ARIES: Energy Systems

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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?

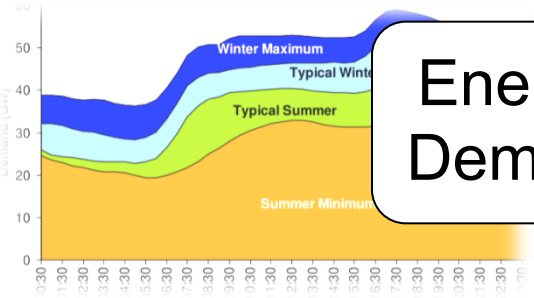
Energy Supply

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

Ability of generation portfolio to react

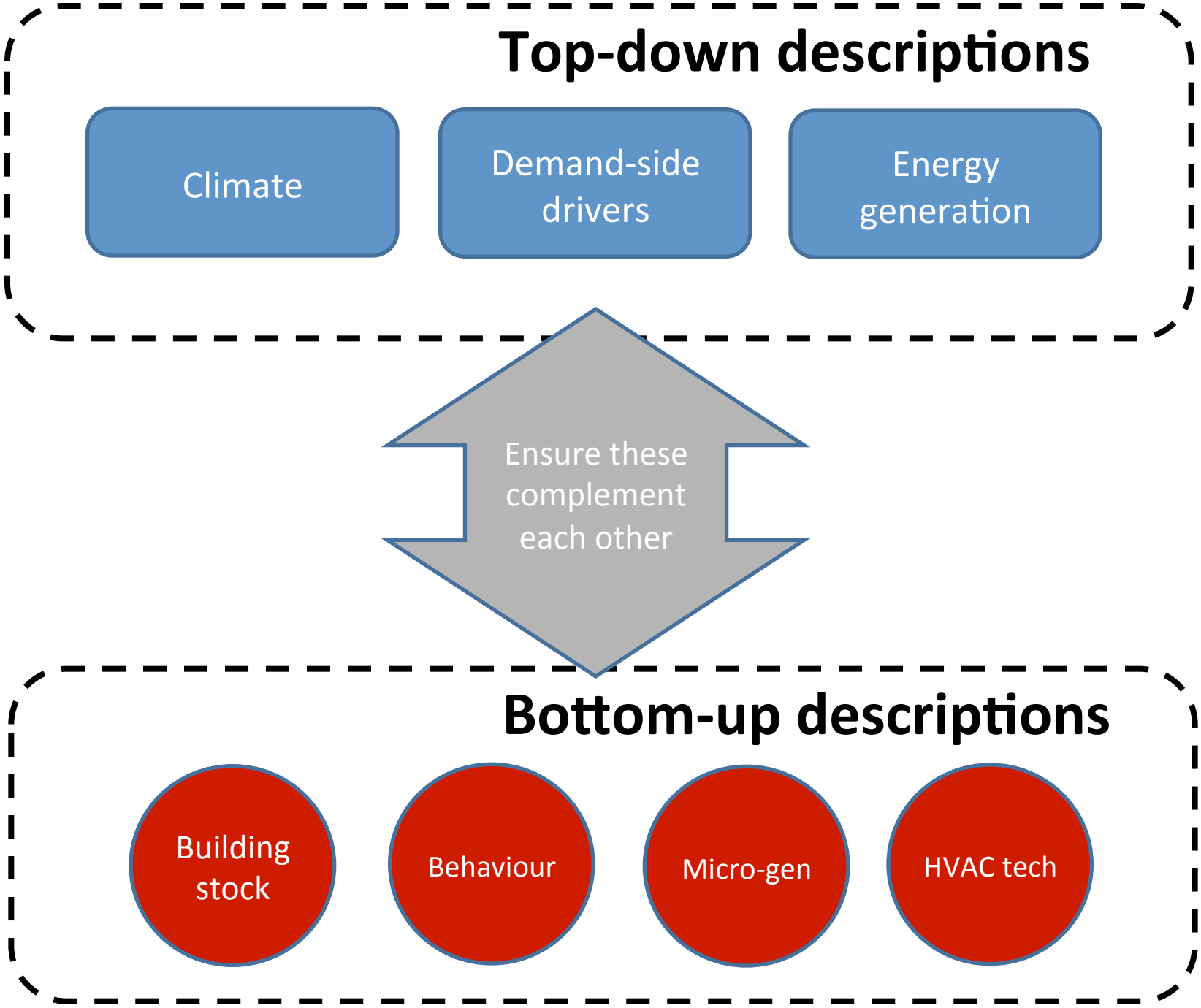
Transmission/ Distribution

Effect of climate shocks on system



