ARIES: Energy Scenario requirements

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ARIES

- **A**daptation and **R**esilience **I**n **E**nergy **S**ystems
- University of Edinburgh (supply-side) and Heriot-Watt University (demand-side)
- Modelling the effect of climate and future conditions on energy demand, supply and infrastructure
  - What problems might occur that are caused or exacerbated by climate change?

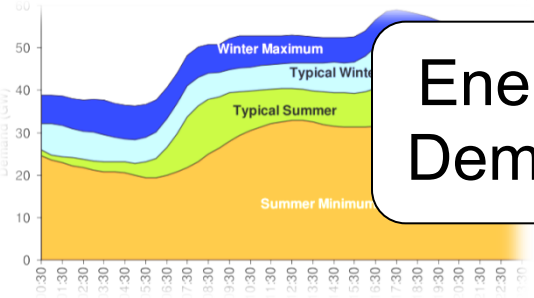
Energy Supply

Change of resource (e.g. wind/tidal/solar)

Ability of generation portfolio to react

Transmission/ Distribution

Effect of climate shocks on system



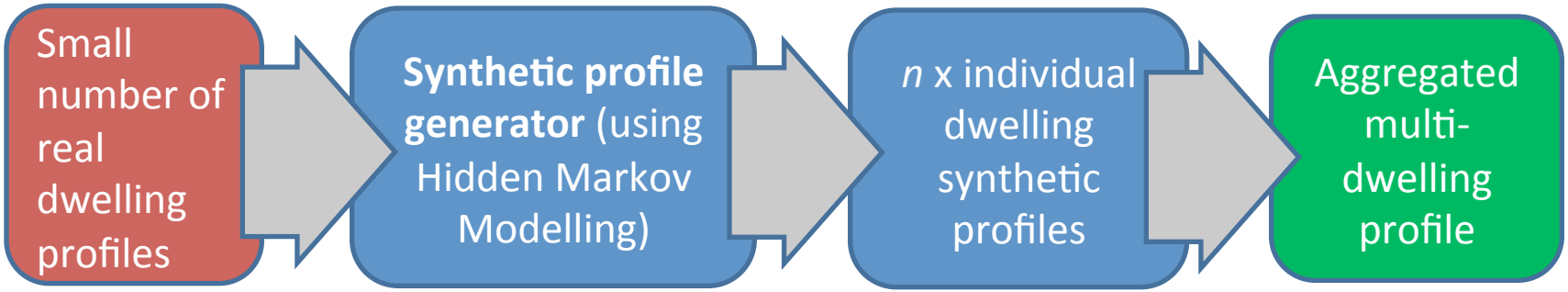
Energy Demand

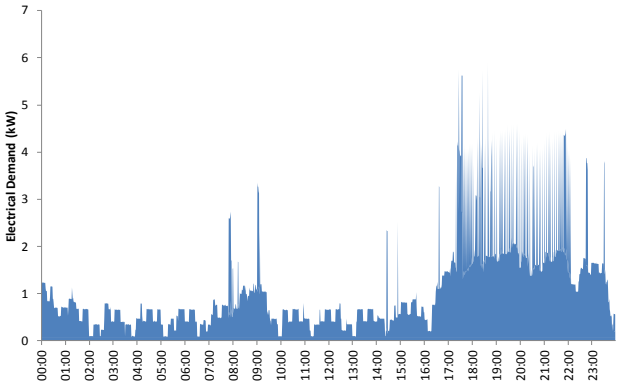
Reduced heating
Increased cooling
New technologies
Change in peak demand

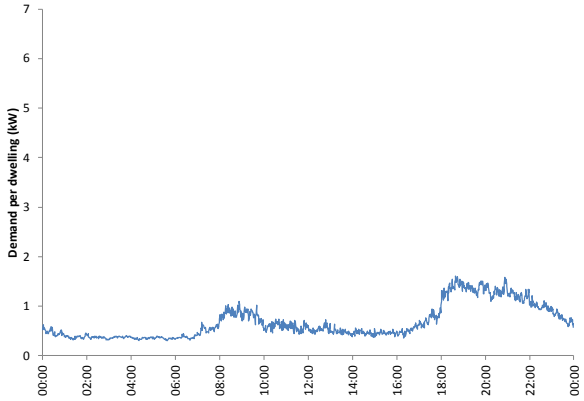
Synthesizing electrical demand profiles

- Individual dwelling demand profiles show clear link with activity and technologies
- Multi-dwelling demand profiles show periods of interest/concern for an energy supplier
- Can a method utilise both of the above?
  - And demonstrate the effect of changing specific parameters on aggregated demand profiles
  - Particularly a challenge as high-resolution dwelling demand profiles are difficult to obtain in great number

