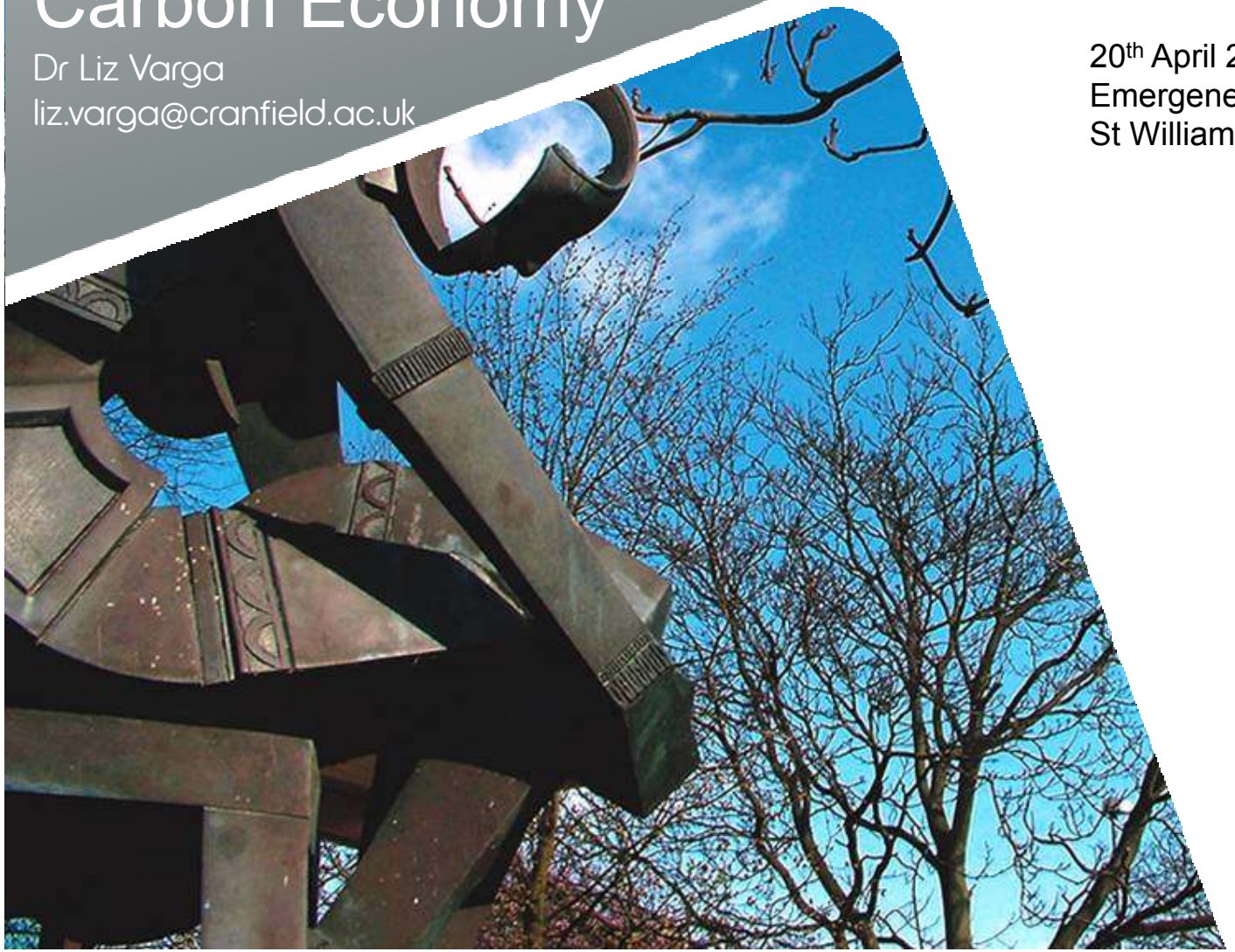

20th April 2010
Emergenet4
St William's College, York, UK

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The problem

http://www.thegogreenblog.info/global-warming/what-is-climate-change-and-how-does-it-affect-us

The goal

- Department of Energy and Climate Change (2009) The UK Low Carbon Transition Plan, The Stationery Office
  - ❑"*deliver emission cuts of 80% on 1990 by 2050*"
  - ❑*Address the risk of "widespread human suffering, ecological catastrophes, and political and economic instability"* (DECC, 2009: 22)

Beyond Copenhagen (DECC, 2010)

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"Climate change is happening even faster than previously estimated; global CO_2 emissions since 2000 have been higher than even the highest predictions, Arctic sea ice has been melting at rates much faster than predicted, and the rise in the sea level has become more rapid. Feedbacks in the climate system might lead to much more rapid climate changes. The need for urgent action to address climate change is now indisputable."

