



Three versions of interdependence

*The ITRC's national infrastructure
system-of-systems modelling capability*

Prof Jim Hall

4 April 2014

Motivation

“The stakes are high. Failure to develop and implement a vision for our infrastructure will mean the UK falls behind its competitors, loses out both economically and socially, and could miss its carbon reduction targets”

“Britain will not be able to compete in the modern world unless we improve our infrastructure.”

“The government recognises that meeting the UK’s infrastructure ambitions requires a long-term sustainable plan, which means taking a cross-cutting and strategic approach”

The image shows the front cover of the 'National Infrastructure Plan 2011' report. At the top right is the logo for the 'COUNCIL FOR SCIENCE AND TECHNOLOGY'. Below it is the title 'A National Infrastructure for the 21st Century' in large white letters, with a small map of the UK in the background. At the bottom are logos for 'HM TREASURY' and 'Infrastructure UK'.

The image shows the front cover of the 'National Infrastructure Plan 2013' report. It features a red vertical bar on the left and a blue vertical bar on the right. The title 'National Infrastructure Plan 2013' is at the bottom, preceded by a red horizontal line. Above the title is the HM Treasury logo.

The UK Infrastructure Transitions Research Consortium (ITRC)

Aim: To develop and demonstrate a new generation of simulation models and tools to inform the analysis, planning and design of national infrastructure

Ambition: Enabling a revolution in the strategic analysis of NI provision in the UK...

whilst at the same time becoming an international landmark programme recognised for novelty, research excellence and impact.



The consortium



Prof Jim Hall
(University of Oxford) is Director of the ITRC



Prof Nick Jenkins
(Cardiff University) is an expert in energy supply and transmission



Dr Nick Eyre
(University of Oxford) is an expert in energy demand



Prof John Preston
(University of Southampton) is an expert in transport systems



Prof Chris Kilsby
(Newcastle University) is an expert in water resource systems



Prof Tom Curtis (Newcastle University)
is an expert in waste water systems



Prof William Powrie
(University of Southampton) is an expert in solid waste and geotechnics



Prof Cliff Jones
(Newcastle University) is an expert in the reliability of computer-based systems



Dr Seth Bullock
(University of Southampton) is an expert in complex systems



Dr Stuart Barr
(Newcastle University) is an expert in geospatial data analysis



Prof Robert Nicholls
(University of Southampton) is an expert in the impacts of climate change



Prof Peter Tyler
(University of Cambridge) is an expert in regional economics



Prof Mark Birkin
(University of Leeds) is an expert in analysis of demographic change



Dr Jim Watson
(University of Sussex) is an expert on socio-technical transitions and the governance of energy systems

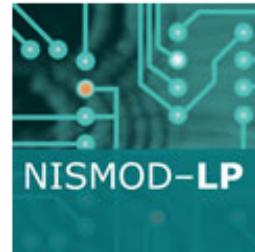
Research questions



1. How can infrastructure capacity and demand be balanced in an uncertain future?
2. What are the risks of infrastructure failure and how can we adapt National Infrastructure to make it more resilient?
3. How do infrastructure systems evolve and interact with society and the economy?
4. What should the UK's strategy be for integrated provision of NI in the long term?

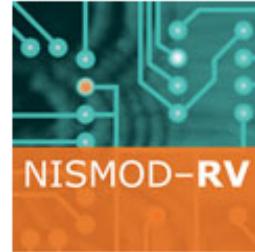


Analysing the solutions: The National Infrastructure Systems Model family



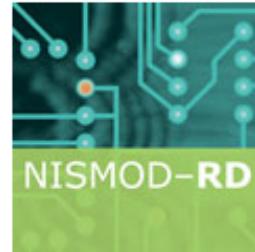
NISMOD-LP

A national model of the long term performance of interdependent infrastructure systems



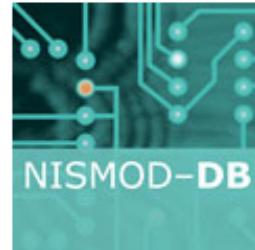
NISMOD-RV

A national model of risks and vulnerability in national infrastructure systems



NISMOD-RD

A model of regional development and how it adapts to infrastructure provision



NISMOD-DB

A national database of infrastructure networks, demand and performance

Three versions of interdependence

Interdependence in:

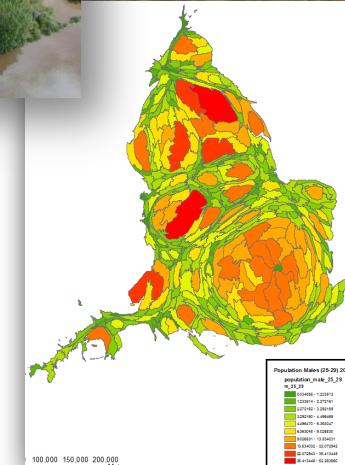
1. Demand



2. Failure

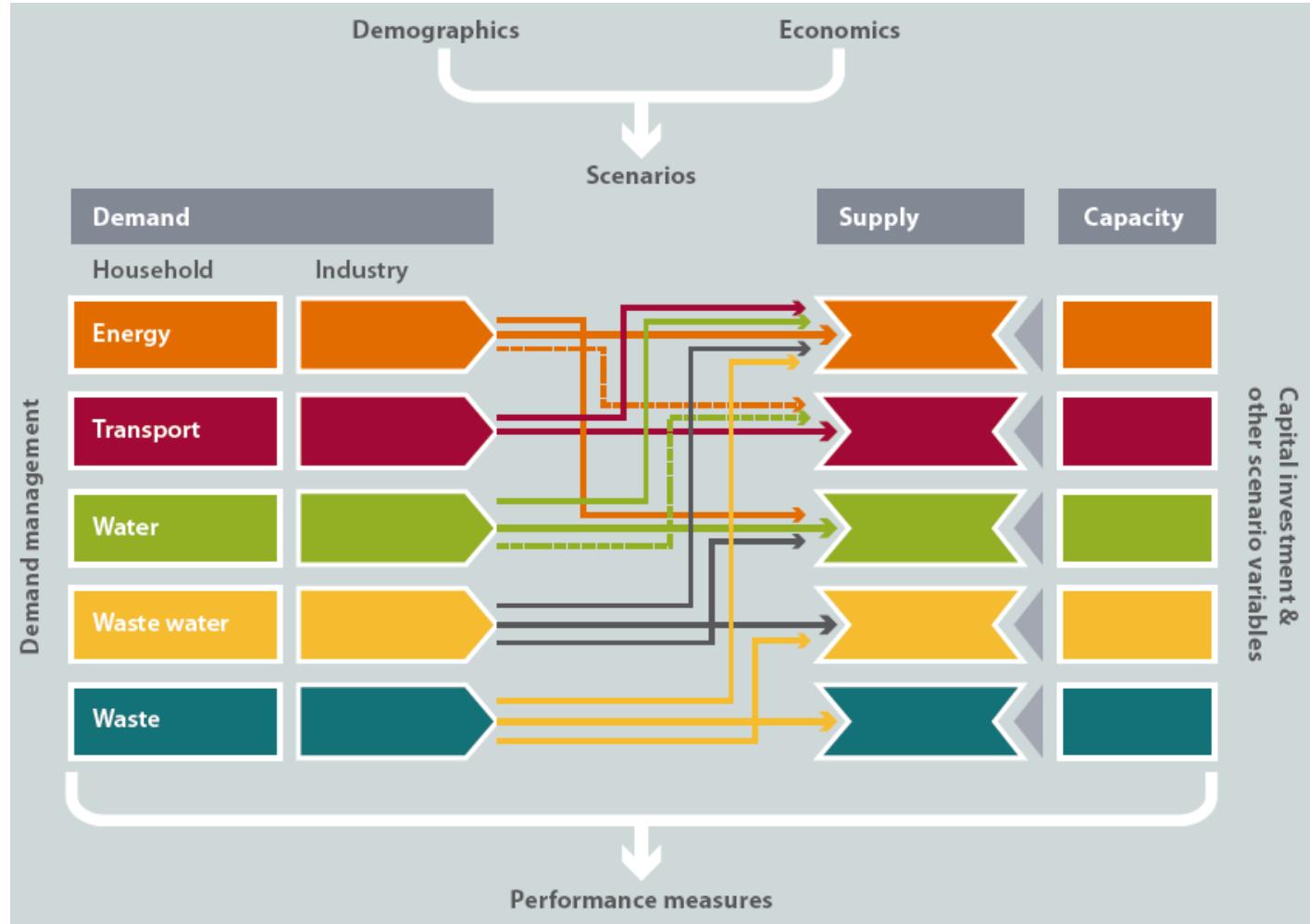


3. Economic growth,
population and land
use change



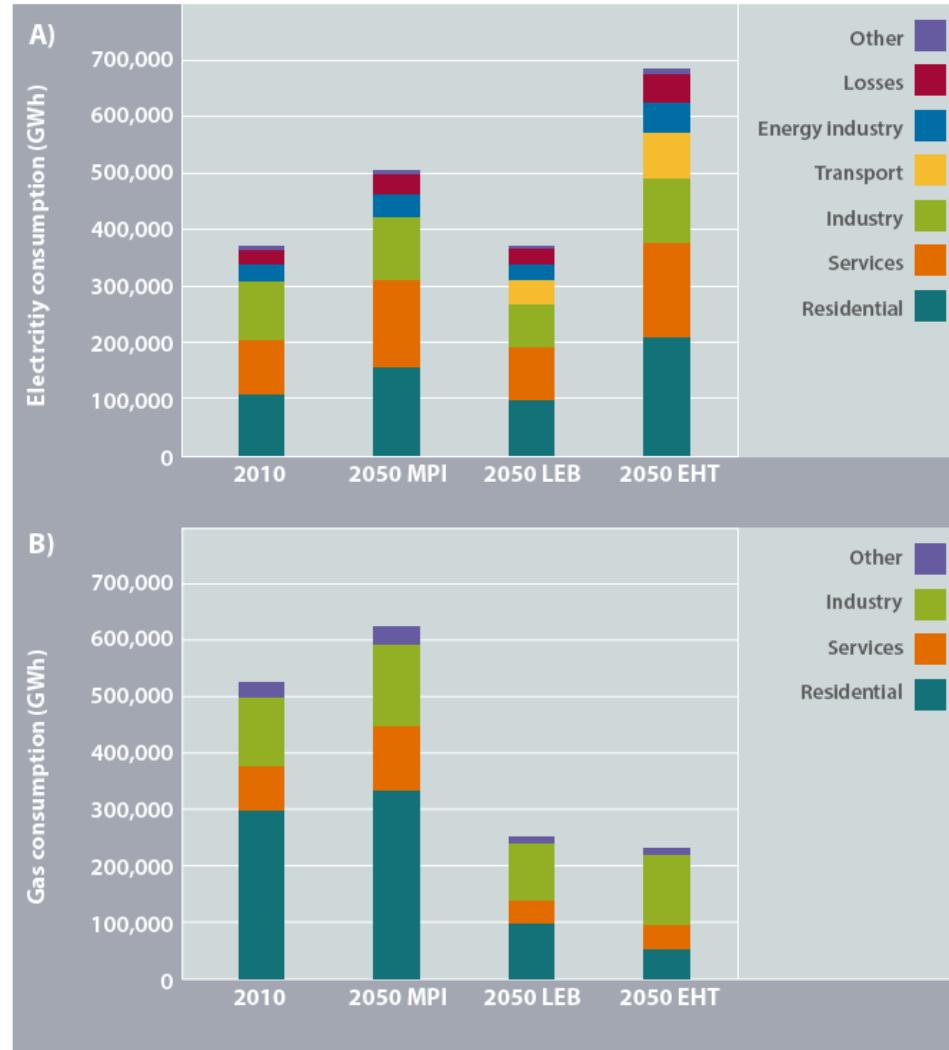


Analysing long term performance of NI



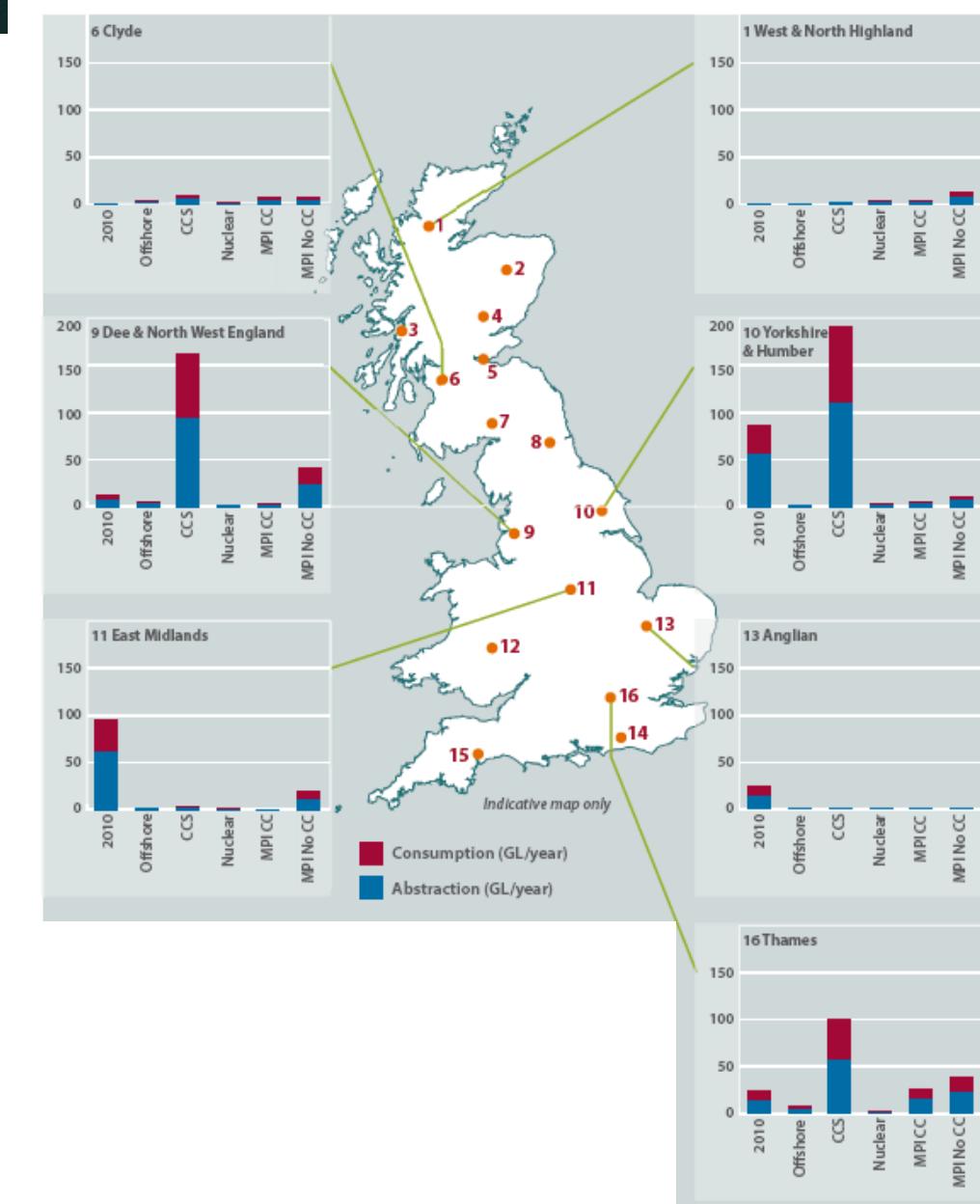
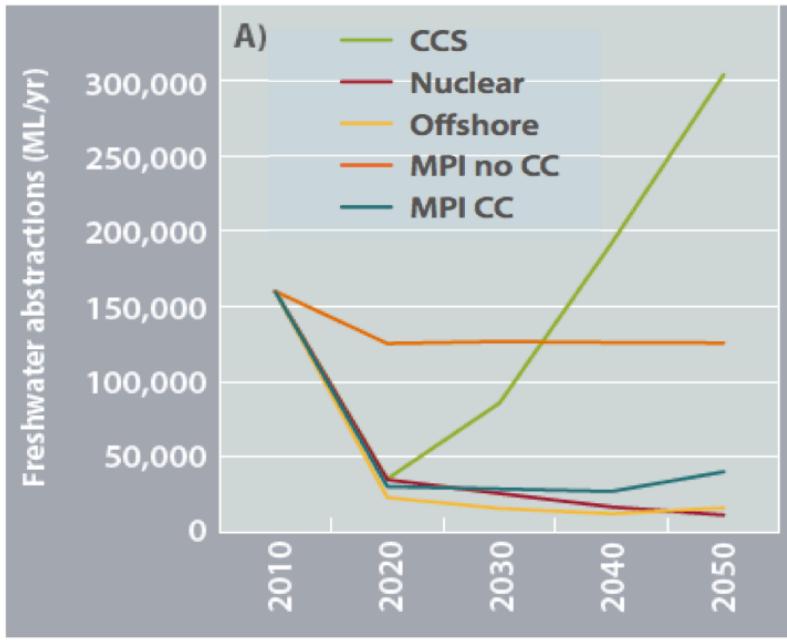