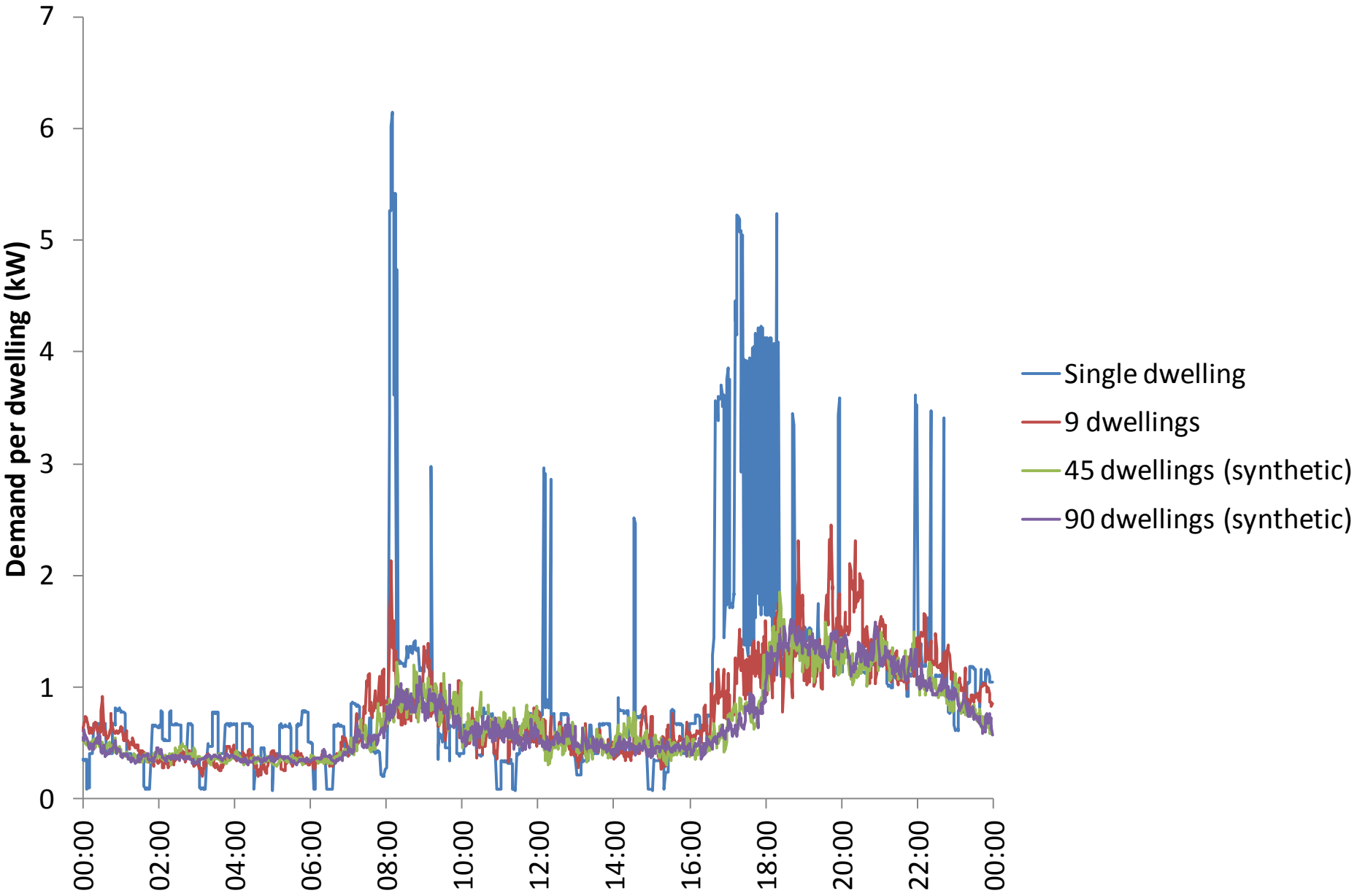
Synthesizing electrical demand profiles



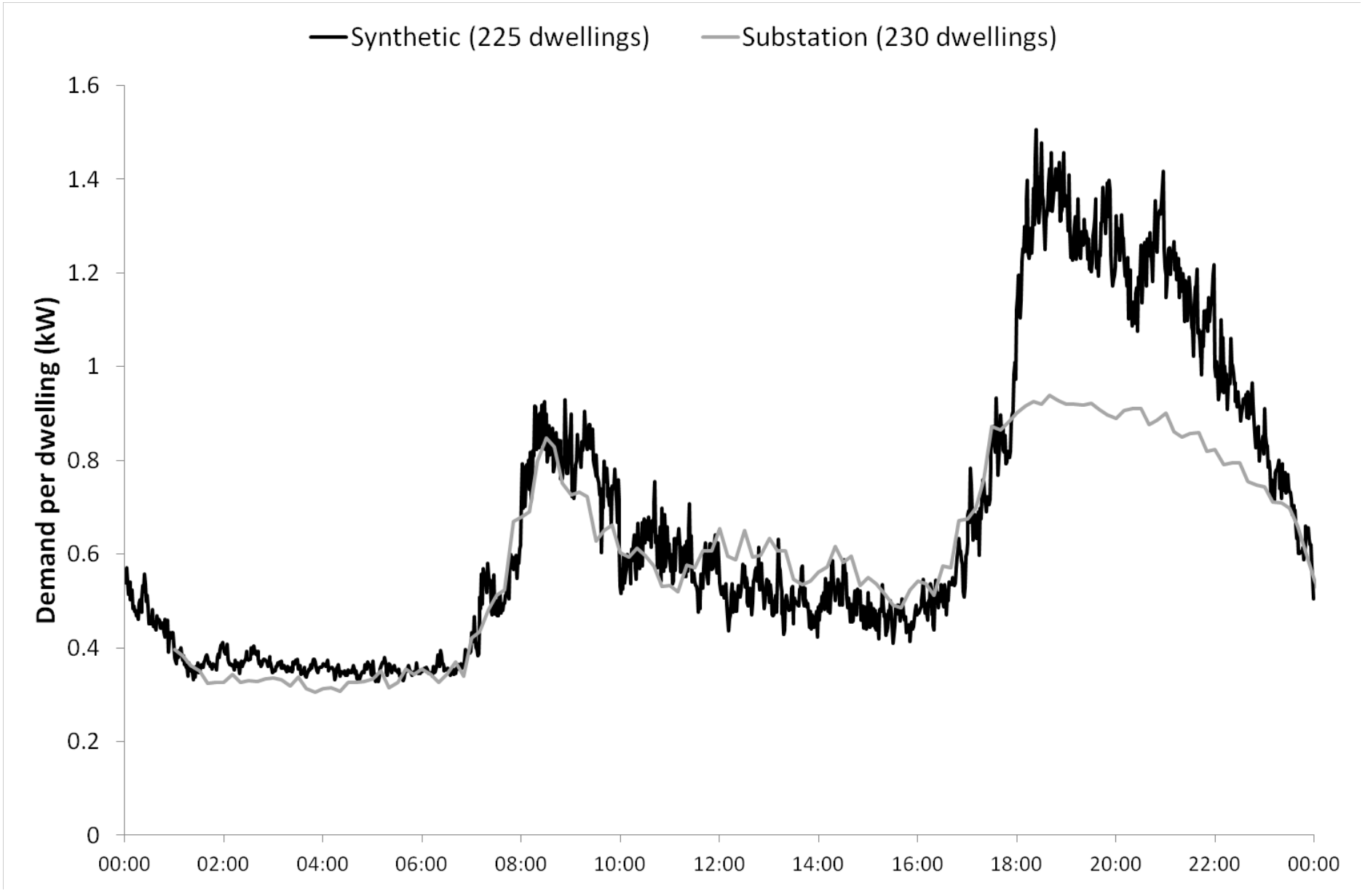




Diversity effect in electrical demand profiles



Do synthetic aggregated profiles mimic real data?



Aggregated thermal demand profiles

- Developed a method for dynamically simulating large numbers of dwellings (in IES-VE)
- In effect, a Dynamic Local-Scale Stock model (DLSSM)
  - Accounts for important aspects of building physics but in way that is suitable for extrapolation
  - Can look at effect of, e.g., large-scale changes in heating technology (in warmer climate)

Sandstone

- Pre 1919 to 1964

Whin

- Pre 1919 to 1964

Brick & Block (unins)

- 1919 to 1975
- 1976 to 1983
- 1984 to 1991

Brick & Block (ins)