G8+5 academies' joint statement – climate change and the transformation of energy technologies for a low carbon future May 2009[1]

Ofgem

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- Ofgem (2010), “Action needed to ensure Britain's energy supplies remain secure”
  - *Address doubt over secure and sustainable energy supplies beyond 2015 brought about by the convergence of various factors*
    - *the financial crisis,*
    - *demanding environmental targets,*
    - *increasing gas imports, and*
    - *closure of ageing power stations.*

The strategy - legislation

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- Carbon Change Act 2008
  - ❑ Limits to total greenhouse gas emissions
  - ❑ 5 areas to be reduced across most government departments
    - power and heavy industry
    - transport
    - homes and communities
    - workplaces and jobs
    - farming, land and waste

The strategy - legislation

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- Carbon Accounting Regulations
  - ❑ *Incremental reduction over 3 budget periods*
  - ❑ *Assigned carbon reduction targets*
  - ❑ *Flexibility across budget periods*

Energy Industry (1)

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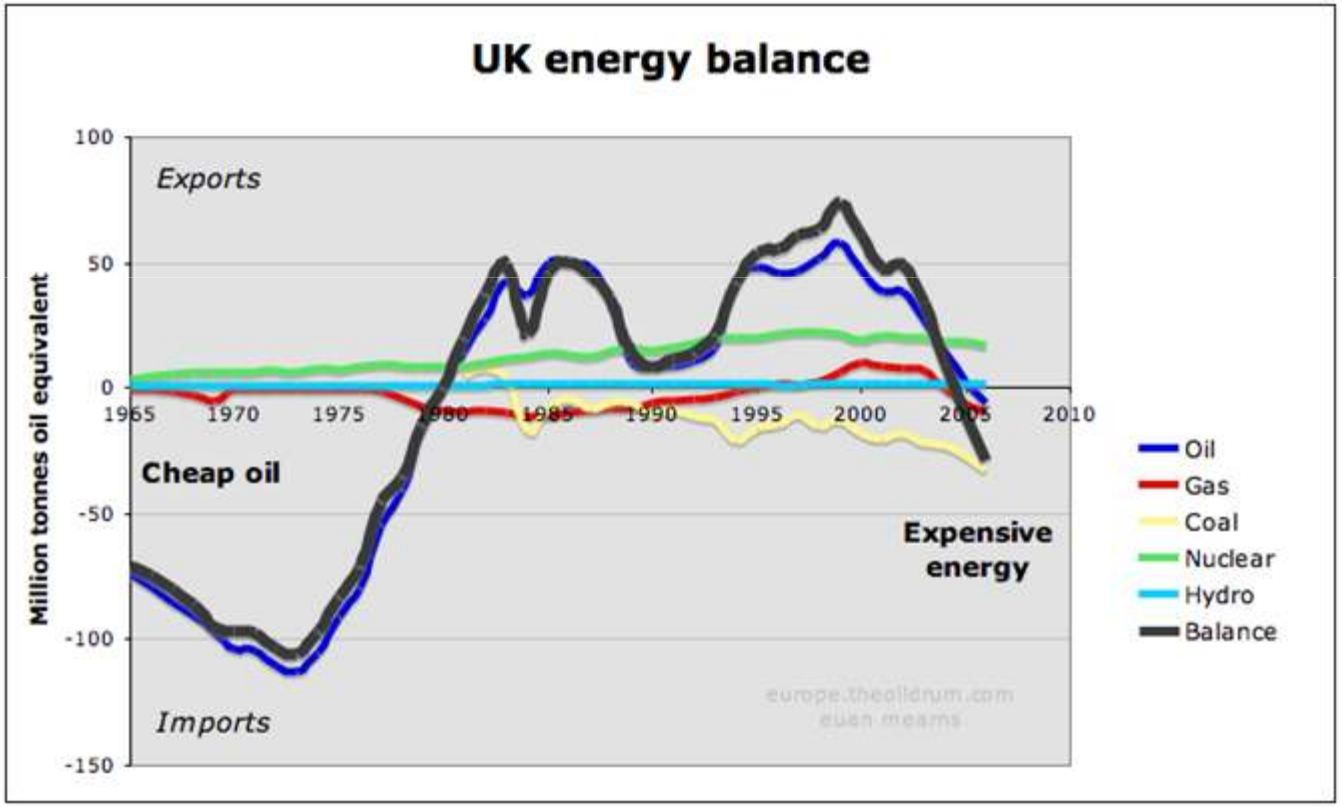
- *Aging infrastructure*
- *Large scale generating plants*
- *Long-range high voltage, local low voltage distribution networks*
- *Local transformers reaching capacity*
- *Expensive standby capacity to meet peak loads,*

Energy balance



Energy Industry (2)

