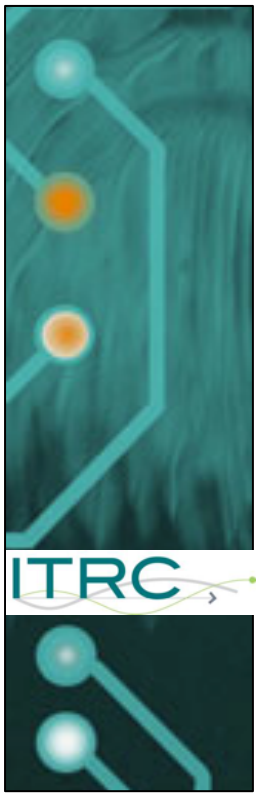
Building interdependent infrastructure networks and customer assignment models for understanding spatial demands

The future of national infrastructure systems and economic prosperity
Cambridge, UK. Mar 27-28th, 2014

Scott Thacker
ITRC WS2: Understanding the current and future risks of infrastructure failure
Raghav Pant, Jim Hall, Scott Kelly, Pete Tyler, David Alderson, Stuart Barr,



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Building interdependent infrastructure networks and customer assignments models for understanding spatial demands

Introduction:
Interdependent infrastructure networks

Introduction:
Extreme weather impacts


THE INDEPENDENT TUESDAY 28 JANUARY 2014 Elephant

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Passengers stranded at Gatwick Airport as flooding causes power outages

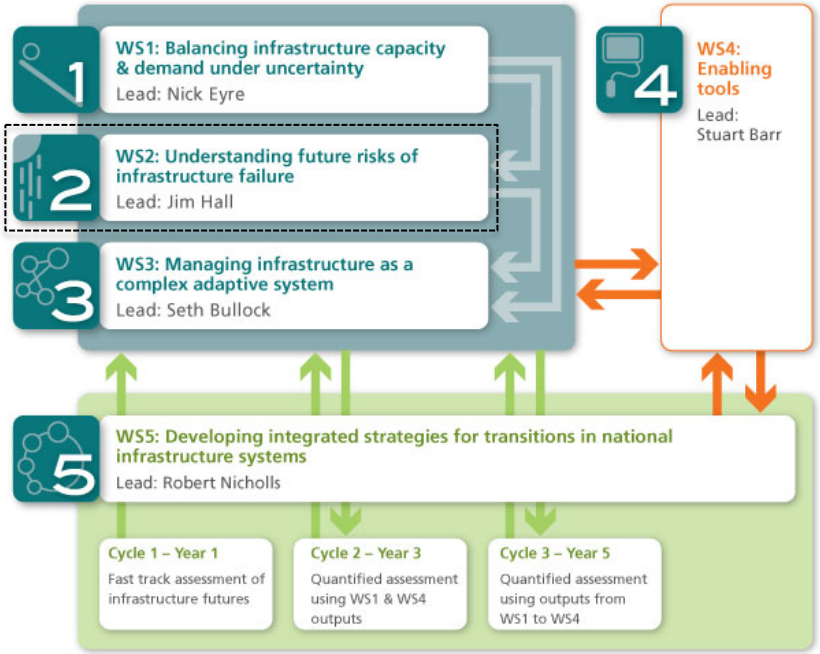
- 350,000 people without water for up to 17 days (Mythe)
- 40,000 people without power for 24hrs
- Near miss (Waltham substation) 500,000 people
- Damages approx. £3.5 Billion

Methods:
Understanding the current and future risks of infrastructure failure

Methodological development:
- Vulnerability analysis
- Risk analysis

Components of the analysis:
- Network models
- Interdependencies
- Direct customer demands
- Indirect customer demands

To facilitate:
- Derivation of customer disruptions under different hazard events
- *Economic disruptions (next talk!)*
- Current and future scenarios