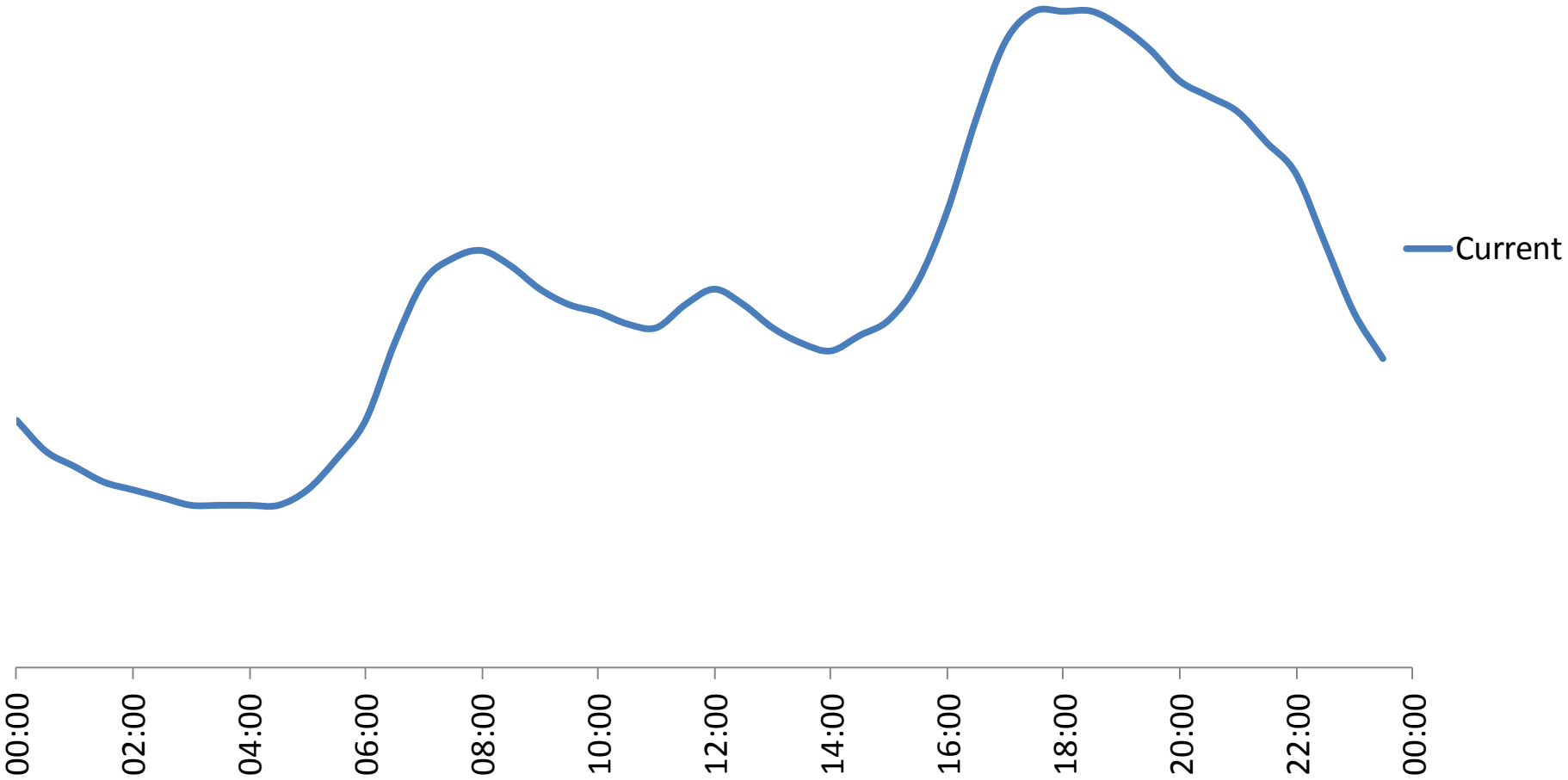
Energy Demand

Reduced heating
Increased cooling
New technologies
Change in peak demand

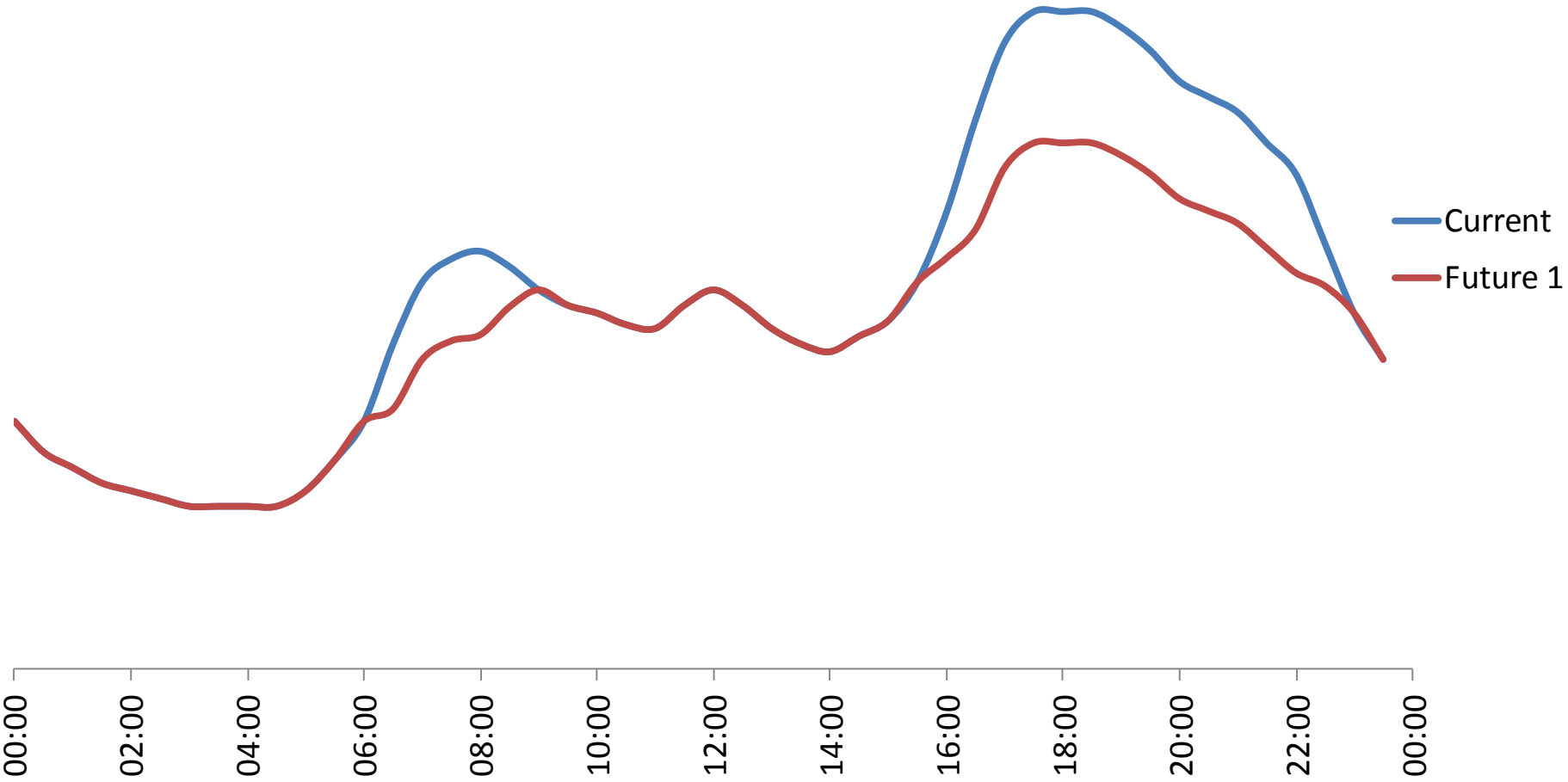

Top-down descriptions
Climate
Demand-side drivers
Energy generation
Ensure these complement each other
Bottom-up descriptions
Building stock
Behaviour
Micro-gen
HVAC tech

The effect of future scenarios on demand:

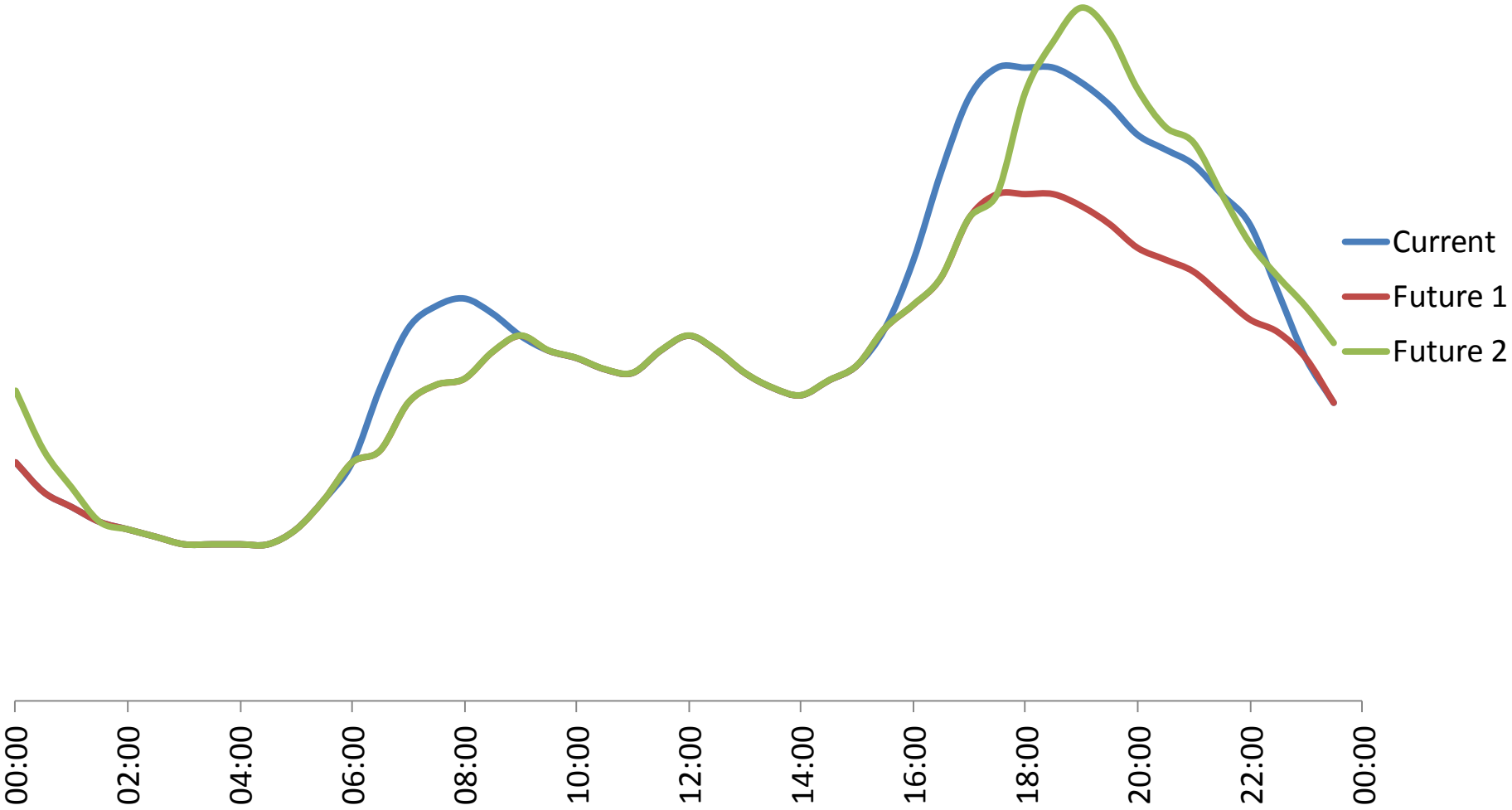
Power demand over a 24 hour period



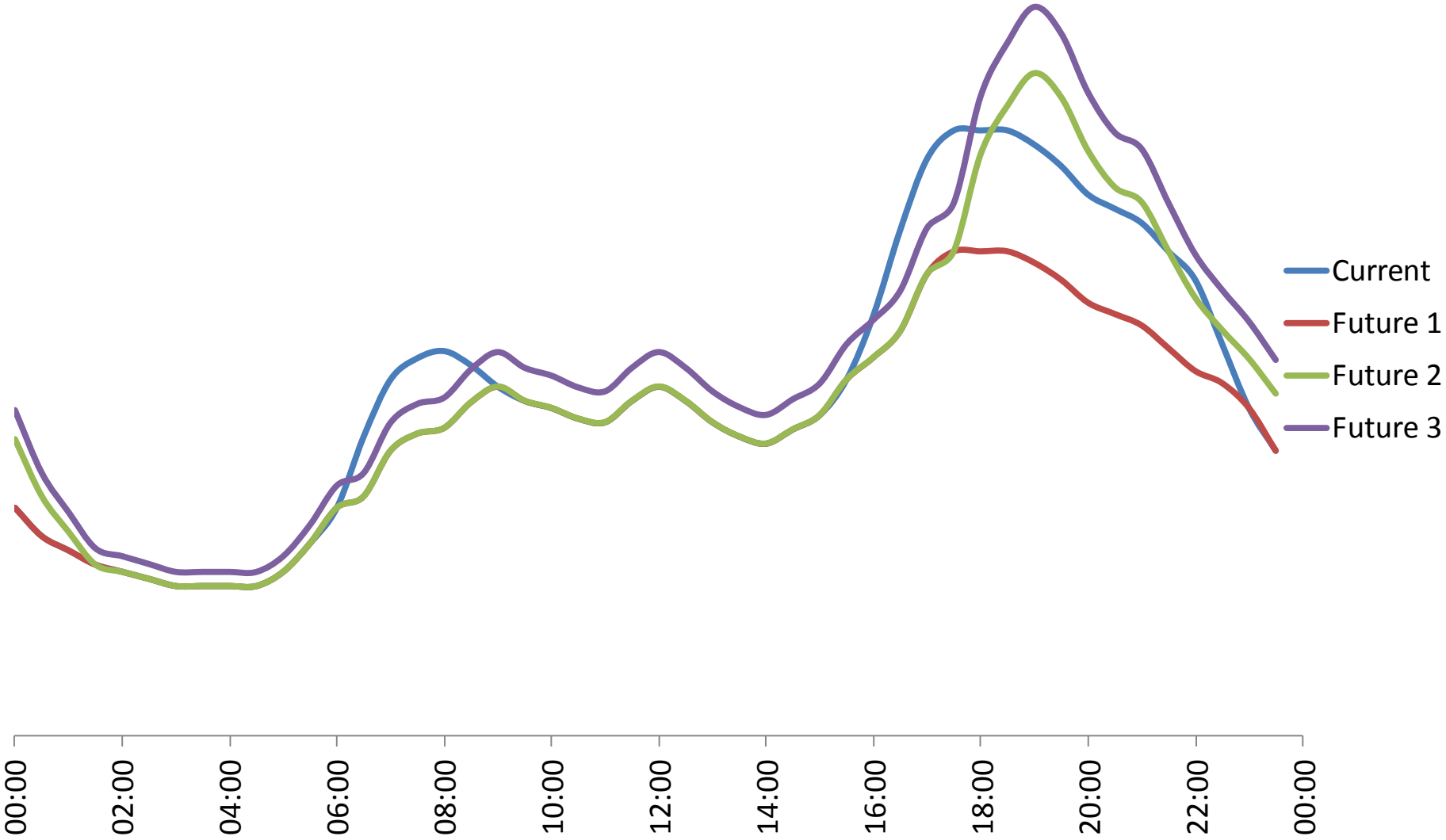
Energy efficient lighting, e.g. LED ?