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- *High capital cost and long lead-times for new plant,*
- *Economic inefficiency due to deadweight losses, external costs and imperfect 'top-down' regulation,*
- *Vulnerability to energy security threats of various kinds, and*
- *Rigidity to change*

National Grid – Opportunities for new generation (2009)

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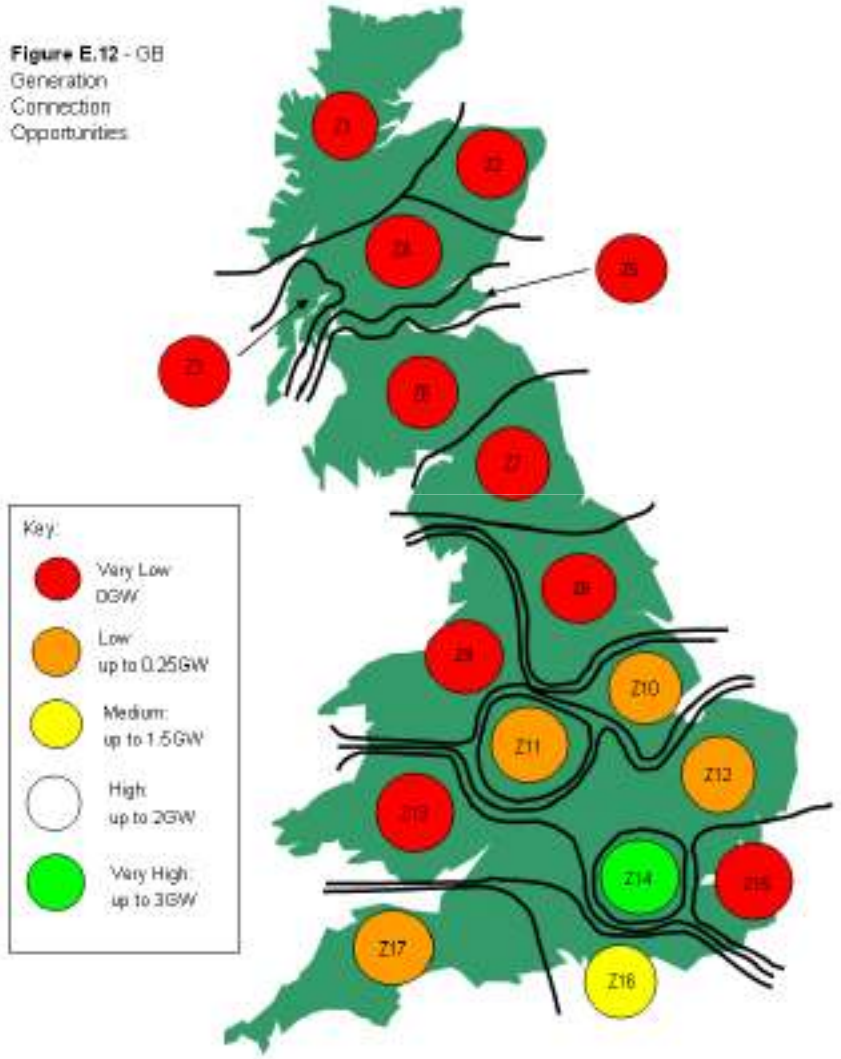
- *17 "Seven Year Statement" Zones*
- *Zones which have the ability to connect new generation (and no planning issues)*



Ofgem options

- *Creation of a central electricity buyer which would essentially regulate the market for sustainable and secure energy generation.*

How to solve the problem of carbon emissions

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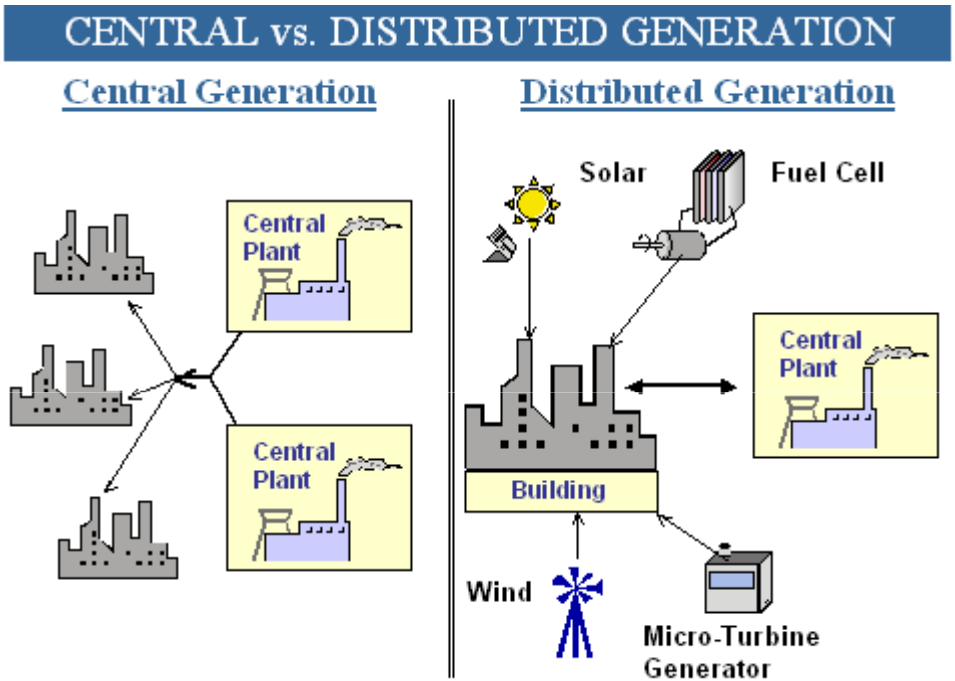
- Reduce energy demand?
  - *Taxation and Regulation*
- Homes and communities
  - *Insulation – half lost via windows and loft (done)*
  - *Legacy housing stock – external wall insulation*
  - *Turn off devices – information lags, social norms*
  - *Generate own energy (household or community) from renewables – PV, wind (interferes with radar, NIMBY)*