- 1919 to 1975
- 1976 to 2002
- 2003 to 2008 onwards

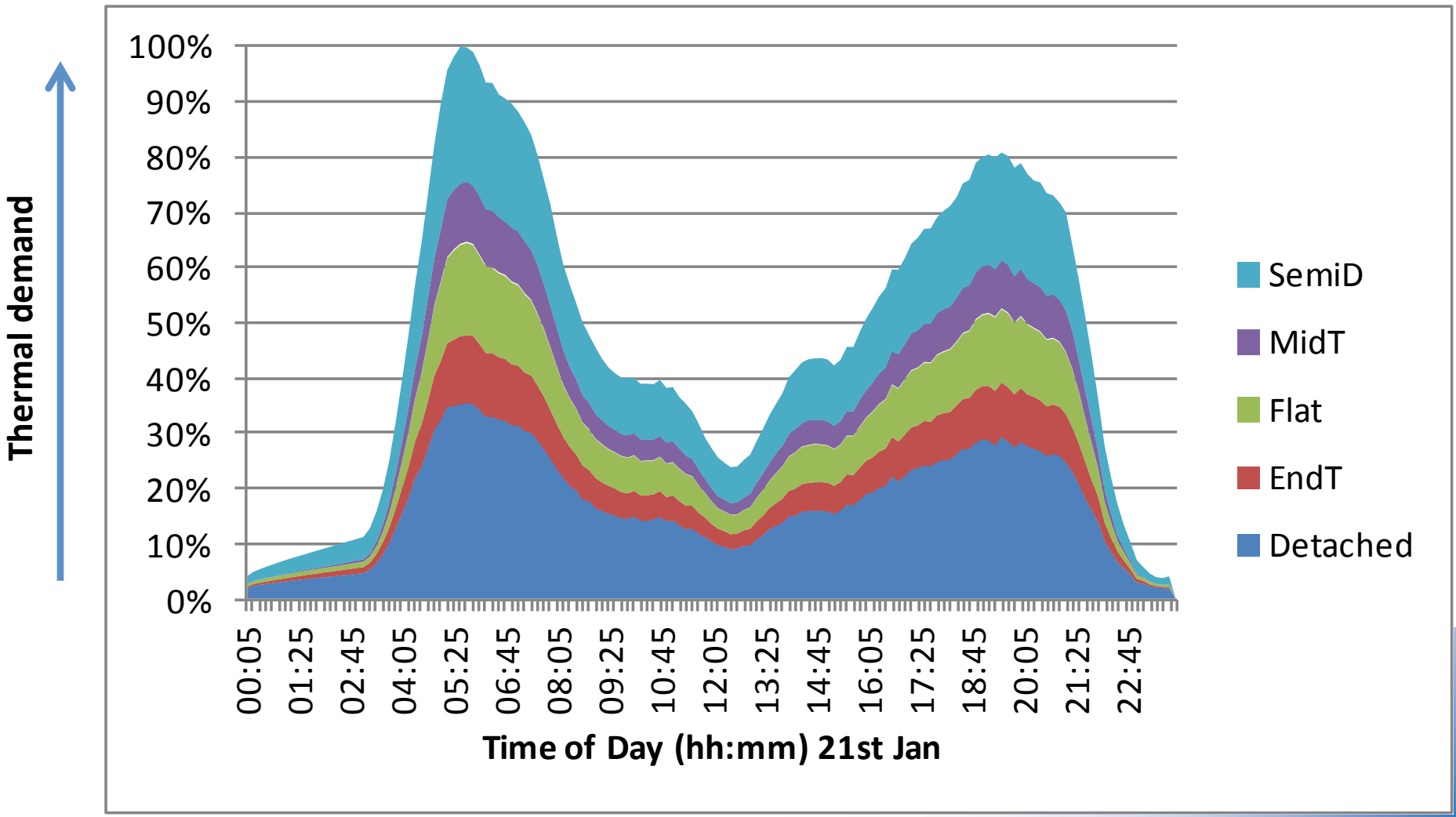
Timber

- 1950 to 1975
- 1976 – 2002
- 2003 to 2008 onwards

Concrete

- 1919 to 1964
- 1965 to 1983

Processing Information

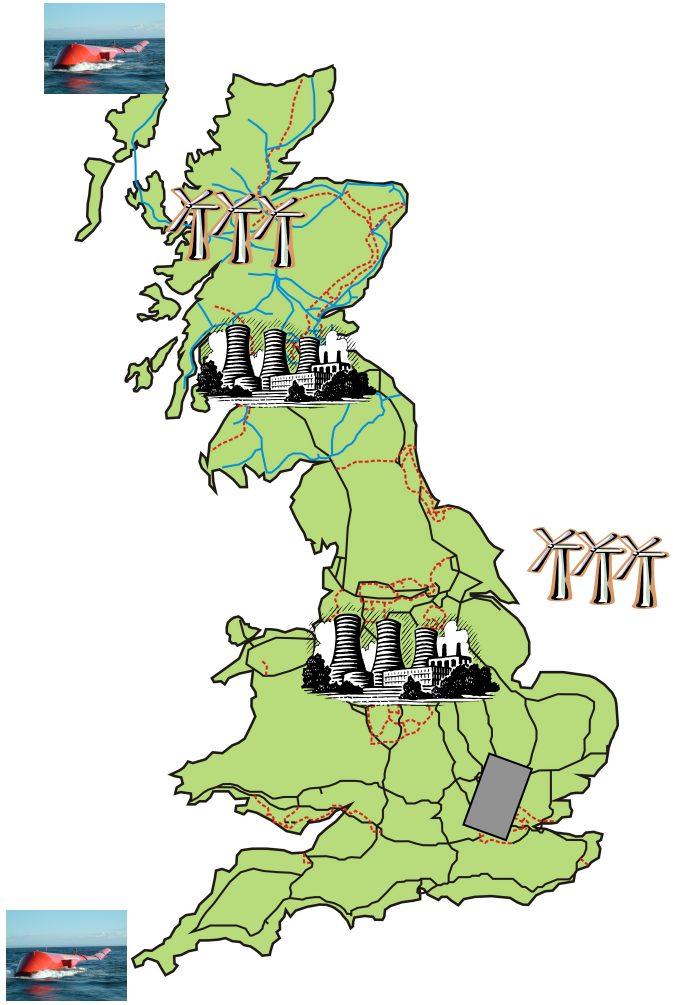


For this we need quite specific “scenarios”...

- Archetypes of dwellings
  - Scottish Building Stock from Housing Surveys, and how these might transform in the future
- Apply theses scenarios to “zones” of 500-6000 homes
- Such bottom-up scenarios do not necessarily need to be *paired* with top-down scenarios
  - But we need to make sure they do not clash with these overarching scenarios
  - e.g. avoid high heat pump usage in higher grid carbon intensity scenarios

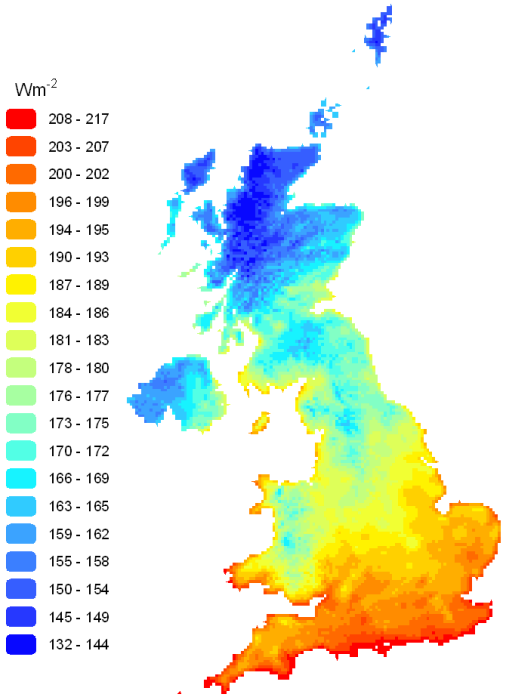
The Supply Side

- Wide range of generation technologies commercially available now and even wider range by 2050
- These have diverse operational characteristics and response to changing climate
  - need to capture these robustly
- Spatial pattern of generation deployment important in credible scenarios
  - resource, economics, grid connection have strong influence

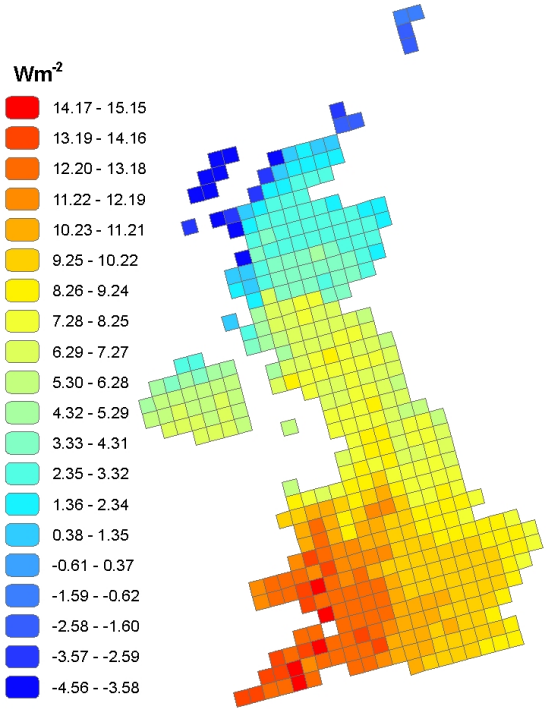


Solar Radiation

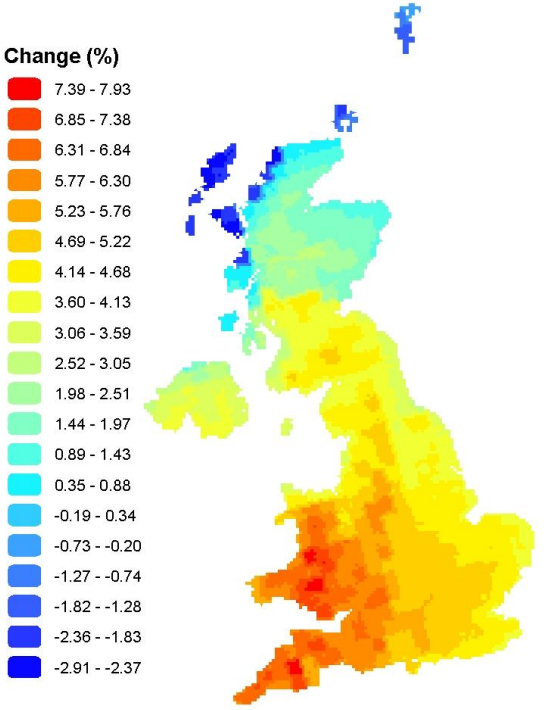
Baseline, relative change, and percentage change (from baseline) for 2050s medium emissions scenario with 50% probability