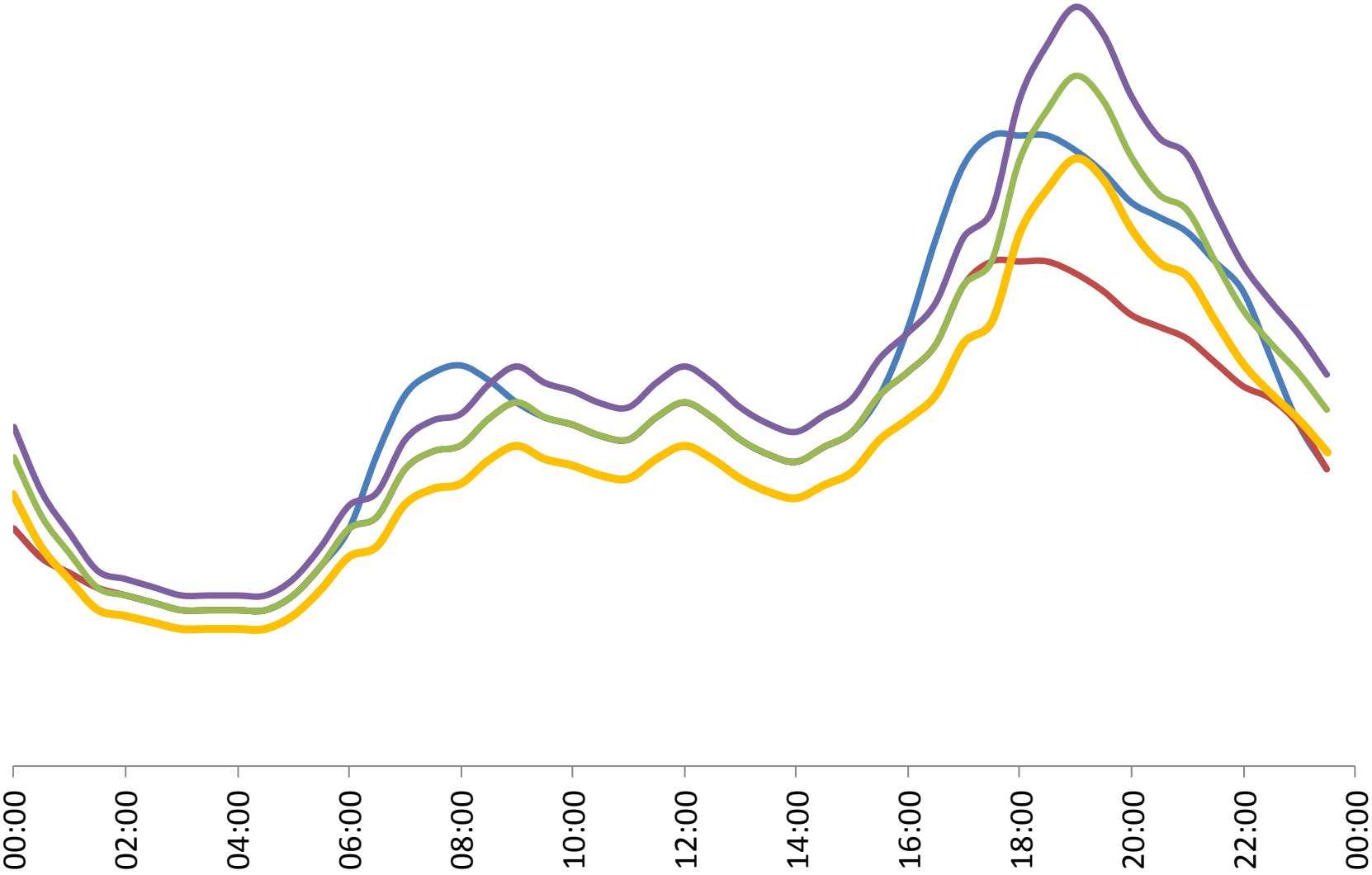
Charge cycle of electric vehicles?



Continuing rise in consumer electronics?



Climate Change?



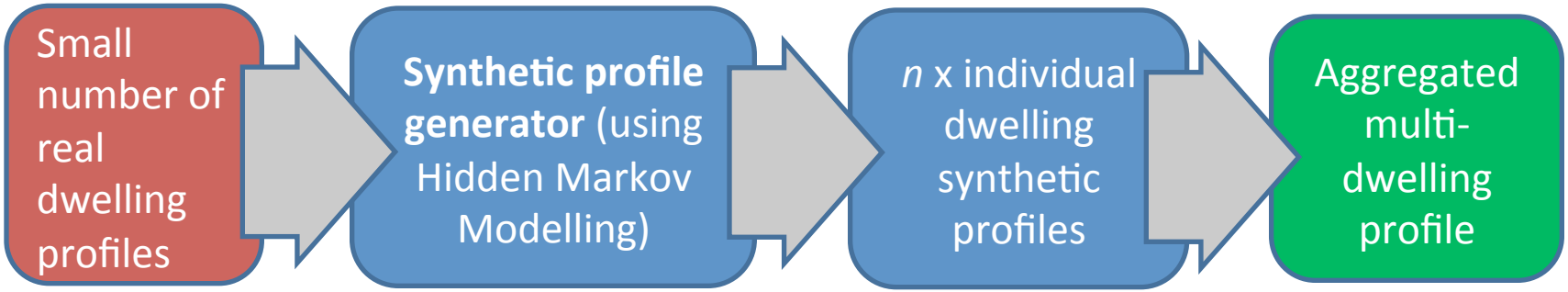
For this we need quite specific “scenarios”...

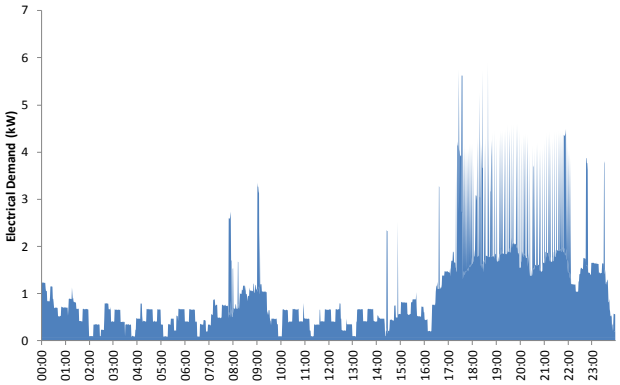
- Archetypes of dwellings
  - Scottish Building Stock from Housing Surveys, and how these might change in the future
- Apply these scenarios to “zones” of 500-6000 homes
- Such bottom-up scenarios do not necessarily need to be *paired* with top-down scenarios
  - But we need to make sure they do not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

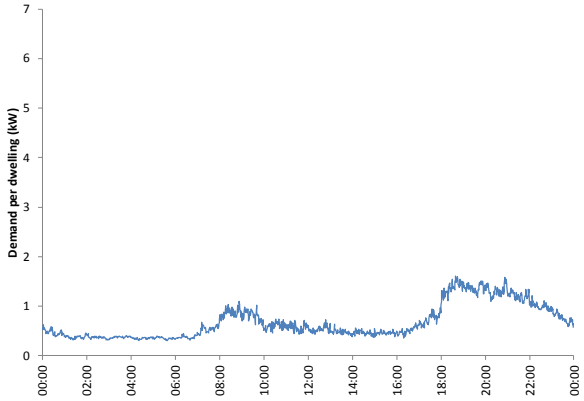
How can we synthesize electrical demand profiles?