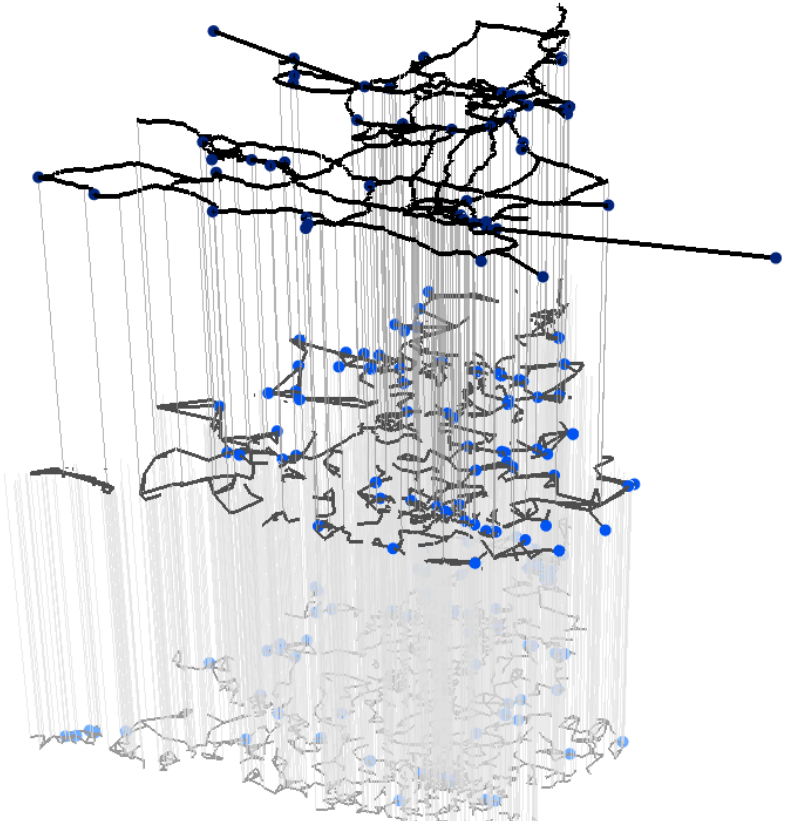


Methods:
Assembling network data

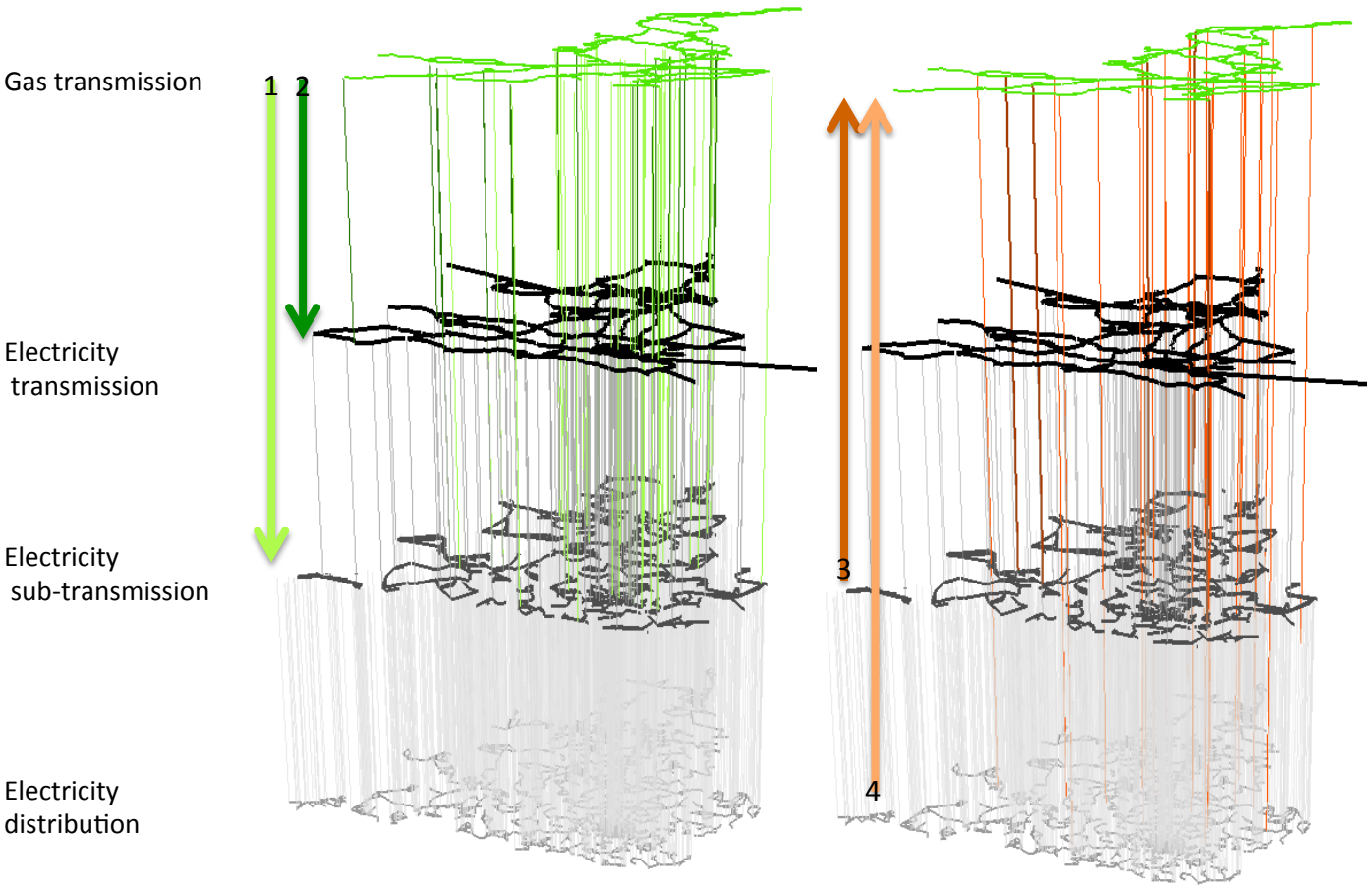
Multiple infrastructure types:

- Electricity
- Gas
- Liquid fuels
- Railways
- Roads
- Airports
- Ports
- Water towers
- Water pumping stations
- Sewage treatment works
- Solid waste facilities
- Telecom masts

- **Great Britain's Integrated electricity network**
- **Hierarchical – bridging scales**
- **180,000 nodes**



Methods:
Accounting for infrastructure 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

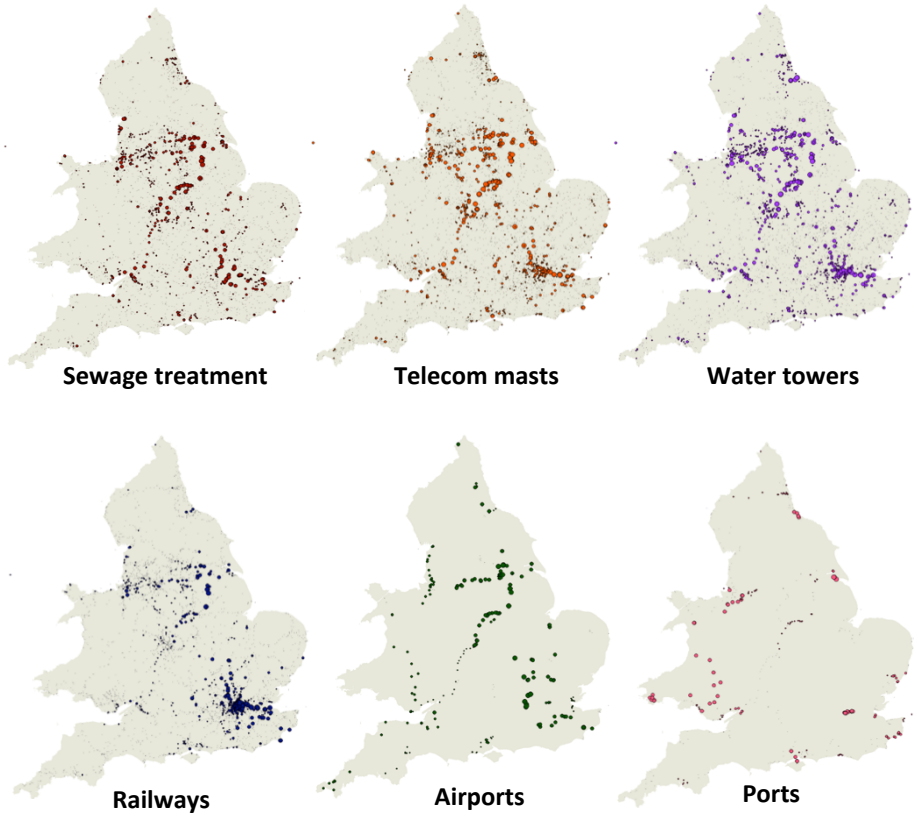
Methods:
Incorporating customer demands

Direct customer demands

- Usage statistics where available
- Networks are more complicated..
  - Customer assignment models: – capacity constrained resource allocation model
  - Network effects