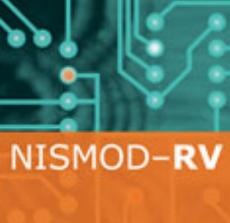
Demand interdependence: transport and energy



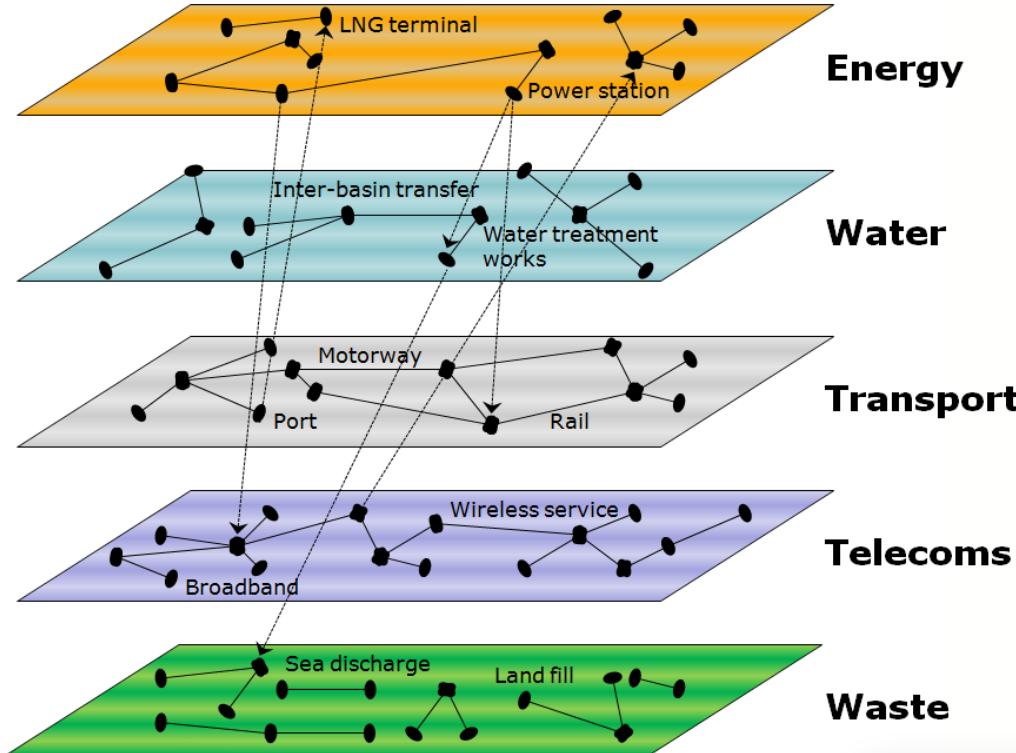


Demand interdependence: energy and water





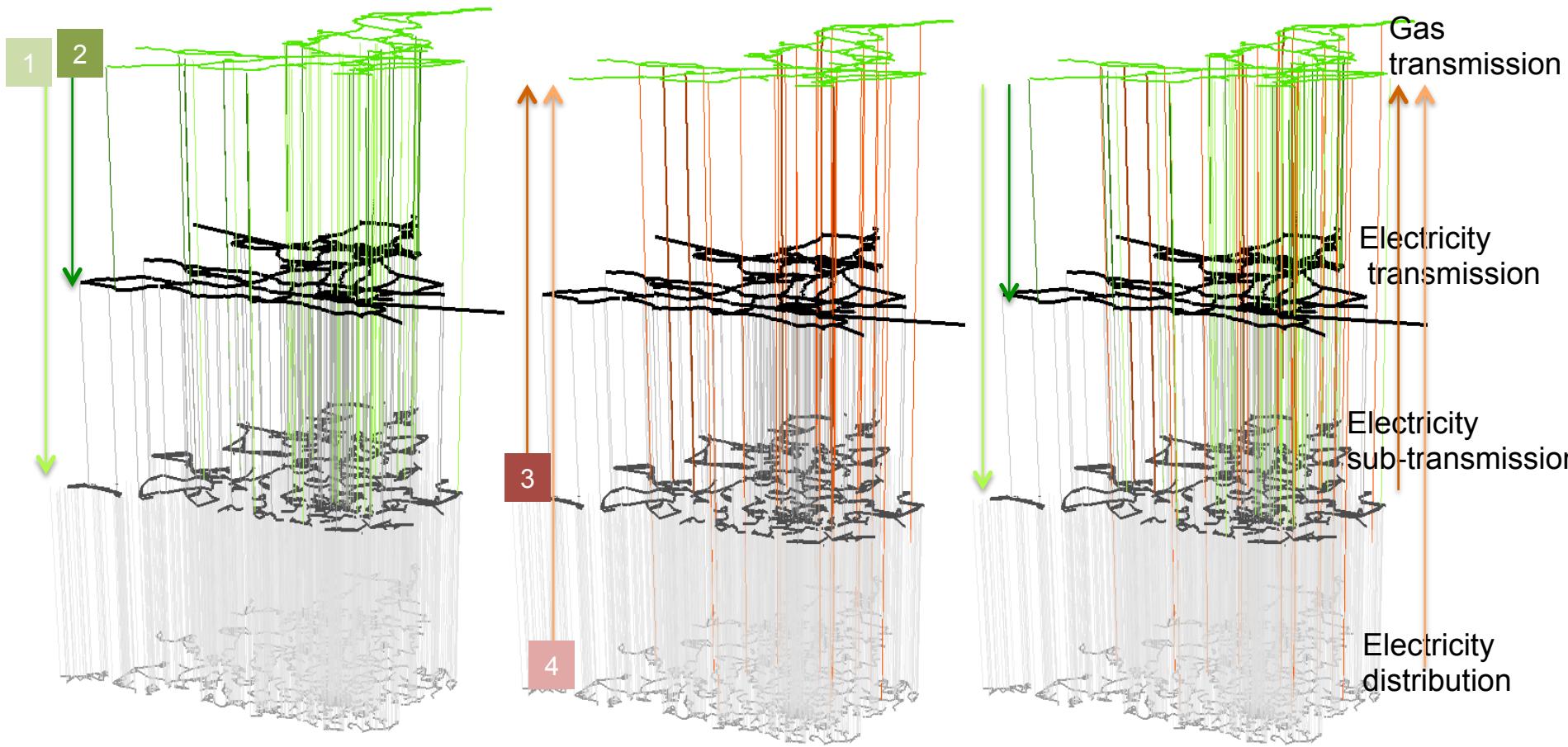
Understanding the future risks of infrastructure failure





NISMOD-RV

Mapping network interdependencies



Electricity dependency on Gas

- 1) Large power stations @ transmission level
- 2) Medium power stations @ 132kV level

Gas dependency on electricity (selected)