Baseline - Summer months

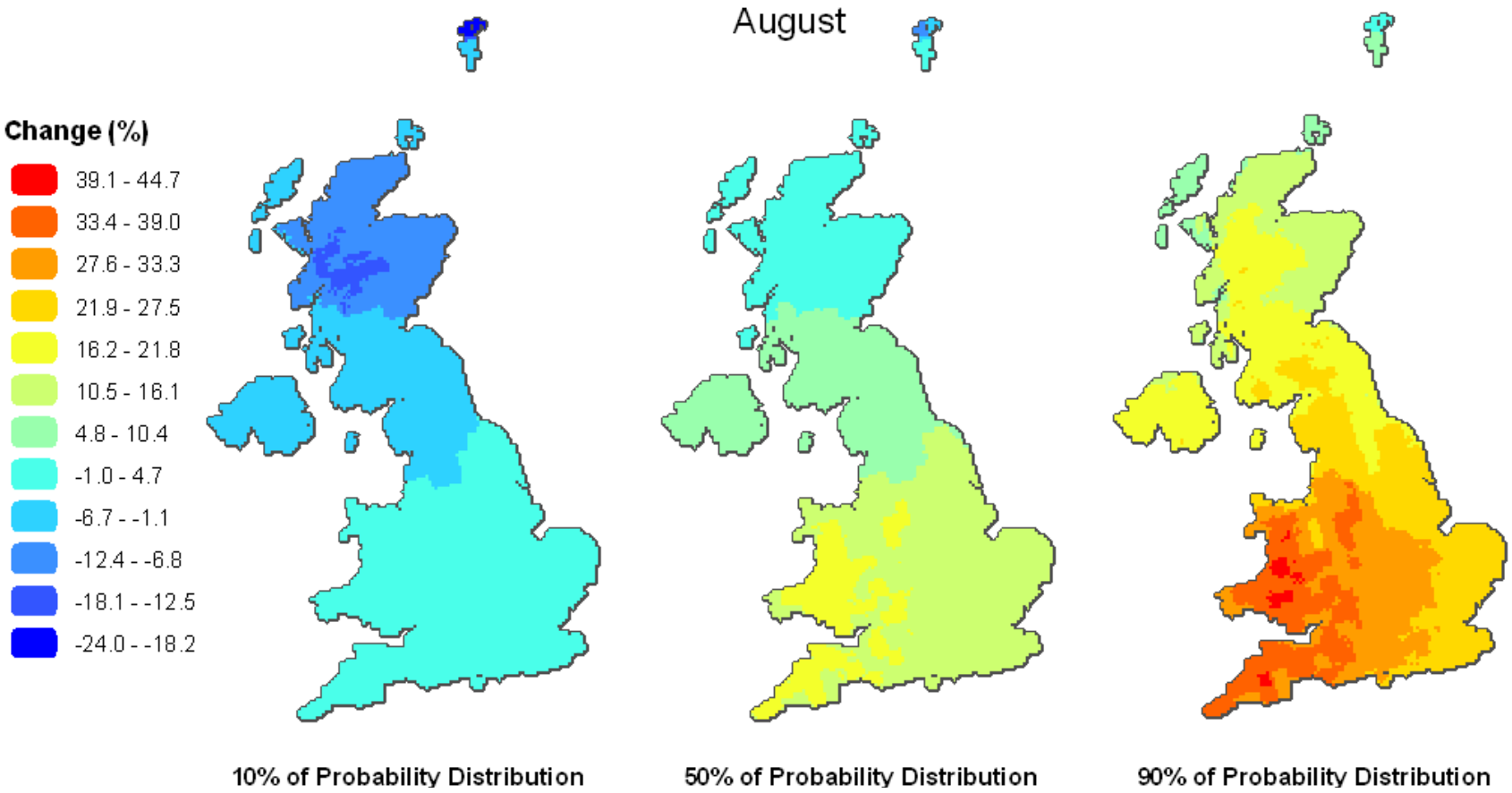


2050s Medium Emissions 50% probability change (Wm^{-2}) Summer months



2050s Medium Emissions 50% probability change (%) Summer months

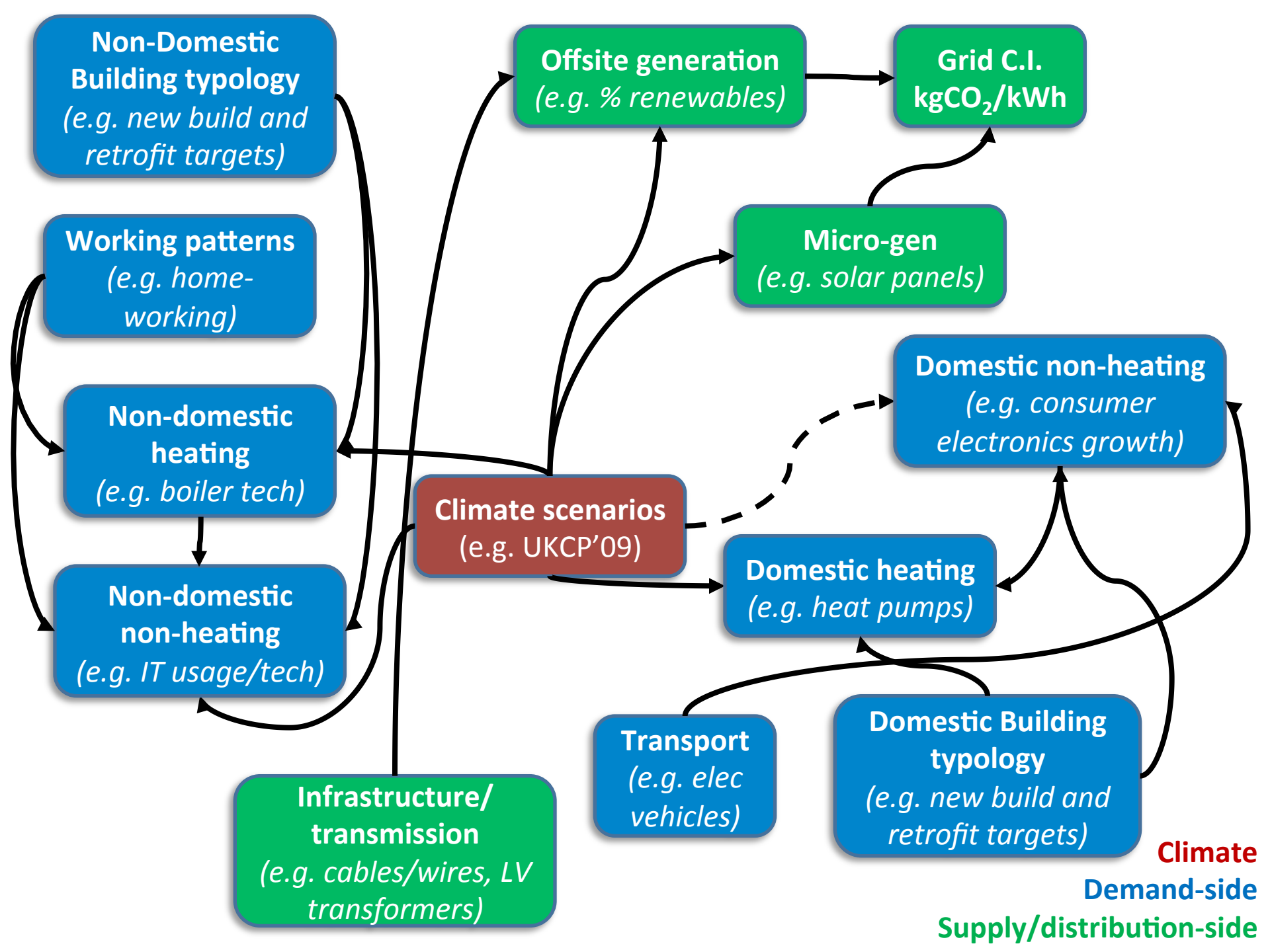
Solar PV Output



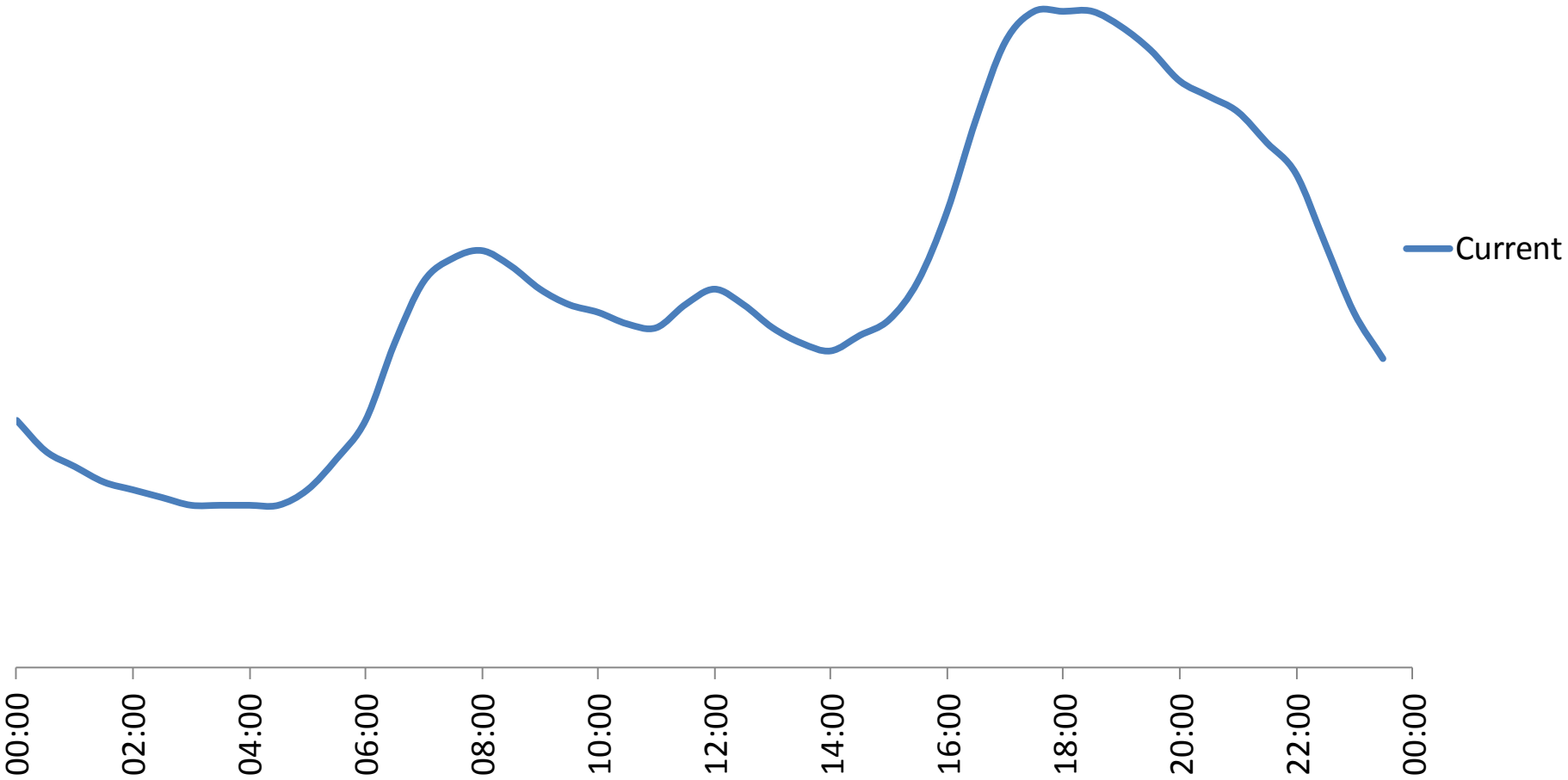
Percentage change for 2080s high emissions scenario (10%, 50% & 90% probabilities)

What we have...

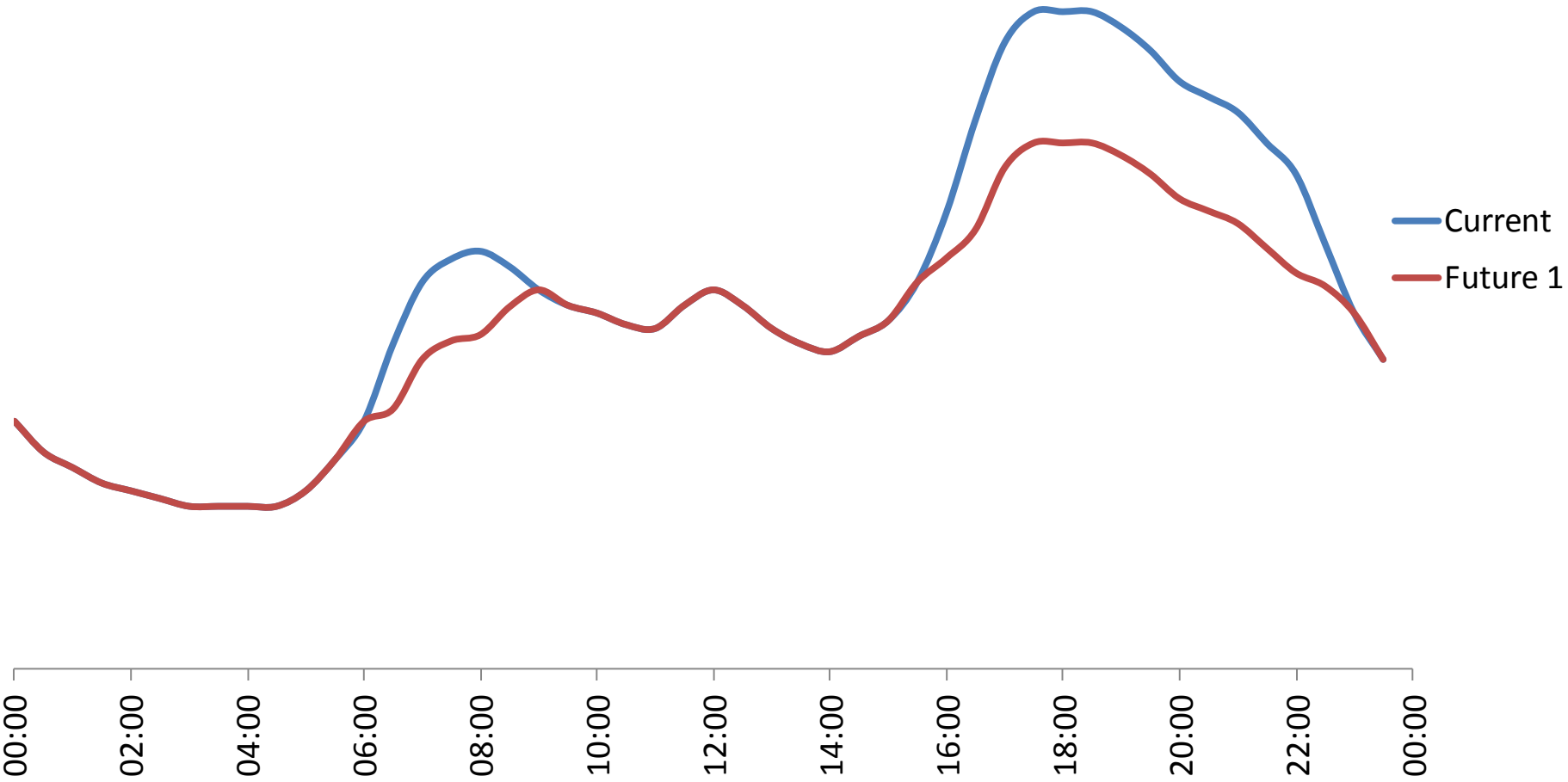
- An approach for modelling an aggregated thermal demand profile for a selection of buildings
- A method for upscaling individual dwelling electrical demands to aggregated demands
- Tool emulating effect of climate on building sims
- A model for estimating the effect of climate on electricity transmission
- Method demonstrating effect of climate on renewable generation
  - Wind, Solar, Hydro, CCGT, Nuclear, Coal, Tidal, Wave (nearly….)


