Adaptation and Resilience In Energy Systems (ARIES)

Professor Gareth Harrison
Institute for Energy Systems
University of Edinburgh

Consortium

Edinburgh Research Partnership

Edinburgh Centre on Climate Change

University of Edinburgh	Heriot Watt University
School of Engineering	School of the Built Environment
School of Geosciences	

Project Summary

Project value: £1.35 million
Timing: September 2011 - February 2015 (42 months)
Staffing: 6 Postdocs (~12 years FTE) and a PhD student

Investigators & Researchers

Prof Gareth Harrison, Edinburgh - Engineering
Prof Phil Banfill, Heriot Watt - Built Environment
Dr Andy Kerr, Edinburgh - Geosciences
Dr Richard Essery, Edinburgh - Geosciences
Dr John Chick, Edinburgh - Engineering
Dr Venki Venugopal, Edinburgh – Engineering
Dr David Jenkins, Heriot Watt - Built Environment
Dr Dougal Burnett, Edinburgh – Engineering
Dr Lucy Cradden, Edinburgh - Engineering
Dr Sandhya Patidar, Heriot Watt – Maths
Atul Agarwal, Edinburgh – Engineering + 2

Background and Aim

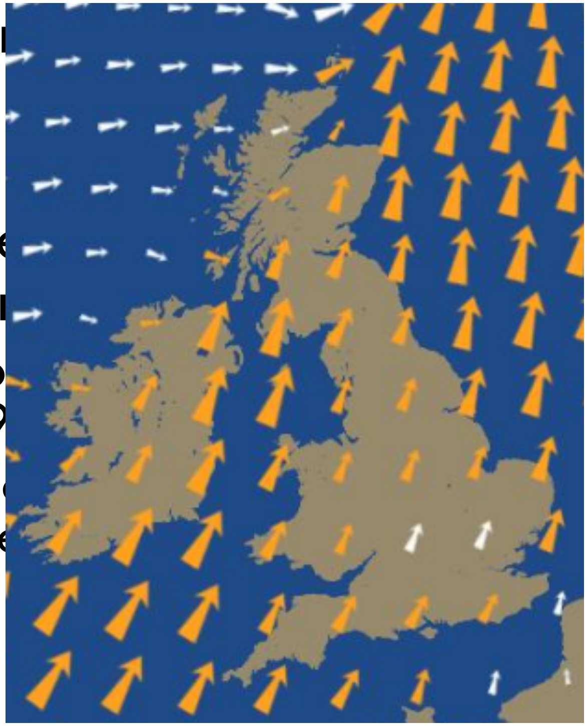
- A resilient energy system balances supply and demand in the presence of internal and external developments including climate change
- Physical climate change to 2050 coincides with a low-carbon revolution in energy: renewables, smart grids, etc.
- Increasing amounts of academic and industry work on energy resilience but little robust linkage to physical climate impacts
- Vital to identify whether future technology and policy strategies for mitigating energy sector emissions imply changes in energy system resilience and capability for climate adaptation
  - particular concern about renewables' weather vulnerability
- **ARIES aims for a comprehensive risk framework to assess and manage UK energy system resilience to climate change**

Objectives

- To examine the physical and economic impacts of climate change on current and new electricity generation technologies
- To examine climate-driven changes in gas and electricity demand in (non-)domestic buildings as well as response to changes in building design, behaviour and micro-generation
- To examine regional and national balance of supply and demand for gas and electricity, its implications for a resilient energy system, and interaction with other infrastructure sectors
- To develop a risk management framework to appraise energy system adaptation, articulate implications and inform CCRAs
- To deliver these via an enhanced set of energy and climate scenarios with new modelling that preserves the spatial and temporal coherence that defines national energy resilience
- To consolidate existing research effort, avoid duplication and build capacity in this important area