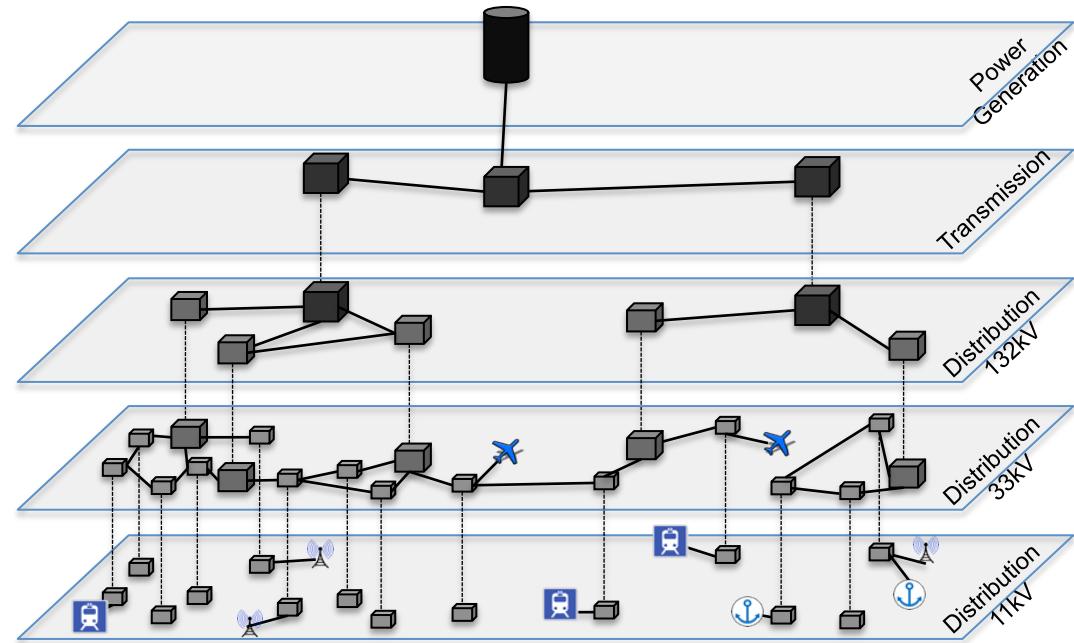
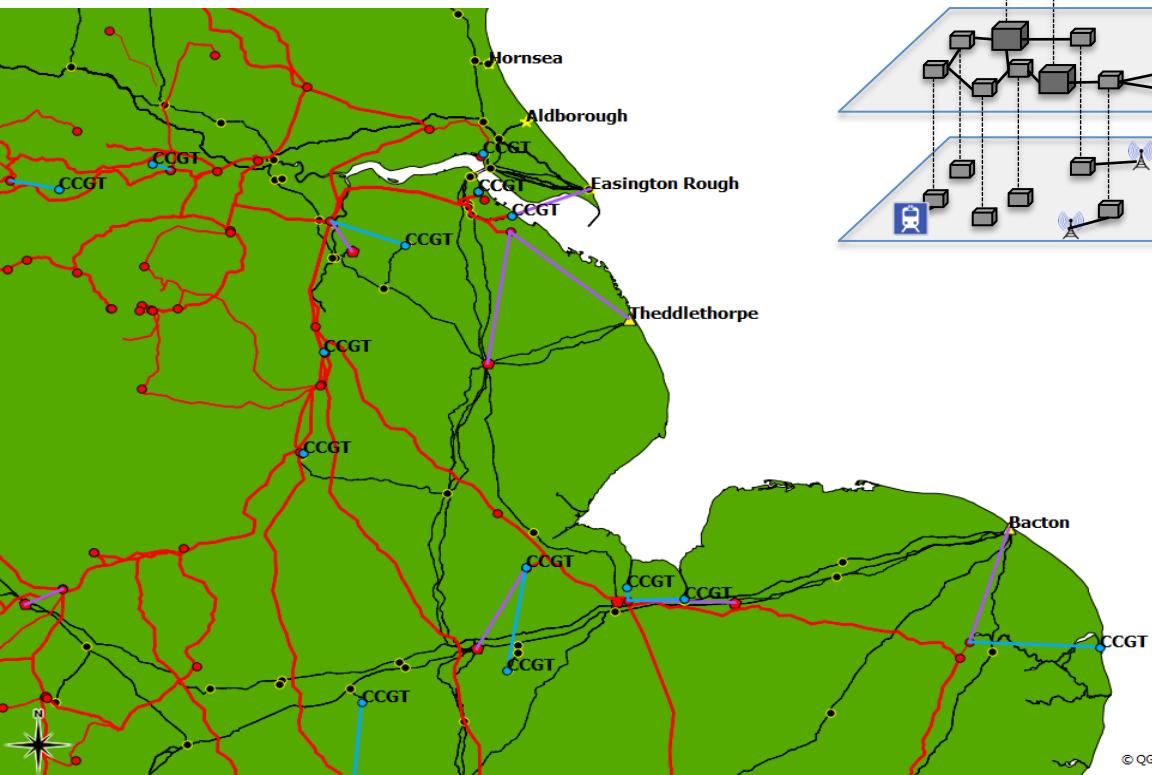
- 3) LNG @ 132kV level
- 4) Compressors at 33kV level

Interdependency representation

- 2 way flows highlighted..