Non-Domestic Building typology (e.g. new build and retrofit targets)
Offsite generation (e.g. % renewables)
Grid C.I. kgCO2/kWh
Working patterns (e.g. home-working)
Micro-gen (e.g. solar panels)
Domestic non-heating (e.g. consumer electronics growth)
Non-domestic heating (e.g. boiler tech)
Climate scenarios (e.g. UKCP'09)
Domestic heating (e.g. heat pumps)
Non-domestic non-heating (e.g. IT usage/tech)
Transport (e.g. elec vehicles)
Domestic Building typology (e.g. new build and retrofit targets)
Infrastructure/ transmission (e.g. cables/wires, LV transformers)
Climate
Demand-side
Supply/distribution-side

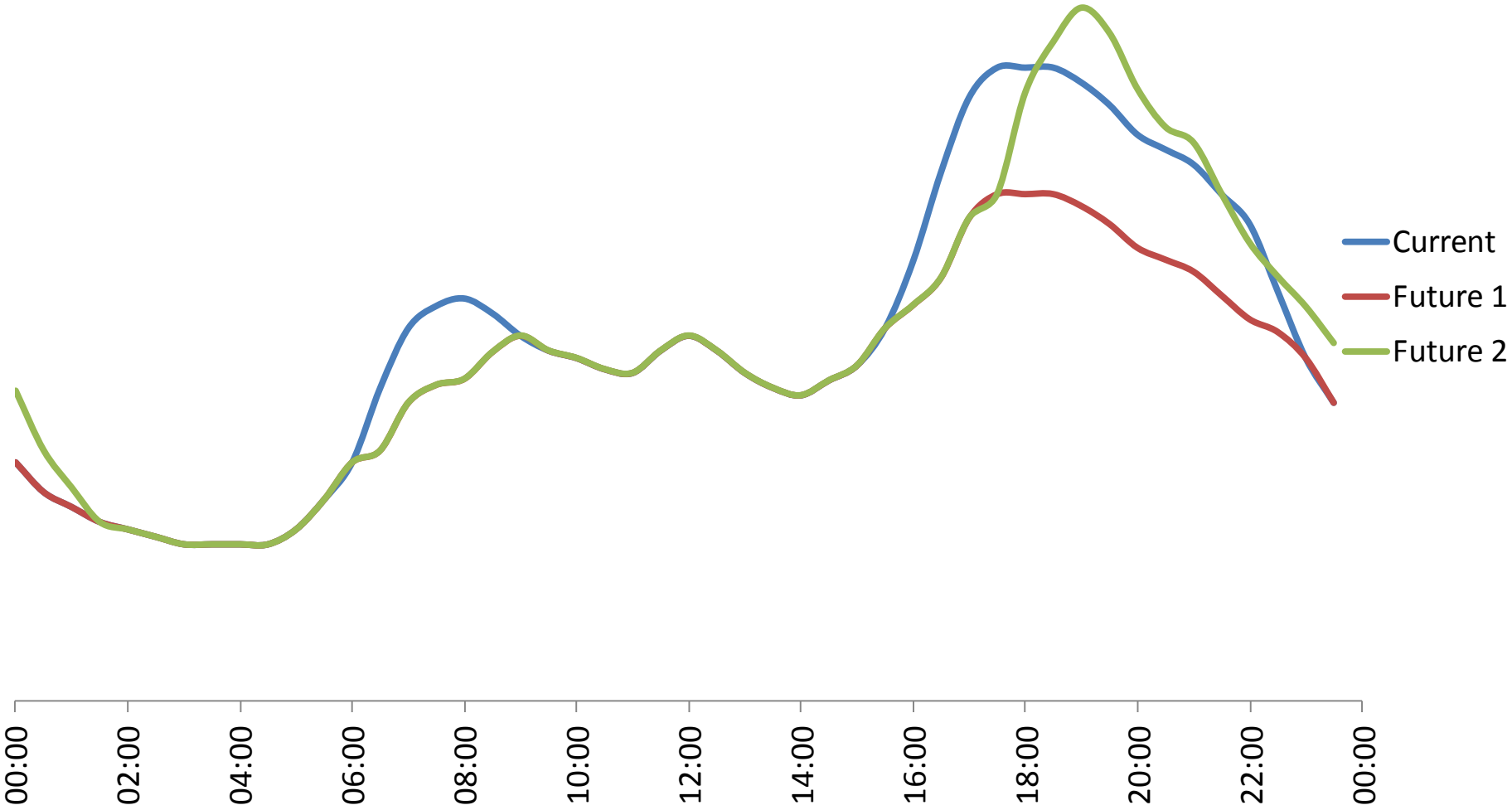
The effect of scenarios on demand...



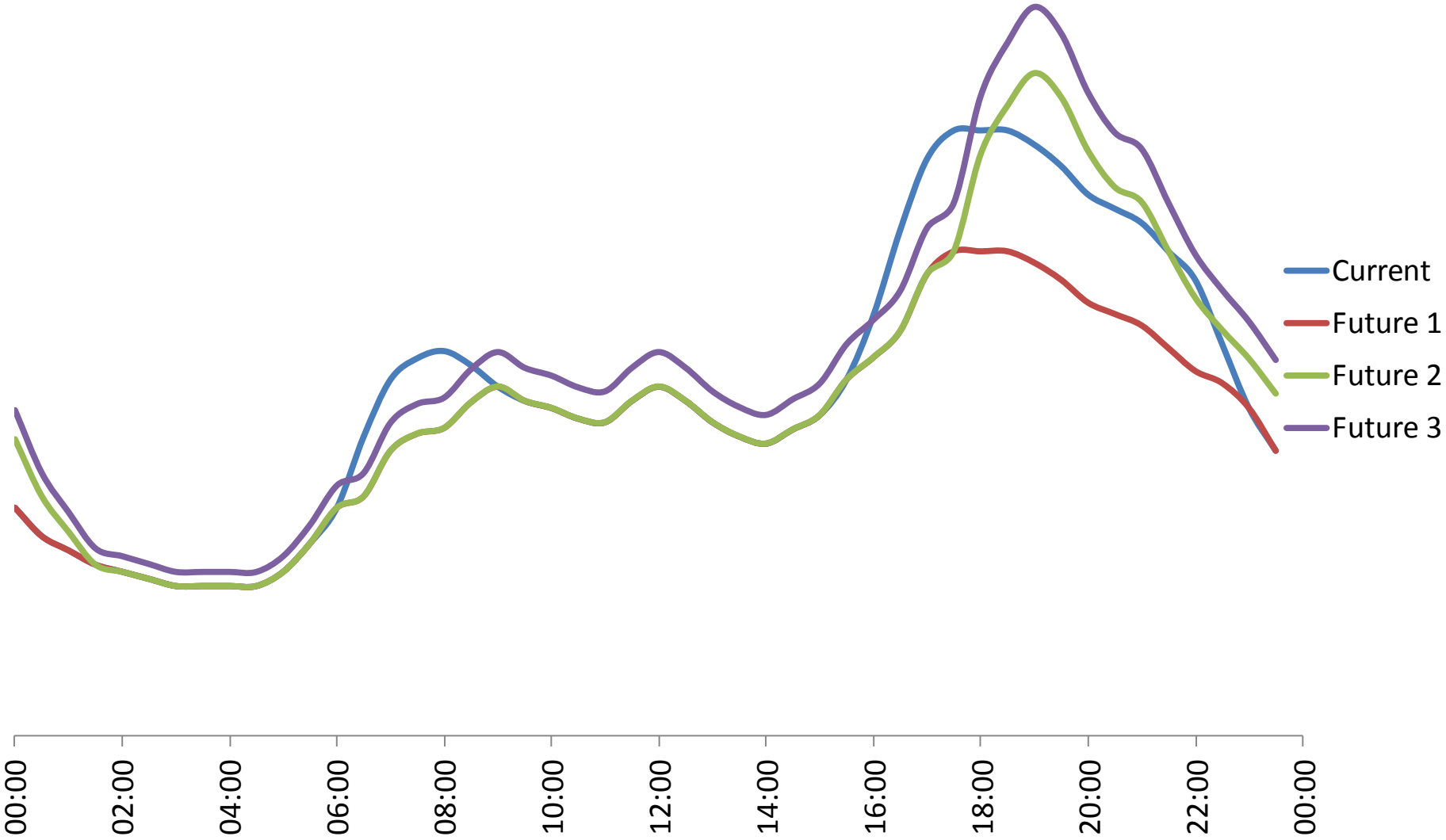
Energy efficient lighting, e.g. LED ?