- Individual dwelling demand profiles show a 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

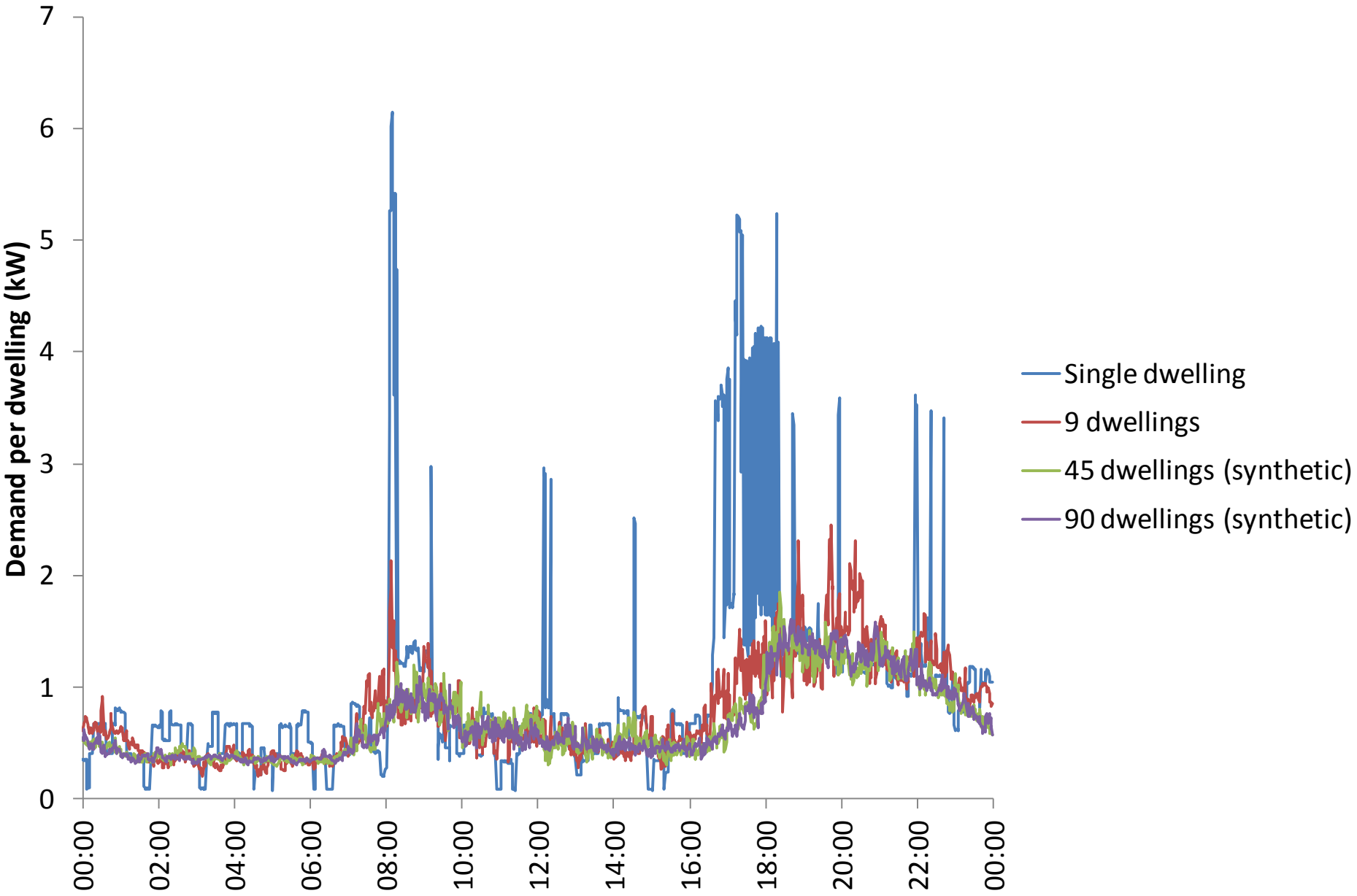
Synthesizing electrical demand profiles







Diversity effect in electrical demand profiles



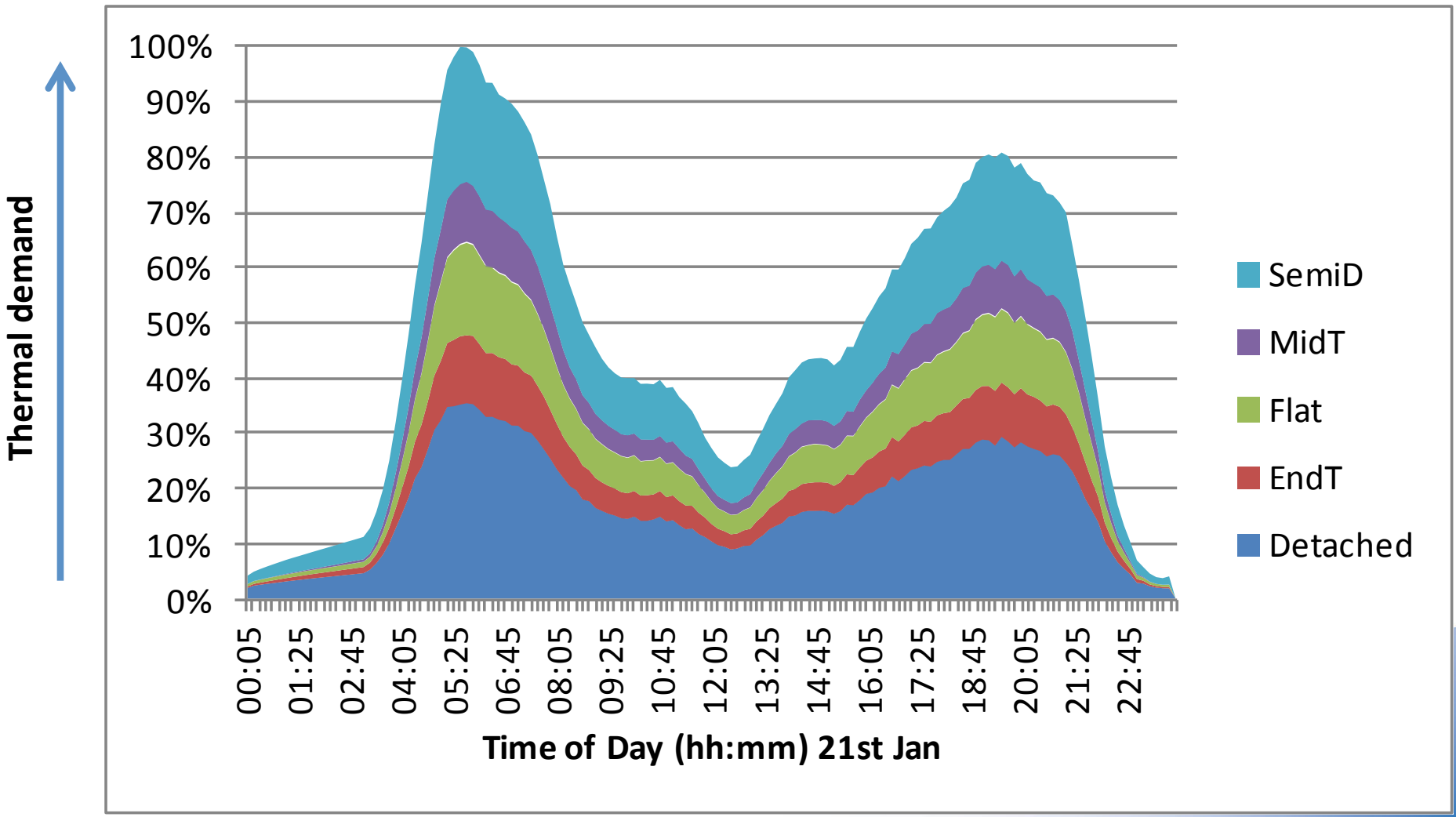
Aggregated thermal demand profiles

- 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 a way that is suitable for extrapolation
  - Can look at effect of, e.g., large-scale changes in heating technology (in a warmer climate)

A local scale stock model

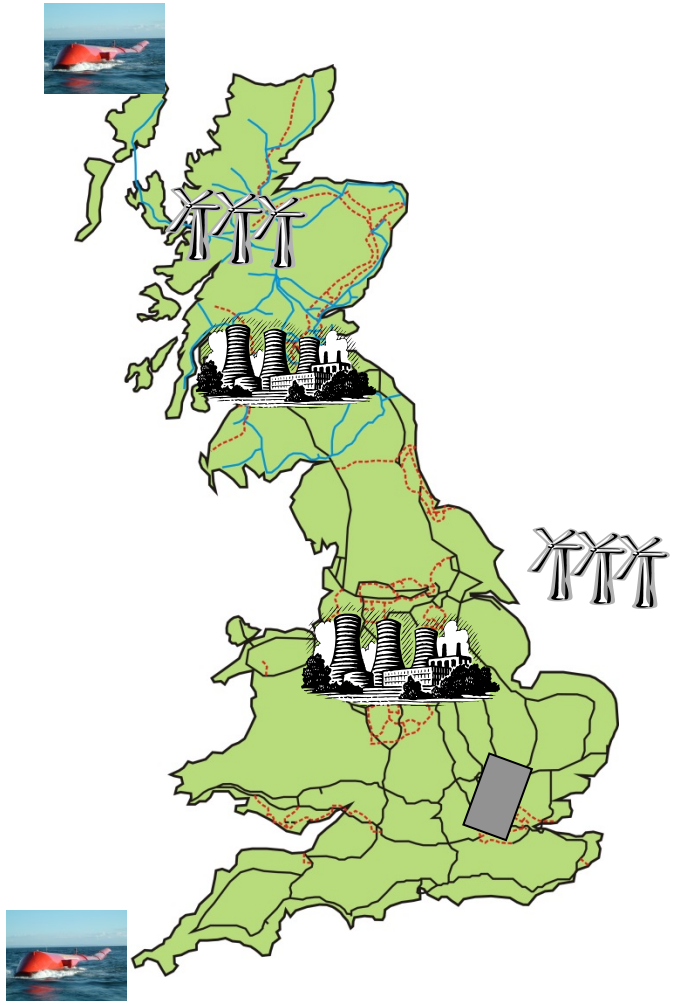
- Zones of Semi-dets, Dets, Terraces, Mid-terraces, Flats, etc
- Zones of 1919-64, 1965-76, 1977-2002, etc
- Building variants created and adjusted by floor area, % glazing, wall construction.

Processing Information



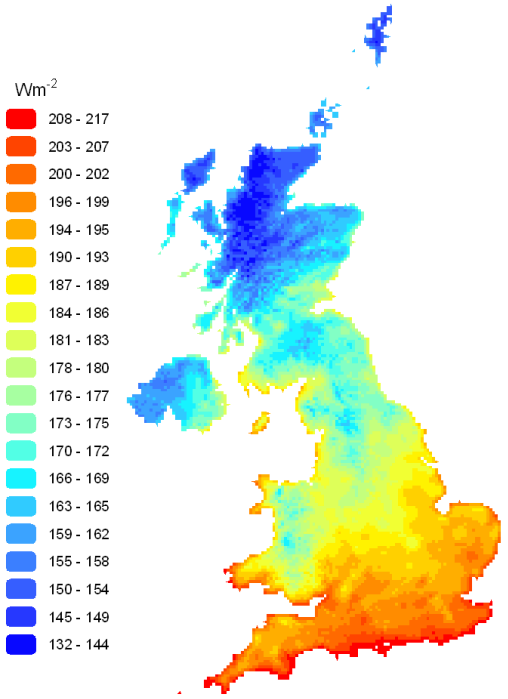
The Supply Side

- 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 is important in credible scenarios
  - resource, economics, grid connection all have strong influence