Mapping network interdependencies

Interdependent networks

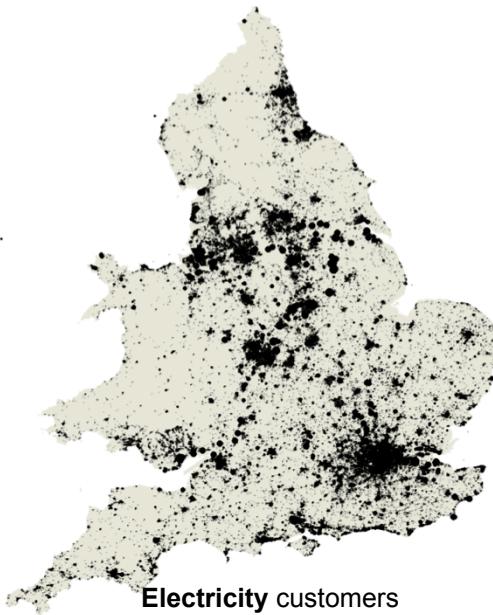




NISMOD-RV

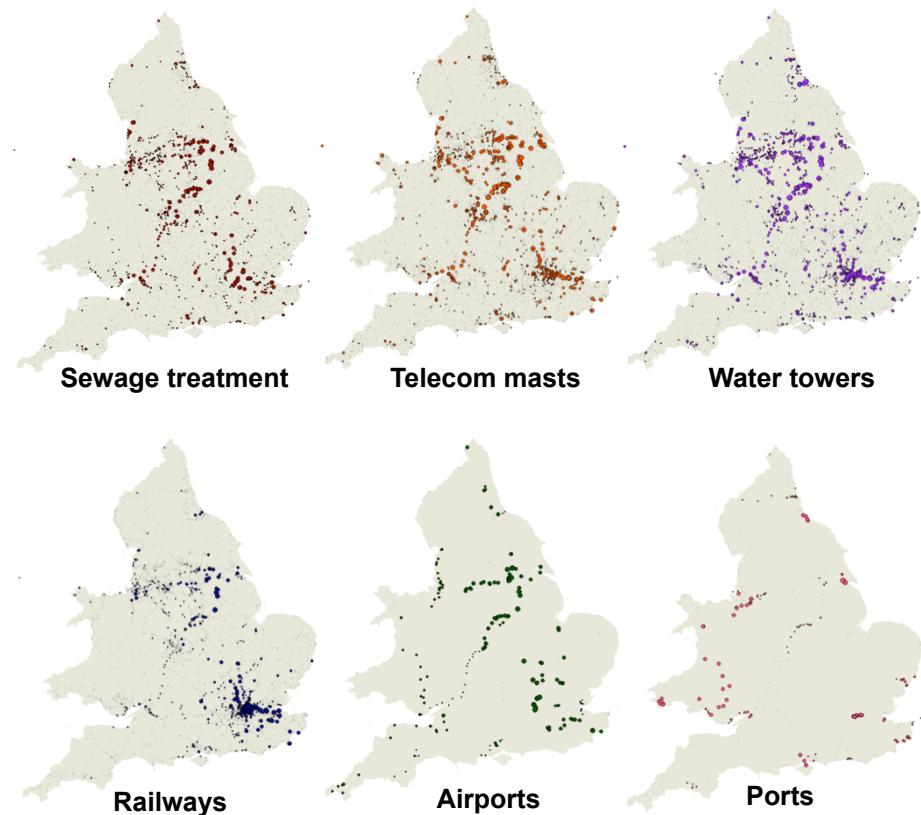
Mapping customer demands

Direct customer demands



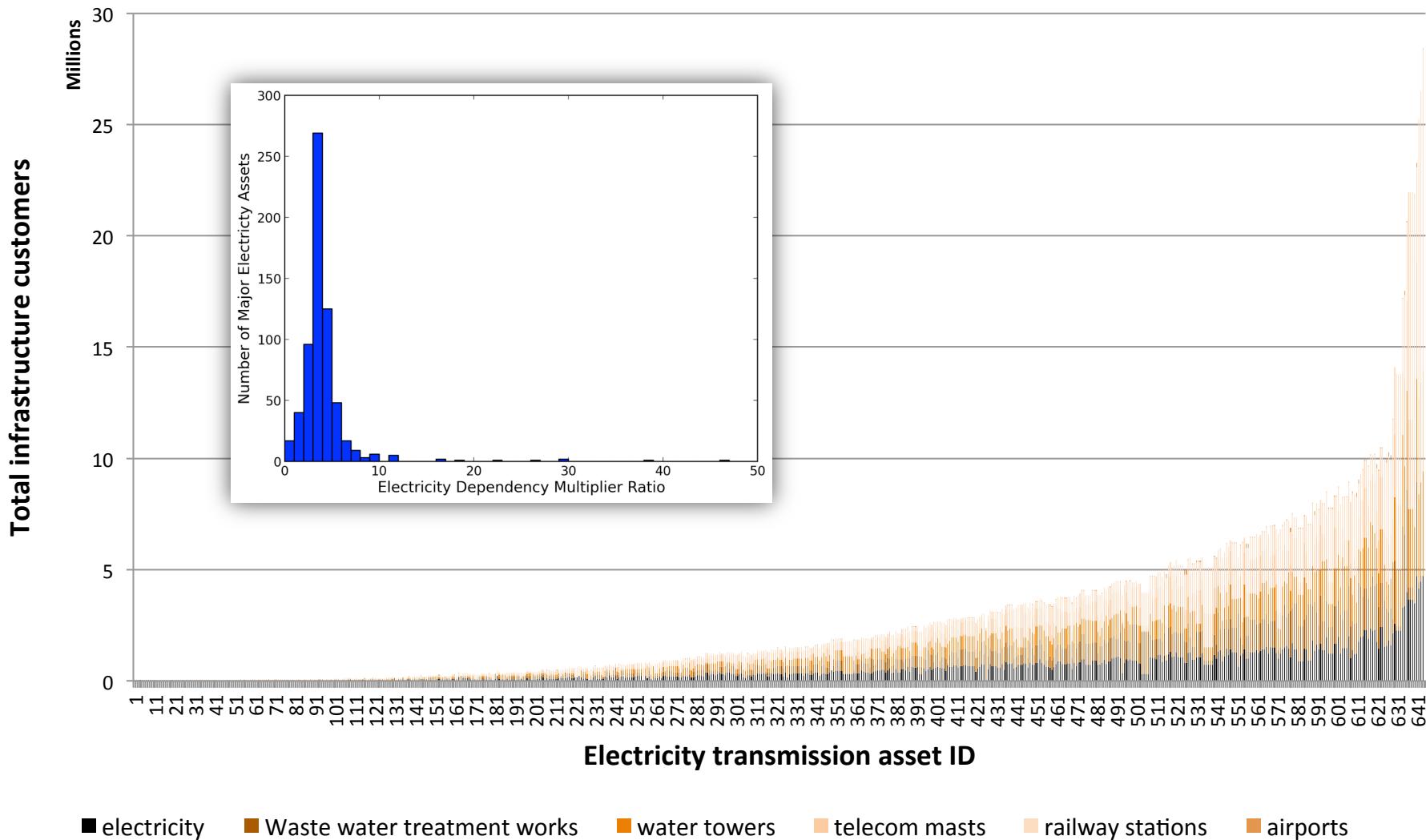
Electricity customers

Indirect customer demands on Great Britain's electricity network