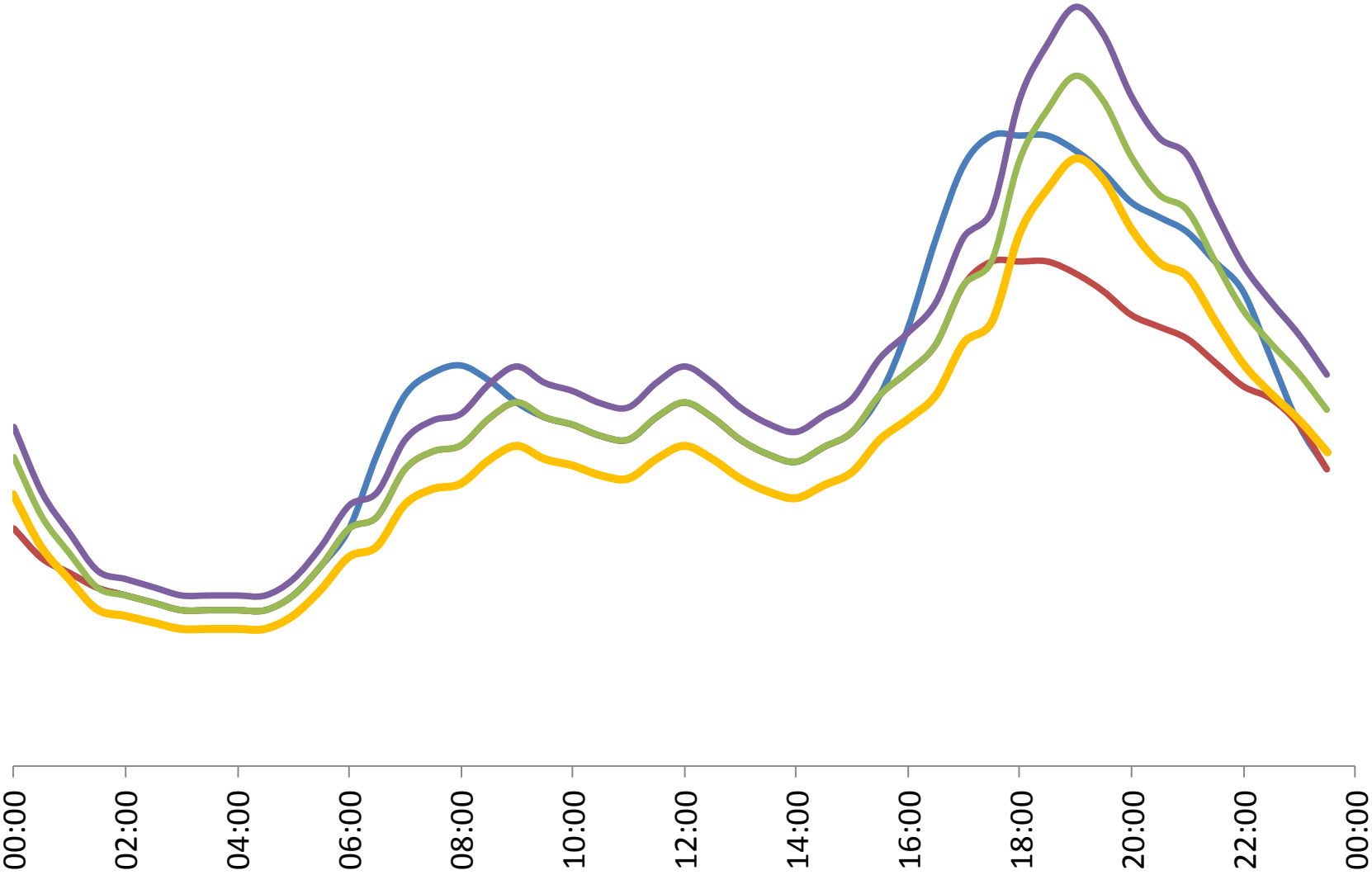
Charge cycle of electric vehicles?



Continuing rise in consumer electronics?



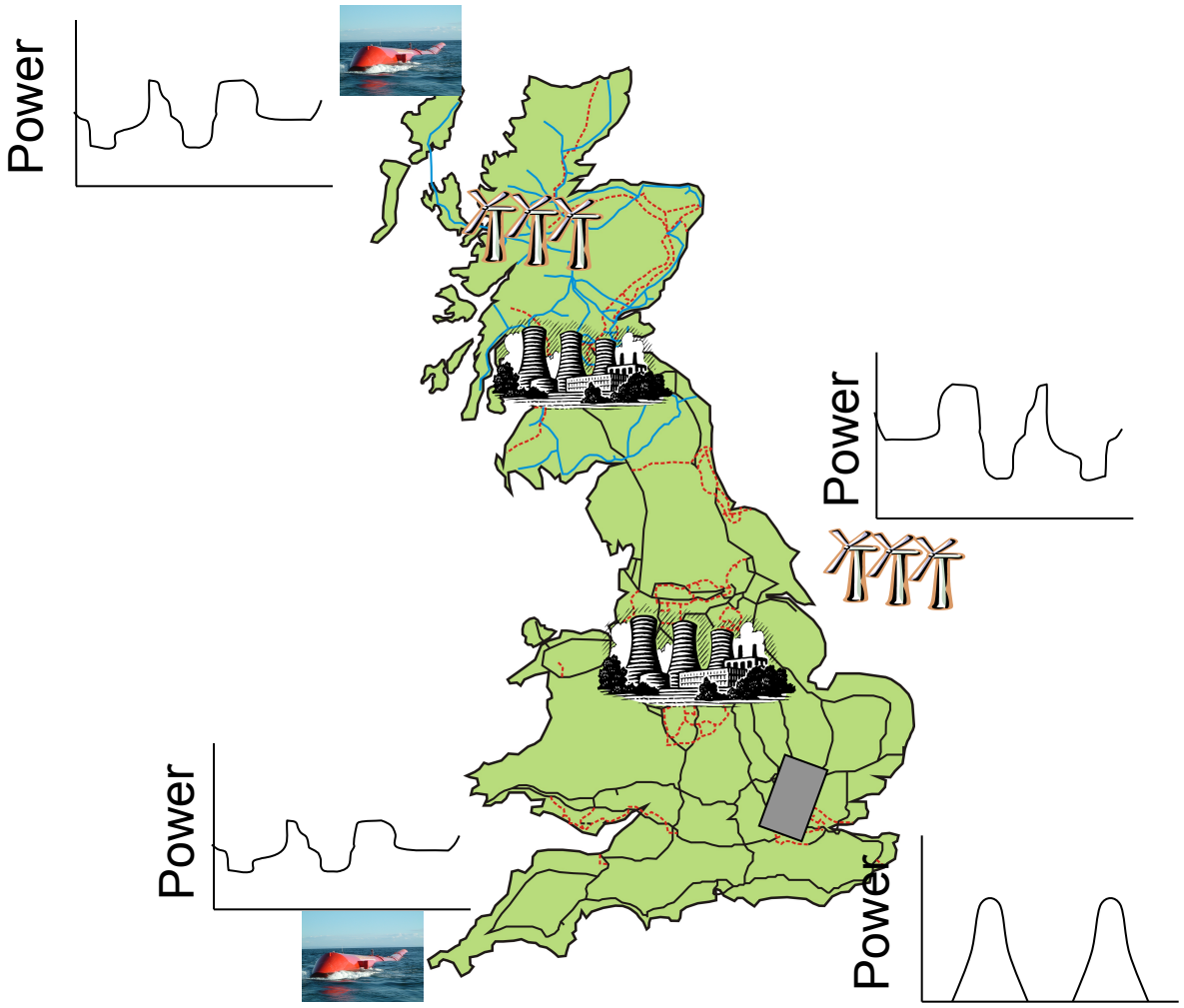
Climate Change?