Electricity customers

Indirect customer demands on Great Britain's electricity network

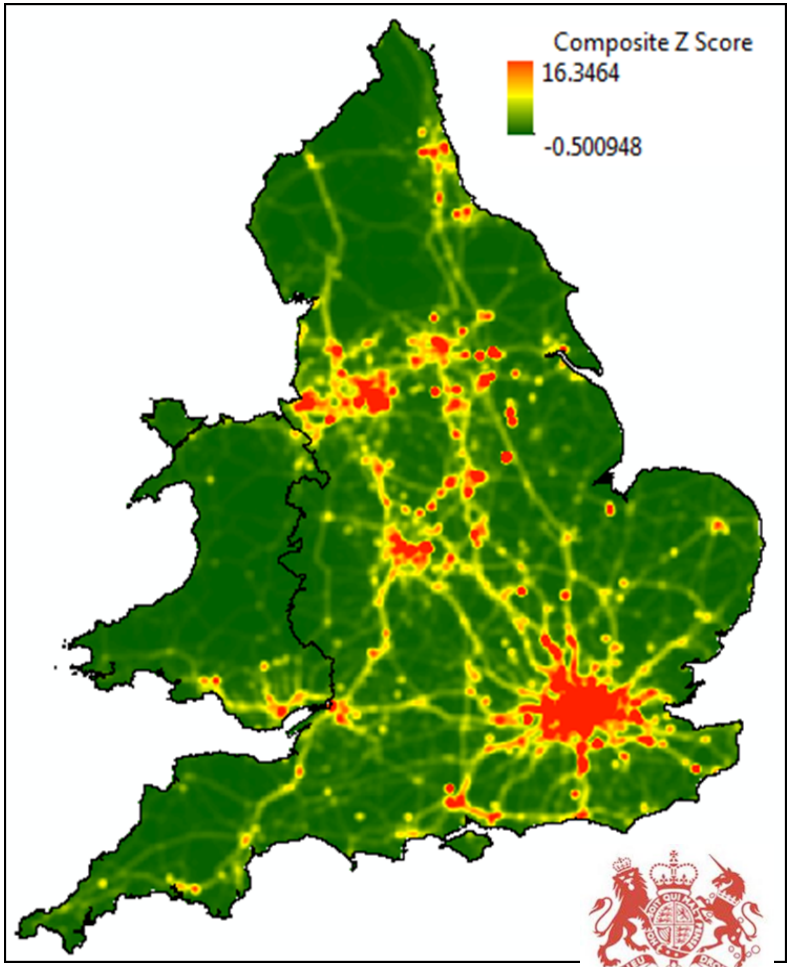


Applications:
Infrastructure criticality hotspots

ITRC Infrastructure Criticality Hotspot Analysis

An infrastructure criticality hotspot is a geographical location where there is a concentration of critical infrastructure, measured according to number of customers directly or indirectly dependent on the infrastructures in that location

Composite criticality map



Infrastructure UK

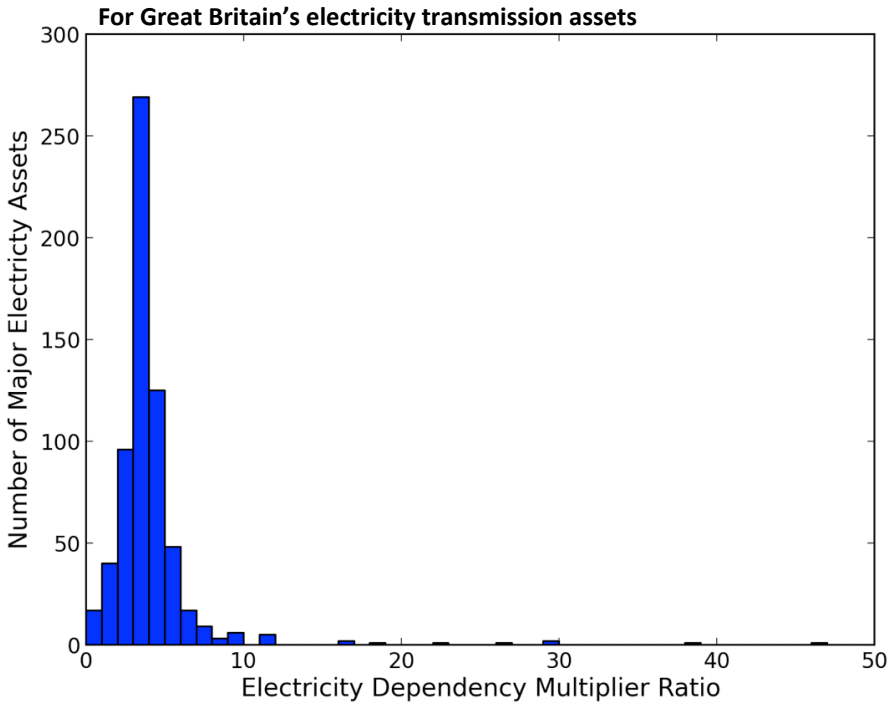
Applications:
Interdependency impacts

Electricity supporting customers from other sectors:

- Mapping indirectly connected customers (previous slides)
- Integrated electricity network
  - *99% of transmission network (636)*
  - *8% of distribution assets (13,348)*

Electricity dependency multiplier ratio =

- *Ratio of non-electricity to electricity customers reliant on a given asset*

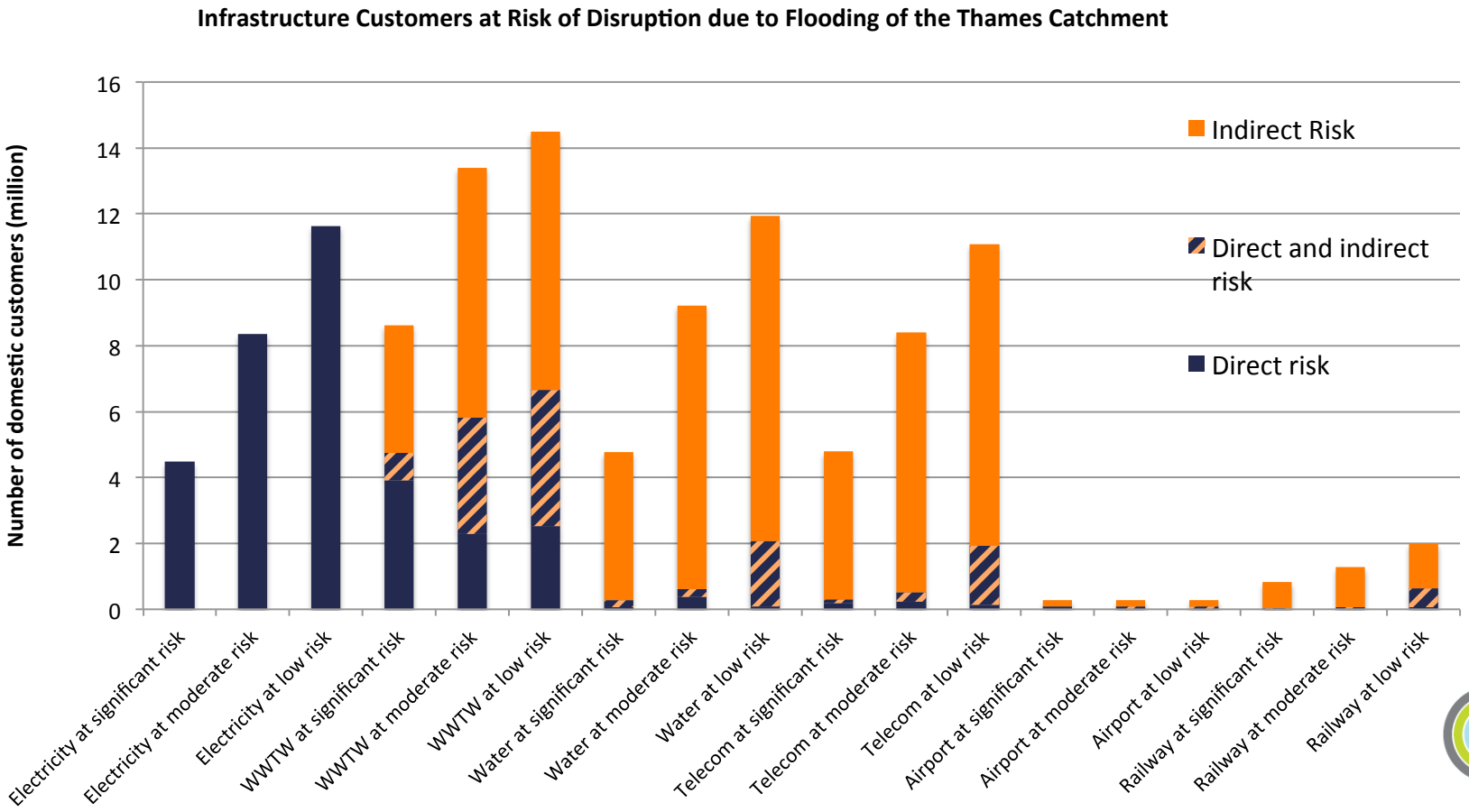


Around (70%) of the major electricity assets could indirectly affect, if they were to fail, at least three times as many customers as they directly serve