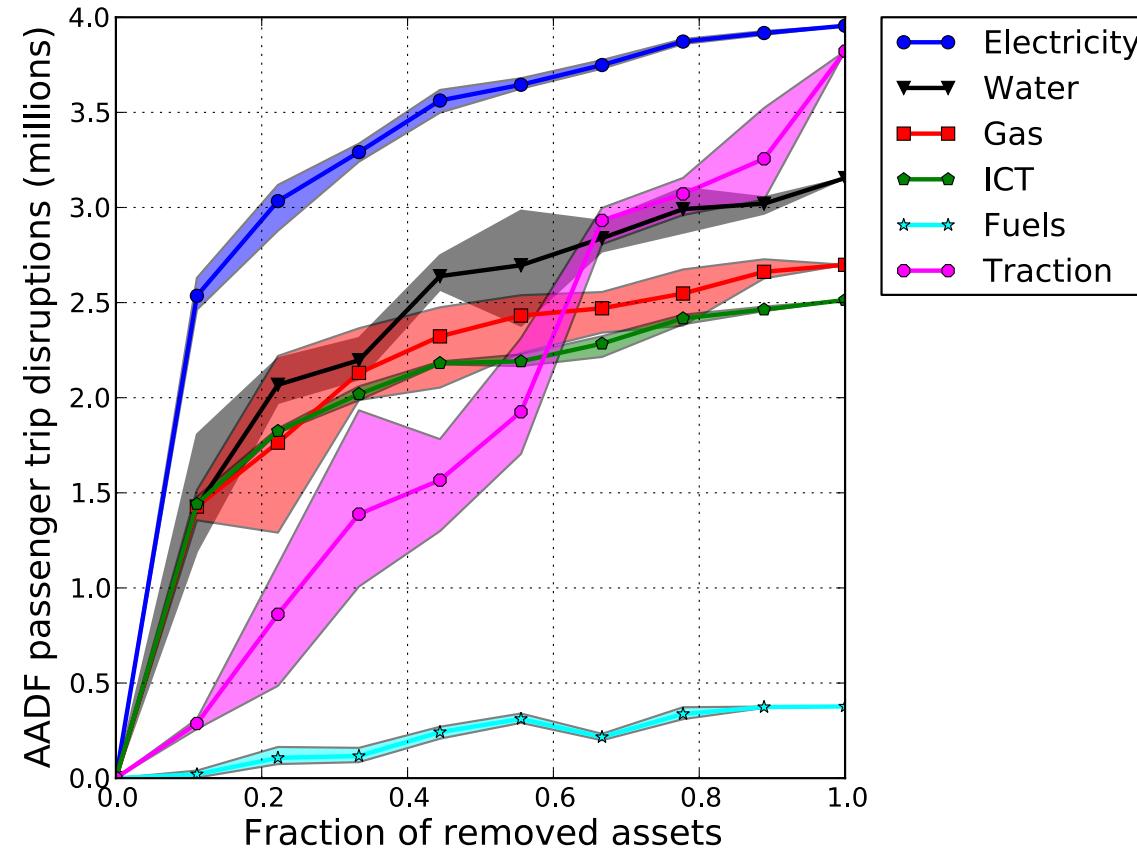


Calculating potential customer disruptions: electricity



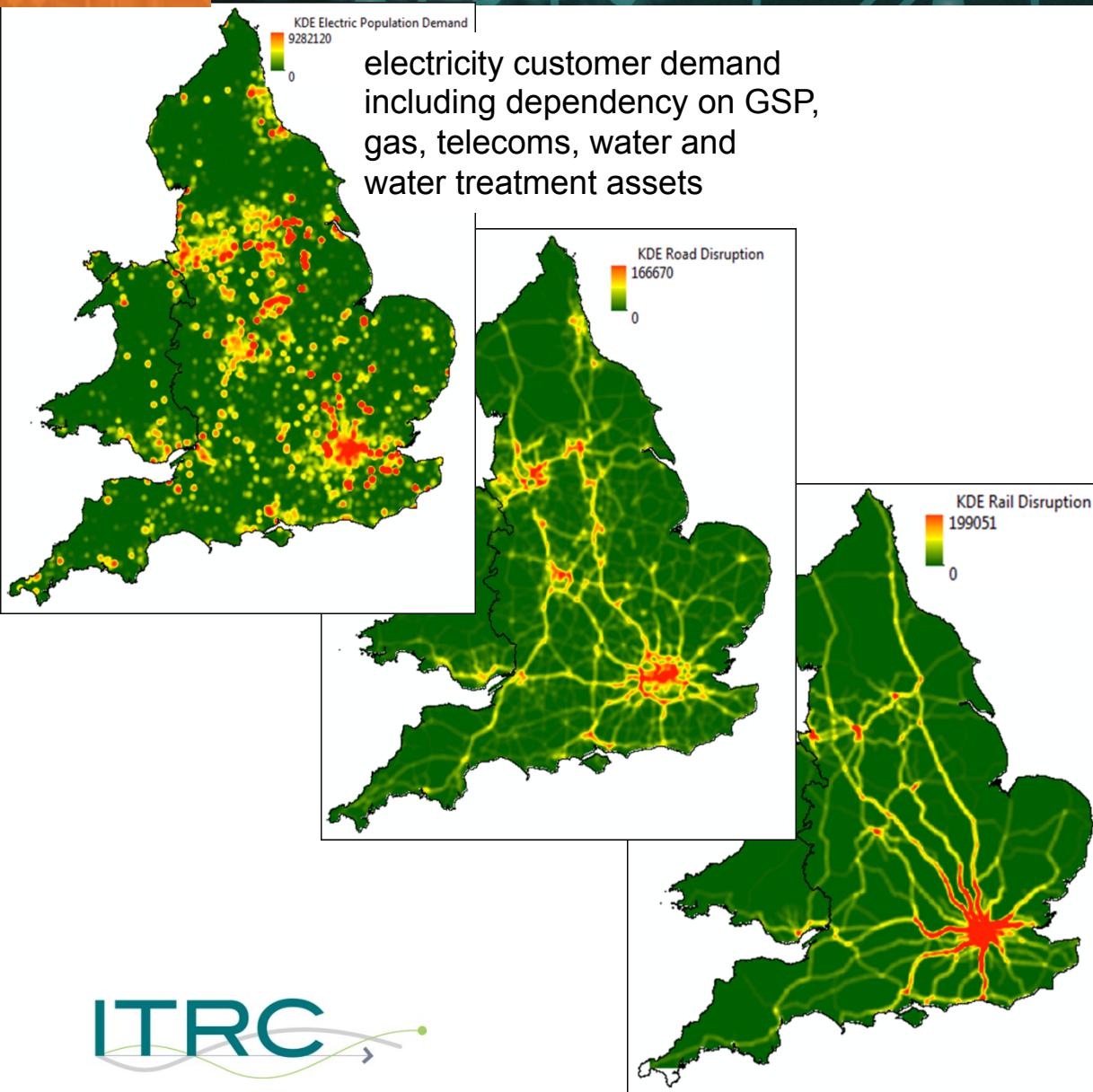


Calculating potential customer disruptions: rail

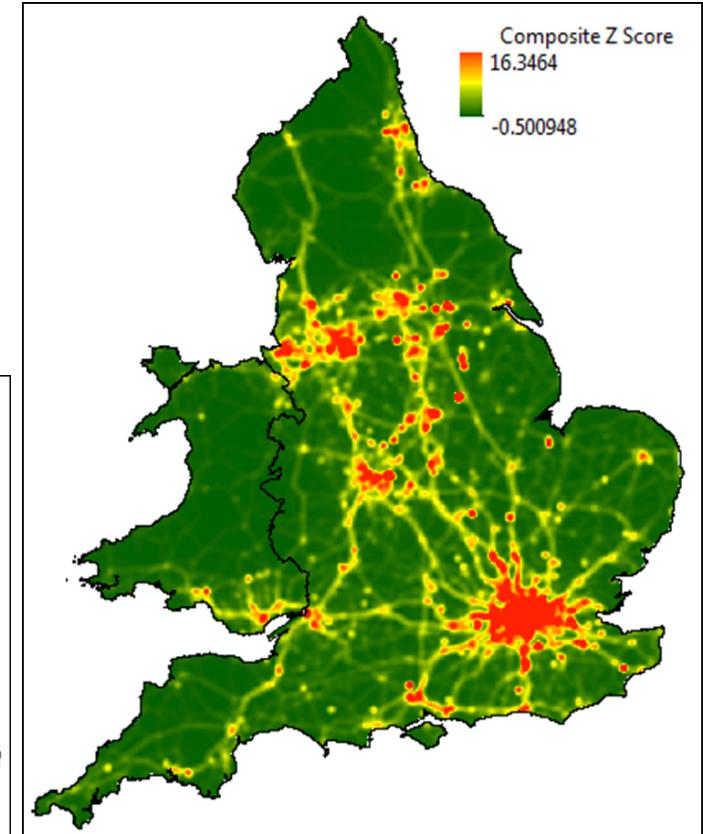




Identifying criticality hotspots

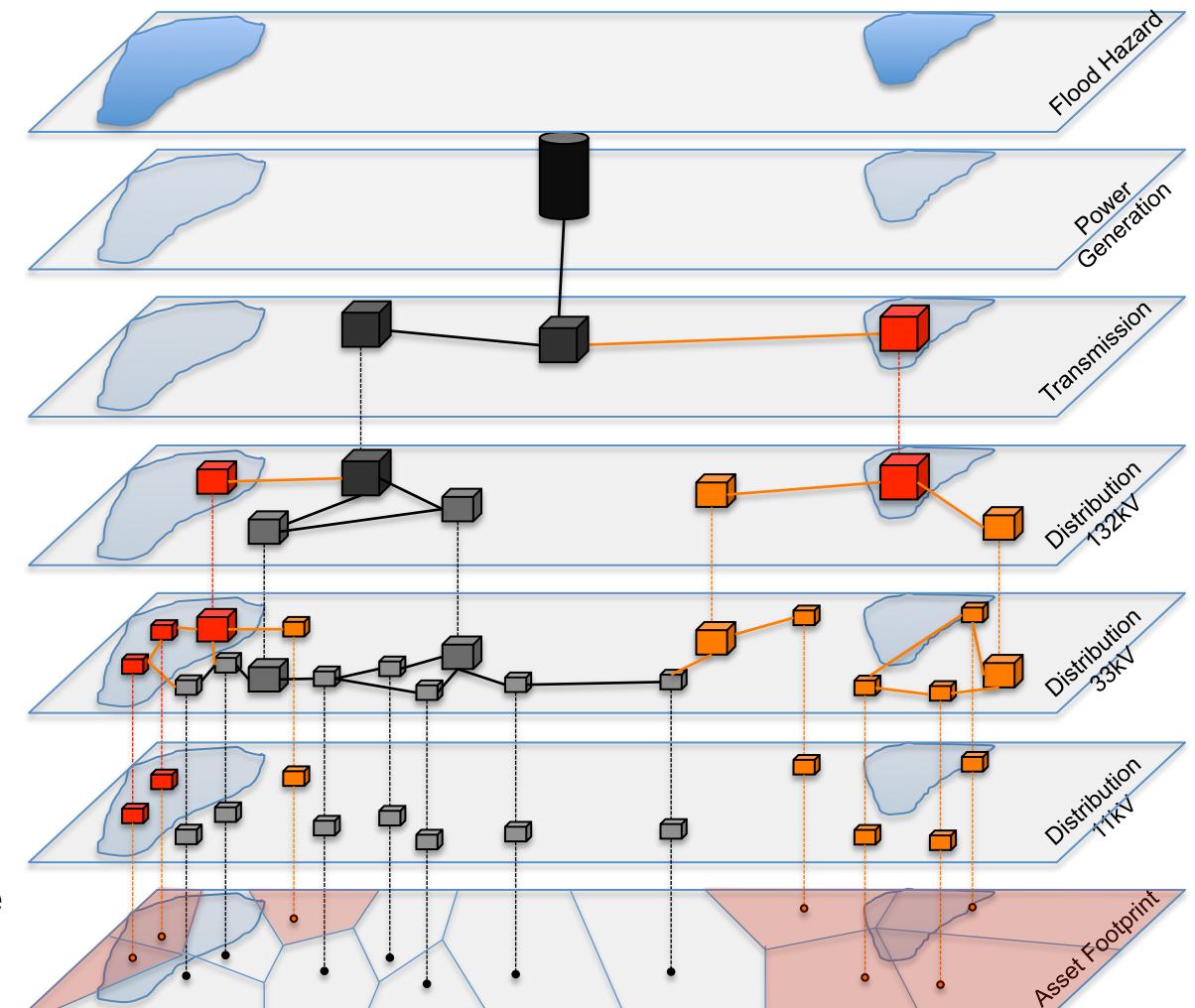