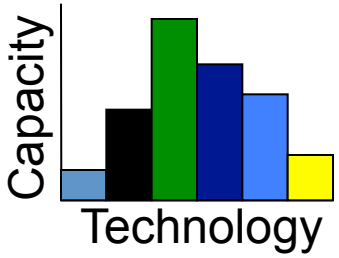
The need to define an external scenario

- We have bottom-up demand modelling methods
  - Millions of possibilities of how these are applied so specific case-studies and scenarios are needed
- Geographical breakdown of
  - Generation
  - Infrastructure
  - Demand
- Highlight regionally-specific issues

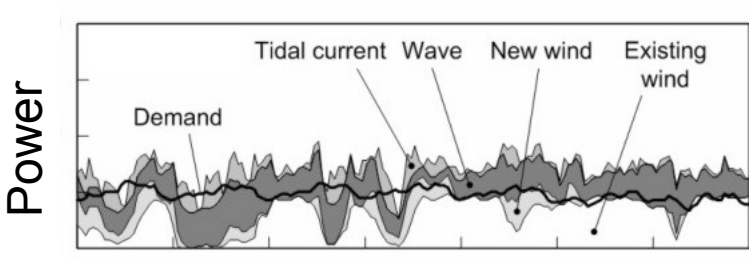
The Supply Side

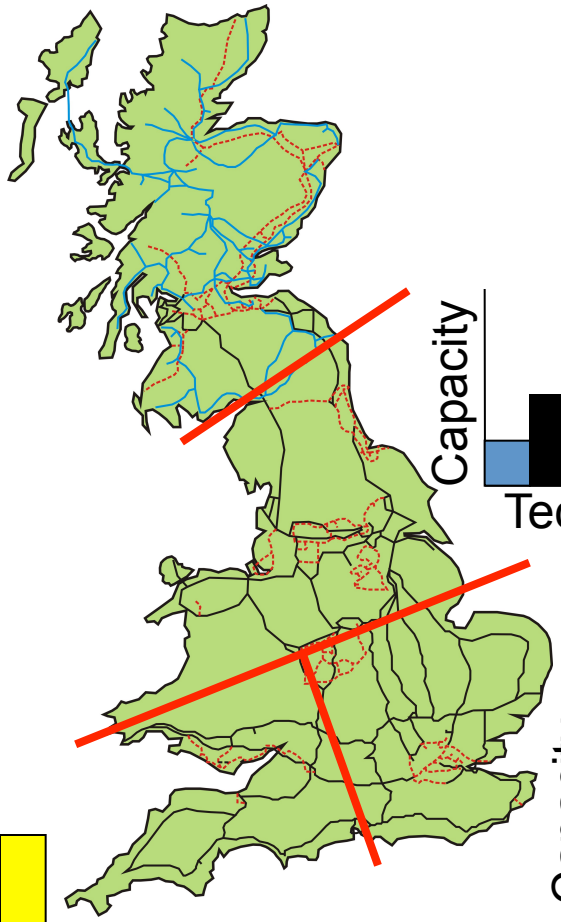


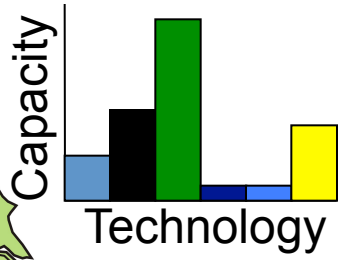
The Supply Side

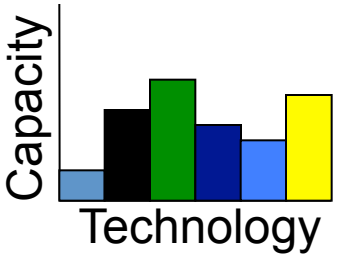


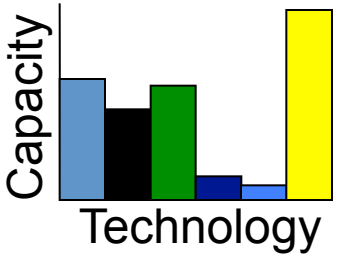
…and match with demand









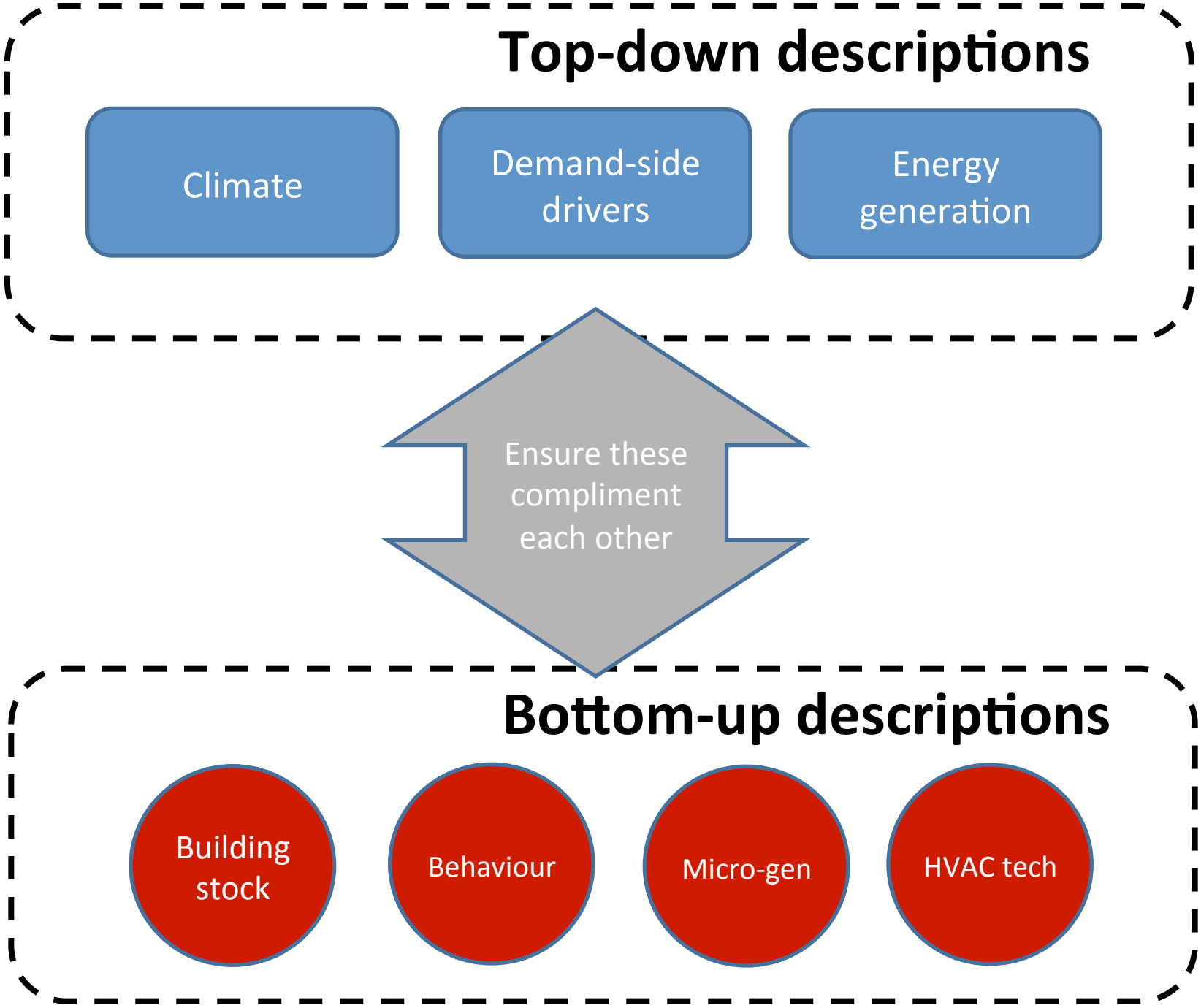


The need to define an external scenario

- Should we define scenarios that are:
  - Likely to happen?
  - Describe a mid-range of possibilities?
  - Relatively extreme scenarios that test the limits of the systems being studied? – What breaks and when?
- Quite possible to point to a scenario that "fails" but is not likely to happen
- Can assign probability to climate scenarios but more arbitrary for non-climate parameters

An example

- **Climate**: UKCP'09, Medium-emission,
- **Location:** London, Regional info
- **Building types**: % mix of low/zero-carbon dwellings
- **Technology**: % use of heat-pumps in domestic and non-domestic sectors
- **Onsite generation**: Assumed GW/yr growth of PV
- **Demand response**: Use of controls/storage, DSM and micro-grids to allow demand to follow supply
- **Offsite generation**: Assumed mix of renewables


Top-down descriptions
Climate
Demand-side drivers
Energy generation
Ensure these compliment each other
Bottom-up descriptions
Building stock
Behaviour
Micro-gen
HVAC tech