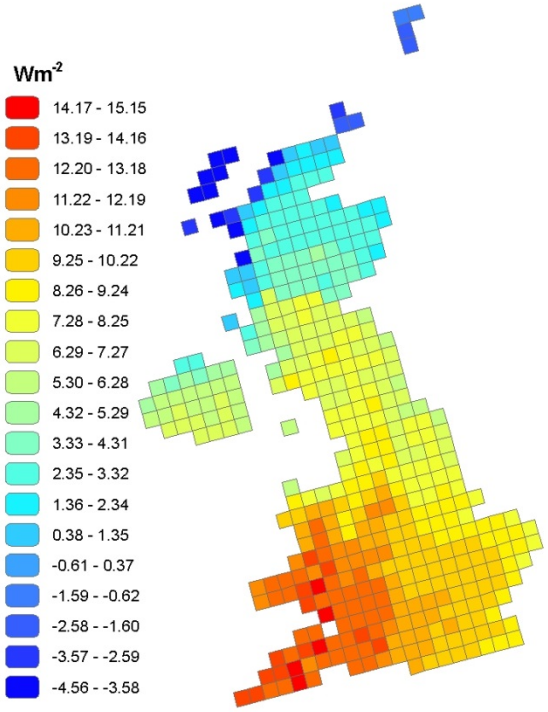


E.G. Solar Radiation / PV Output

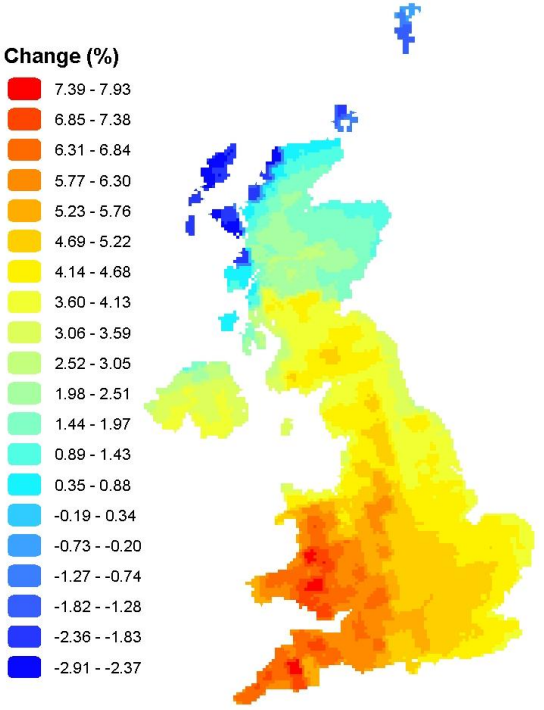
Baseline, relative change, and percentage change (from baseline) for 2050s medium emissions scenario with 50% probability