Composite criticality map





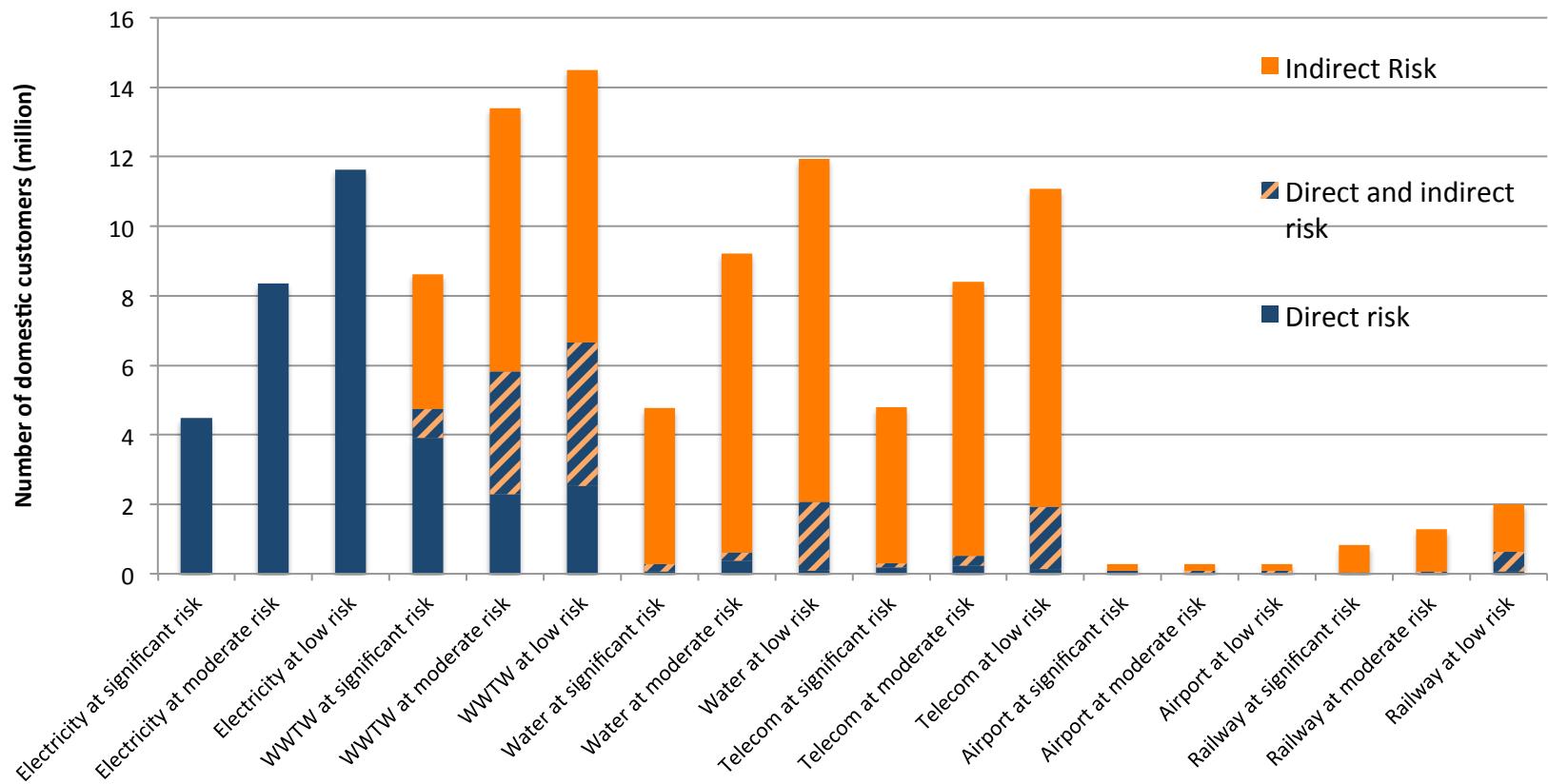
Superimposing hazard maps



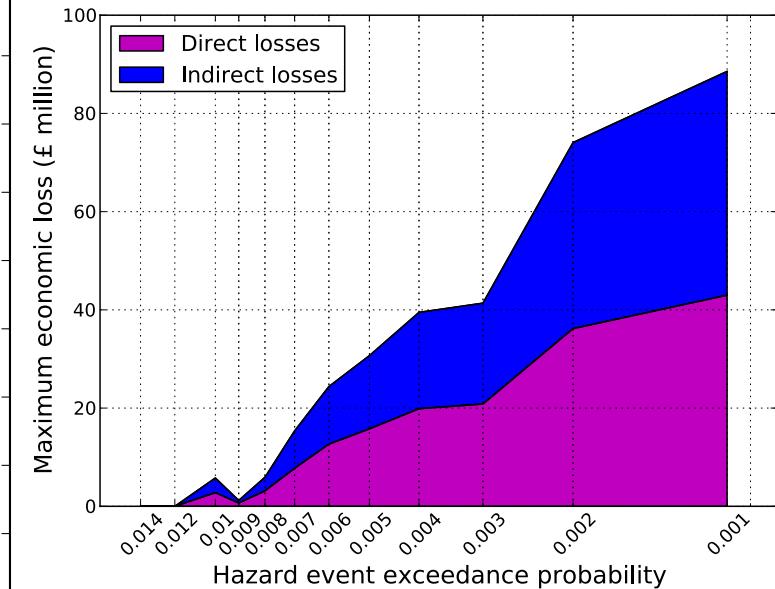
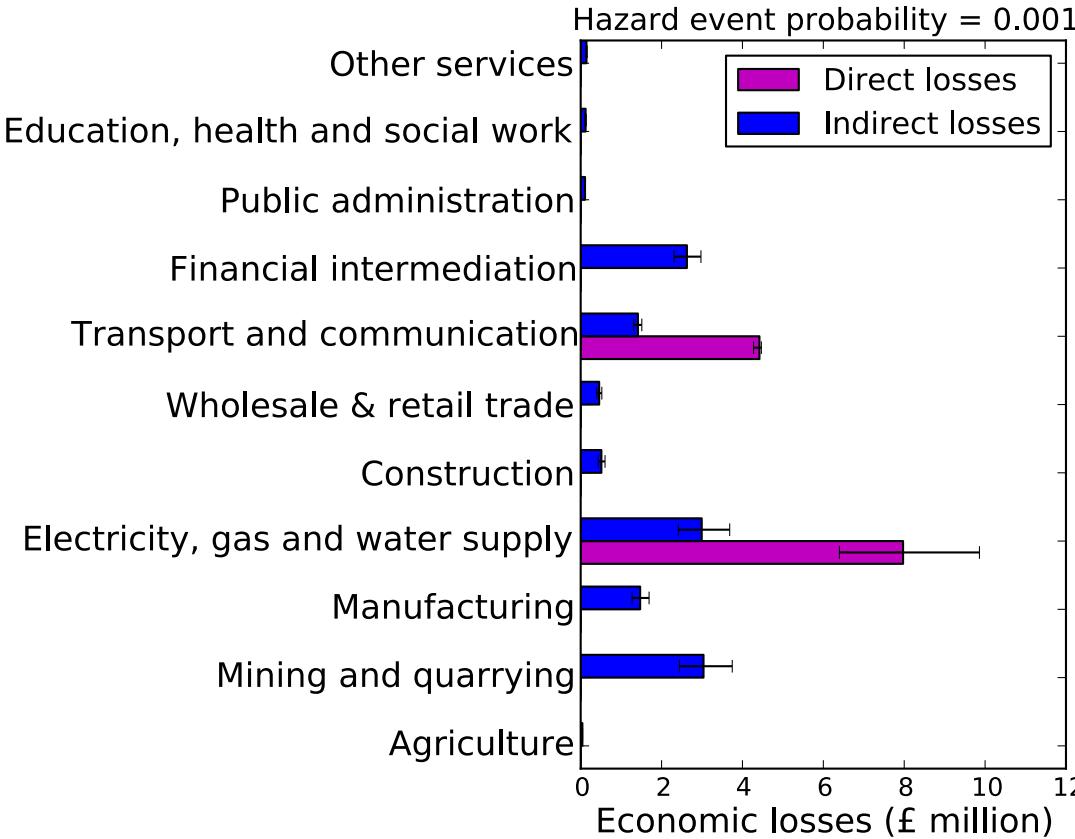
- Asset – Direct failure
- Asset – Indirect (network) failure



Infrastructure Customers at Risk of Disruption due to Flooding of the Thames Catchment