Distributed energy options for renewables

- *Opportunity to exploit distributed energy resources and the development of more flexible and sophisticated energy services that might lead to greater energy efficiency.*
- *Needs to address resilience and security*



The nature of socio-economic systems

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- *Co-evolutionary with natural and built environment*
- *Agent behaviours*
  - *Paradox of increased availability creating more creating more demand (Alcott, 2008, "The sufficiency strategy")*
  - *Imitation, motivation and knowledge*
- *Organizations (and their actions) influencing use of energy, e.g. transport, production*
- *Technology – innovative, trustworthy products and services*

Solution – brings together desired outcomes

- Low carbon
- Sustainability
- Security
- Resilience
- Efficient
- Needs transformational change
- Creates a distributed energy network

Agent Based Model – of de-centralized system

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- *Two problems in different time frames:*
  - *Structural Change*
    - *Should renewables connect to National Grid?*
    - *How should information networks be integrated?*
    - *What types of homes/firms are there?*
    - *What economic possibilities are there?*
    - *What local environment resources apply?*
  - *Dynamics, peaks of electricity flow*

Model structural change – amount generated by micro renewables

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- *Amount generated by an agent (consumer-generator) at zone i is a function of the utility of a household installing or removing their micro renewable energy solution, e.g. micro solar (miso)*

dmiso(i)/dt = g*(Revenueso(i)/costso(i) -1)*

(1 – miso(i)/RfArea(i)) *(1 + s*miso(i)/RfArea(i))

Micro renewables (2)

- ***dmiso(i)/dt = g*(Revenueso(i)/costso(i) -1)* (1 – miso(i)/RfArea(i)) *(1 + s*miso(i)/RfArea(i))***

- g expresses how fast the installation of household solar and wind can proceed.
- Revenue would depend on payment policy and on the suitability of the site for solar or wind use.
- Costs of the relevant technology vary over time

Micro renewables (3)

- ***dmiso(i)/dt = g*(Revenueso(i)/costso(i) -1)* (1 – miso(i)/RfArea(i)) *(1 + s*miso(i)/RfArea(i))***

- RfArea(i) is the total available area for micro solar panels and is therefore proportional to the number of houses. This will be a function of the type of housing

Micro renewables (4)

- ***dmiso(i)/dt = g*(Revenueso(i)/costso(i) -1)* (1 – miso(i)/RfArea(i)) *(1 + s*miso(i)/RfArea(i))***

- The term (1 + s*miso(i)/RfArea(i)) implements the fact that the rate of growth of the micro solar (in this example) is affected by the spatial dynamics of knowledge. As the concentration of installations increases so will the knowledge of the pay-offs, and if these are positive, the rate of growth will increase.

Demand

- **Demand(i) = Σj (e(t,j)*Pop(j) – Intmiso(t,j)*miso(j) – Intmiw(t,j)*miw(j))*Att(ij)/ΣAtt(i'j)**
- Where e(t,j) is the instantaneous energy requirements of the population at j.
- Intmiso(t,j) and Intmiw(t,j) represent the intermittency of local solar and wind at zone j, and demand is therefore generated by the rapidly changing household and business demand as well as the intermittent solar and wind local production.

Combining structural change and flows

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- Create new agents – consumer/generation
- Transition – moves those most able to, with most incentive and reward
- ABM demonstrates the path from now to the future
- ABM models emergent properties of the system
- Distributed Energy Resources address resilience and security

The strategy - legislation

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- Carbon Change Act 2008
  - ❑ Government to regulate and incentivize (sticks and carrots), the 5 areas to be reduced across most government departments
    - power and heavy industry
    - transport
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