Baseline - Summer months

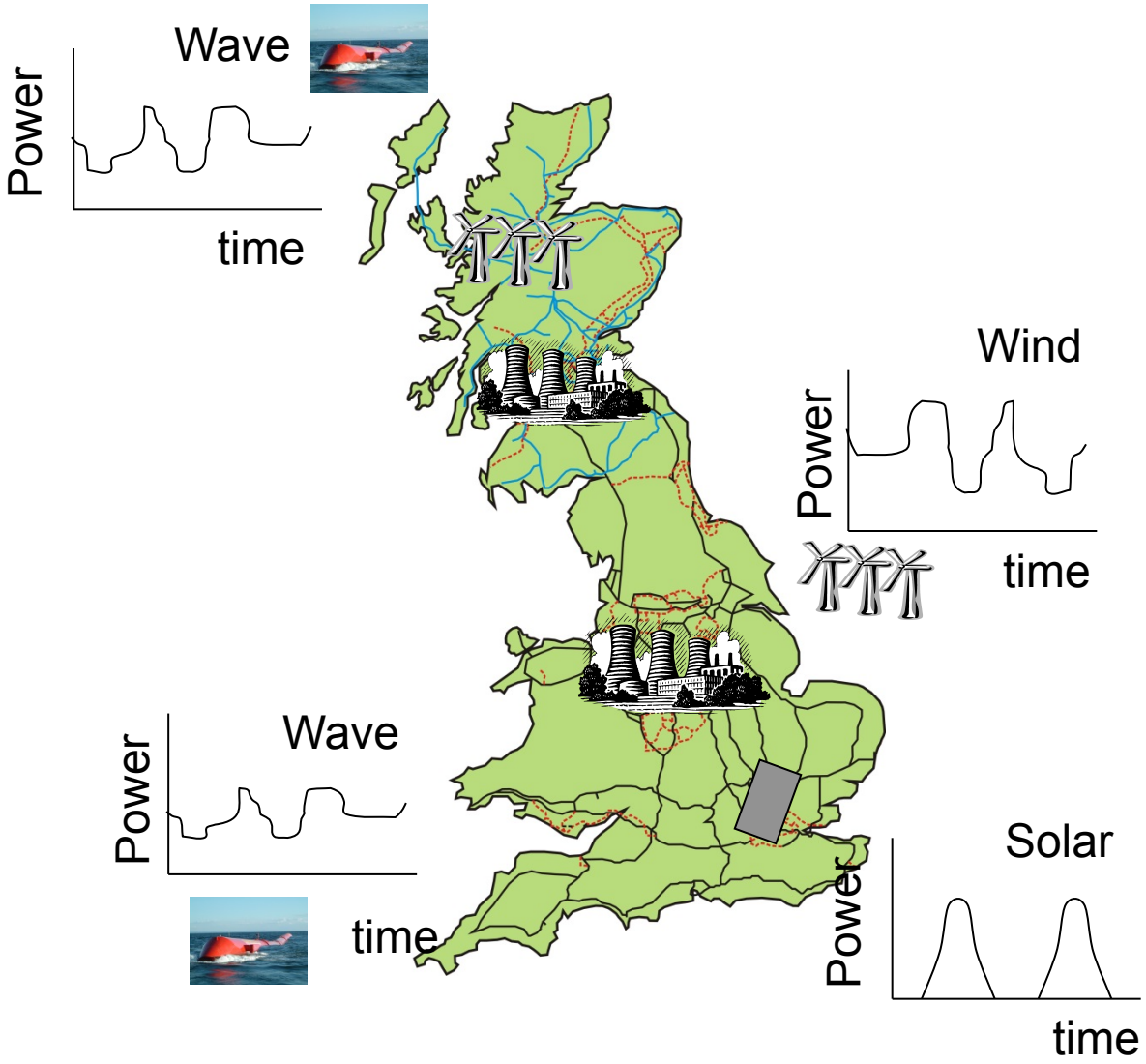


2050s Medium Emissions 50% probability change (Wm^{-2}) Summer months

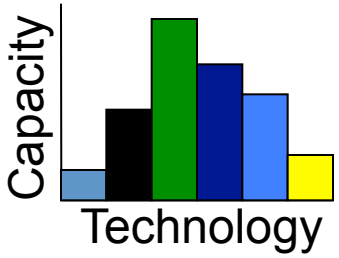


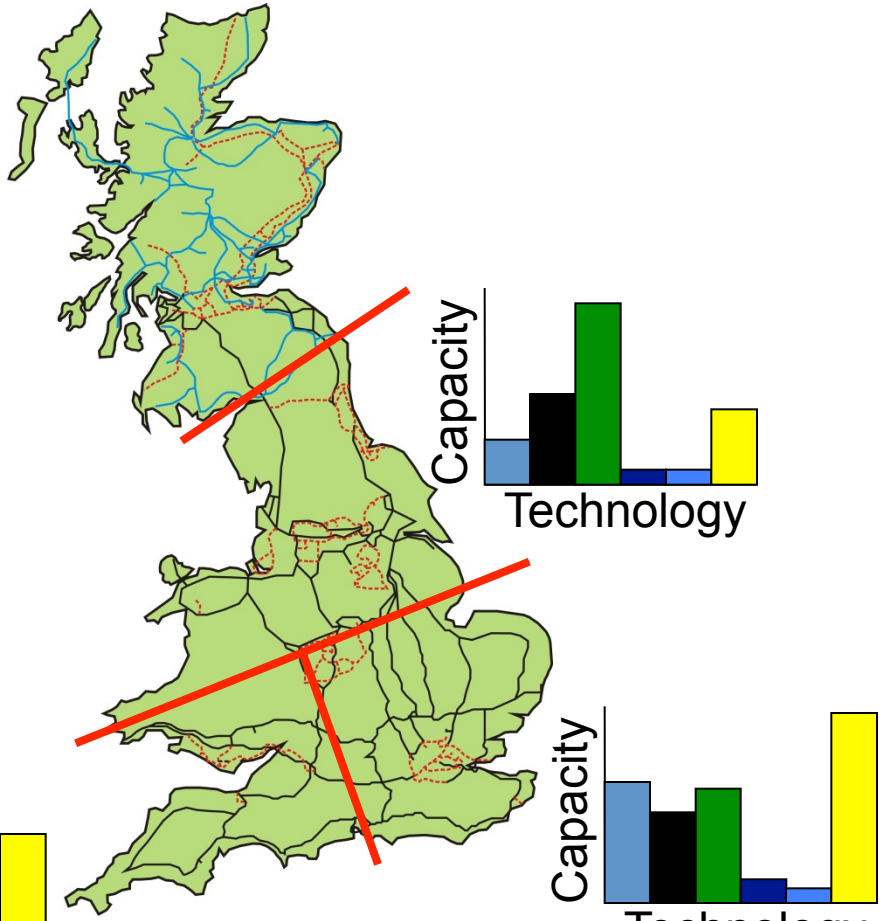
2050s Medium Emissions 50% probability change (%) Summer months

The Supply Side

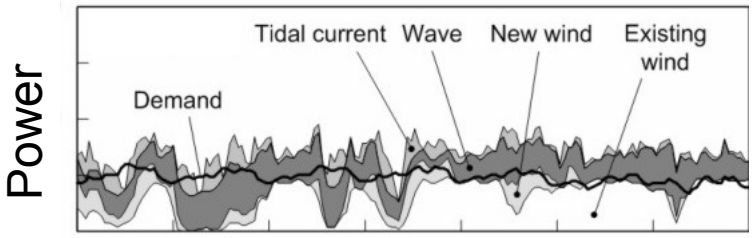


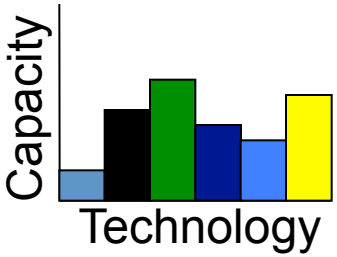
The Supply Side





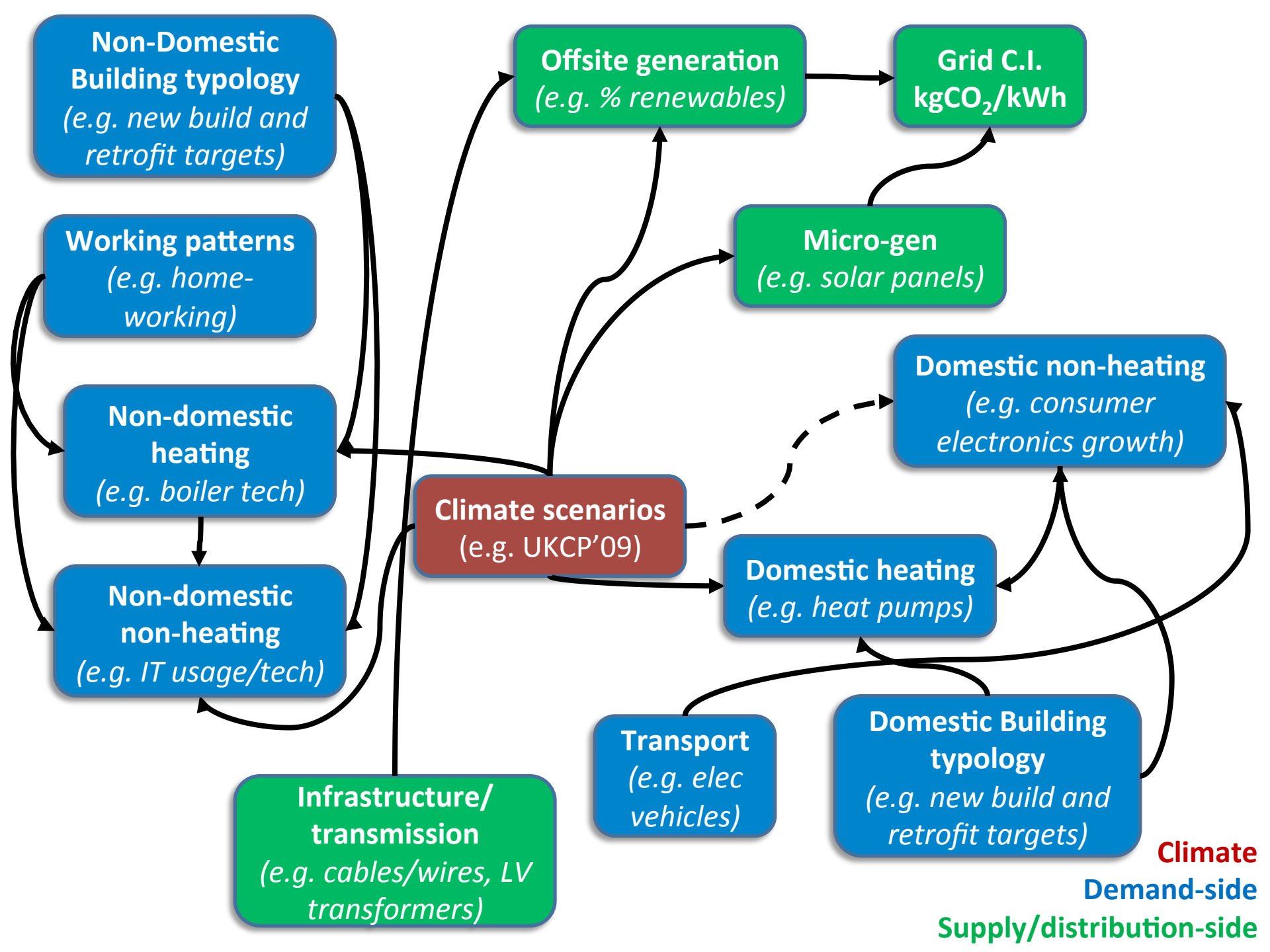
…and match with demand





In conclusion 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
- A tool emulating the effect of climate on building simulations
- A model for estimating the effect of climate on electricity transmission
- Method demonstrating the effect of climate on renewable generation
  - Wind, Solar, Hydro, Tidal, Wave


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

So now we just have to put them all together!!

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