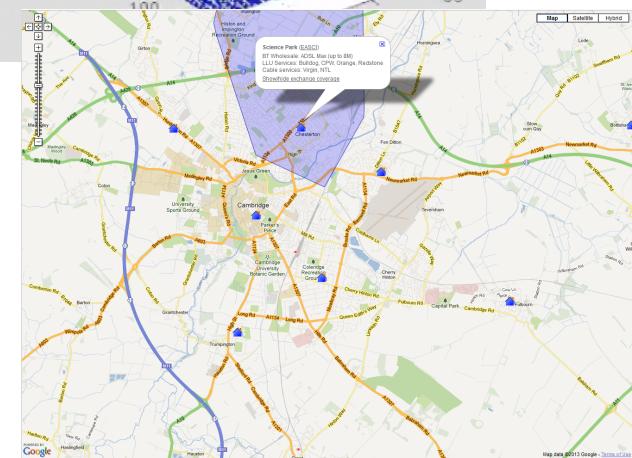
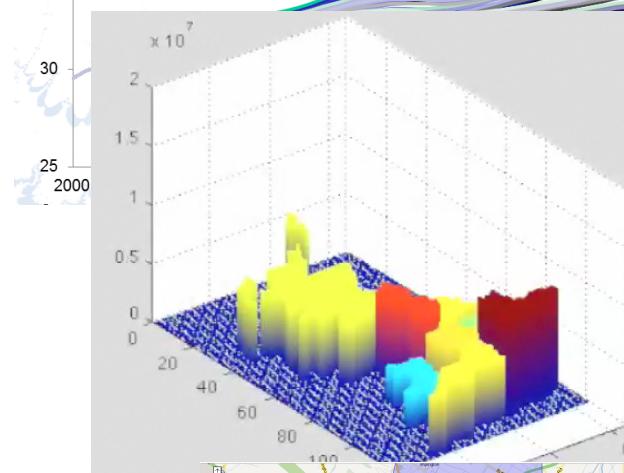
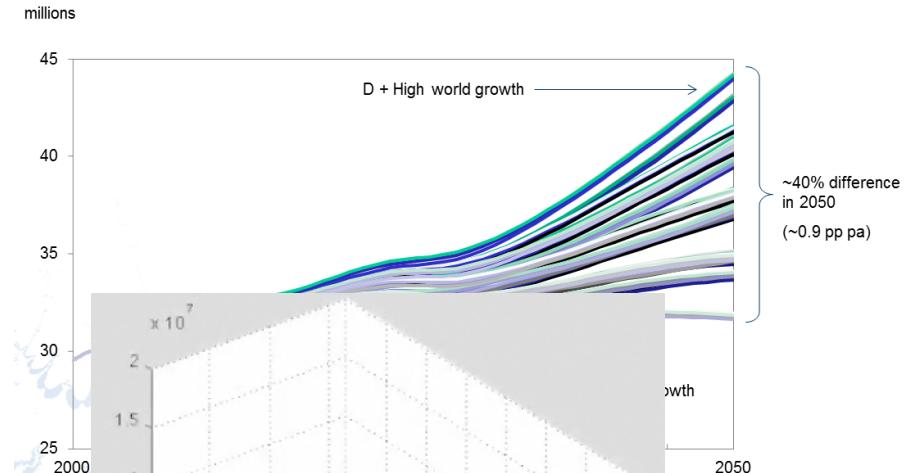


Indirect impacts on the economy

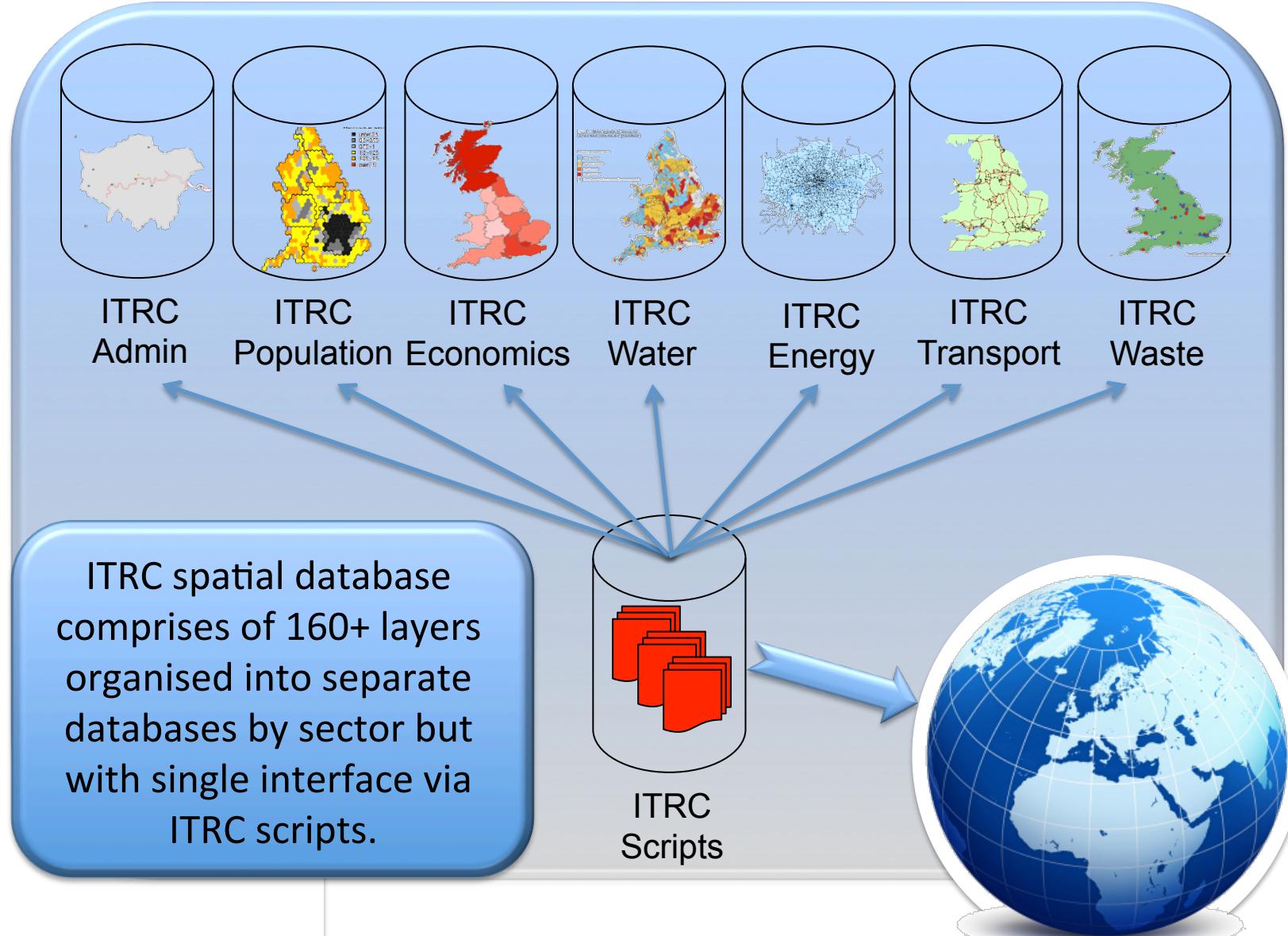


Simulating the relationship between infrastructure, the economy and land use

- The role of infrastructure in the macro economy
- A multi-regional model of demography and growth
- Understanding the influence of infrastructure on business location decisions



National Infrastructure Database



Outcomes of our 'systems of systems' analysis and modelling

For the first time, globally, tools to analyse strategic pathways for national infrastructure provision that are:

- cross-sectoral
- long term
- national scale

in order to provide evidence to:

- build long term visions for national infrastructure and plan how it can be delivered
- identify vulnerabilities and adapt to risks
- understand uncertainties and develop robust strategies

Progress

- 2011 Fast Track Analysis of strategies for infrastructure provision in the UK
- 2012 Development of the NISMOD models and database
- 2013 Quantified assessment of the performance of national infrastructure strategies
- Programme mid-term review
- 2014 ITRC first National Infrastructure Assessment
- Integration of the NISMOD system
- 2015 NISMOD results and analysis tools available on-line



Jim W. Hall, Robert J. Nicholls, Martino Tran,
Adrian J. Hickford & Alex Otto

Planning Infrastructure for the
21st Century

Systems of systems methodology for analysing
society's lifelines in an uncertain future

Stakeholder engagement, communications and impact

- International Expert Advisory Group
- Enthusiastic group of stakeholder partners
- Ongoing collaboration with Infrastructure UK and other government departments
- Stakeholder champion



ITRC UK Infrastructure Transitions Research Consortium

HOME ABOUT ITRC OUR WORK OUTPUTS NEWS

Search this site

Infrastructure Transitions Research Consortium

ITRC delivers research, models and decision support tools to enable analysis and planning of a robust national infrastructure system. The research addresses major challenges for the energy, transport, water, waste and ICT systems.

The consortium brings together seven leading UK universities to conduct a five-year programme of research that:

- establishes a series of long term visions for national infrastructure in the UK;
- models the interdependencies between infrastructure

Next step: test long term strategies
First report: analysis of NI systems
Presentations
Workshops & conferences
Modelling change and adaptation in infrastructure systems workshop, 14 May
Infrastructure interdependency report highlights costs of extreme weather events Australia
World Bank considers global infrastructure facility
International Symposia for Generation Infrastructure September and October Australia

www.gov.uk/defra

Department for Environment Food & Rural Affairs

Climate resilient infrastructure: Preparing for a changing climate
Progress update report

July 2013



NewStatesman

Infrastructure research for a sustainable future: taking the long view





For further information contact:

PI: jim.hall@eci.ox.ac.uk

Programme Manager: miriam.mendes@ouce.ox.ac.uk

Stakeholder Champion: roger.street@ukcip.org.uk

www.itrc.org.uk