Applications:
Vulnerability to extreme flooding – Thames catchment example

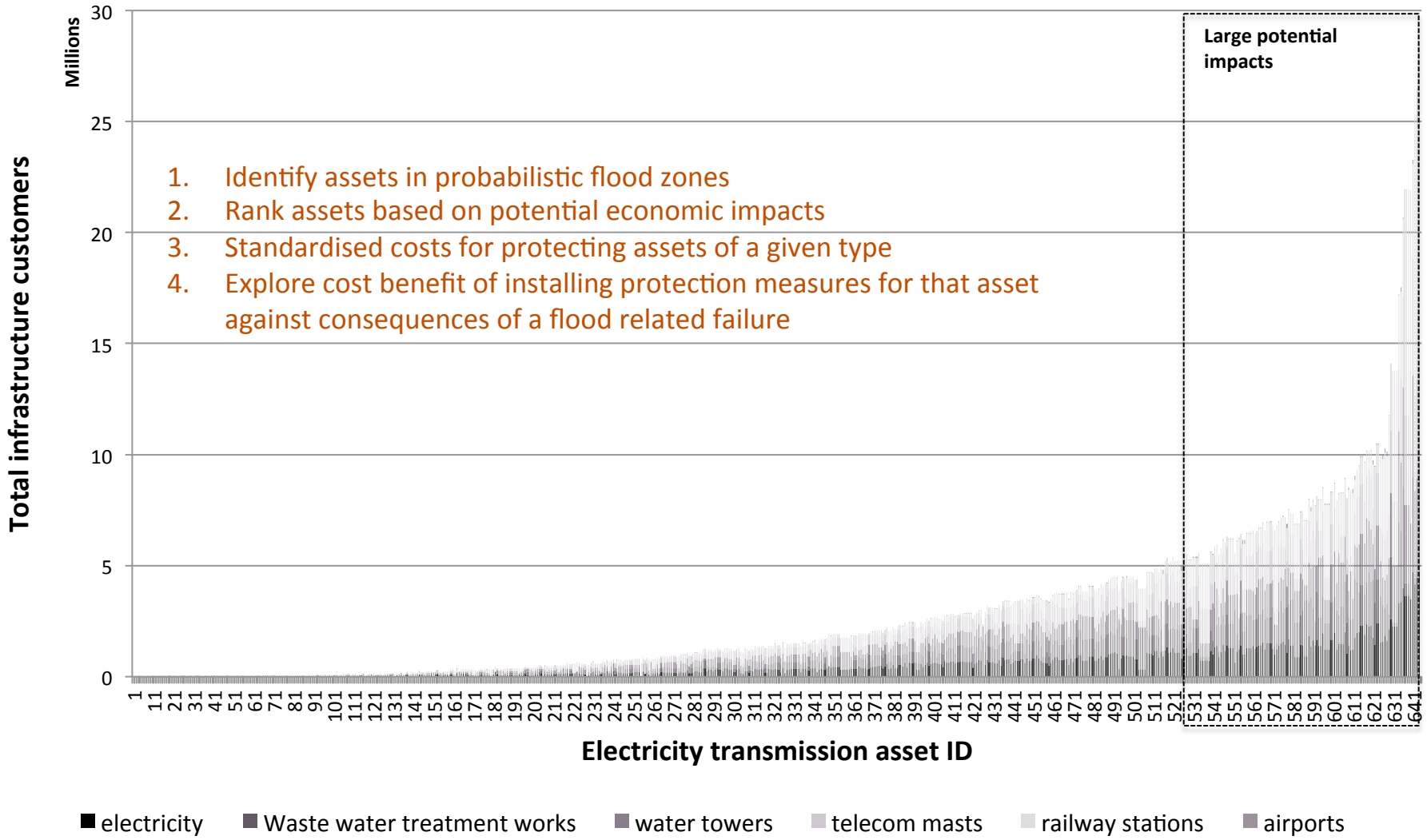
Environment Agency, NAFRA flood hazard maps: significant, moderate, low probability

- Vulnerability of customers (potential customer disruptions)



Committee on Climate Change Adaptation

Applications:
Adaptation planning – methodology in development



Conclusions:
Main points to take from the presentation

Methods

- Importance in developing detailed network models
- Explicitly capturing interdependencies
- Direct and Indirect customer demands mapped to assets
- *Facilitates economic impacts – coming next!*

Applications

- Infrastructure criticality hotspots
- Insights into interdependencies
- Vulnerability to extreme events
- Adaptation planning

Conclusions:
Any Questions?

For further information:

www.itrc.org.uk

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