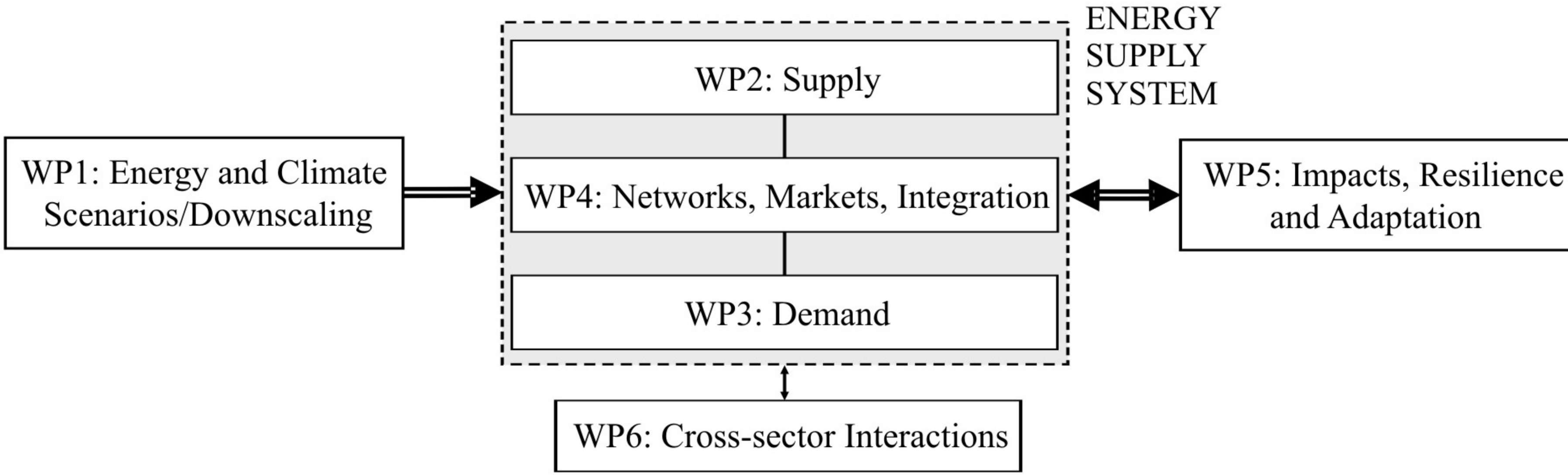
Approach

- Extends work on matching renewable generation and demand to incorporate long-term climate variability and change
- Bottom-up analysis identifies climate risks fo and demand factors as well as system-level risks
- *Interdependence* of renewable supply and de challenge for analysis at regional and natio
  - respecting temporal and spatial coherence in sup patterns precludes simple application of UKCP09
  - other challenges arise from a short temporal scal climate model scale and local renewable resourc



Approach

- ARIES will use UKCP09 scenarios/tools plus additional climate model runs and downscaling for engineering-quality inputs
  - a key tool will be a new *mesoscale weather synthesis model* that preserves regional spatial and temporal coherence for probabilistic analyses
- Delivery of a sound framework for assessing *future* impacts and adaptation at a UK level with application in the *current* system



Climate Scenarios/Downscaling

- Flexible and progressive approach to applying climate scenarios
  - Twin track approach using time series *or* probabilistic scenarios
- Direct use of UKCP09 PDF/weather generator where independence assured, e.g. *local* gas/electricity demand
- Time series for interdependence or where no probabilistic information plus new GCM/RCM runs for wider set of data
- Not known what structure will best suit *MWSM*: multi-variate statistics, multi-site weather generator, resampling, weather typing or combination of these
- Down

Adventure, complexity, computing requirement

Downscaling	Time Series	Probabilistic
Direct local downscaling	UKCP RCM Ensemble	Direct local application of UKCP PDFs and weather generator
Relate RCM to mesoscale climate	'Enhanced' RCM Ensemble (more time series)	
RCM drives mesoscale model	Mesoscale Weather Synthesis Model	

Energy Supply

- Will deliver a suite of analyses in vulnerability of renewable and thermal generation based on future availability
  - For individual and portfolios of technologies
  - Mix of time series and probabilistic analysis
  - Aiming to discern hourly patterns

- Technologies:
  - On and offshore wind – application of existing high res. dataset
  - Marine energy – direct application of 3rd generation wind wave models
  - Hydropower – extend current distributed hydro model to relvant parts of England and Wales
  - Solar PV/Thermal
  - Thermal power – build on existing plant models, incorporate water body heat balance

- Will develop guidelines for specific technology assessment

Energy Demand

- Estimates of energy demand change well developed but largely based on regression or degree days
  - Implicitly assume relationships will hold but scale of changes in building intervention and technologies make this problematic
  - A real need to discern time-of-day changes as these will determine significant components of system risk
- Scenario-driven approach with empirical baseline to which mitigation and adaptation measures may be applied
- Bottom-up building physics models will better capture time-of-day impacts as well as those of interventions in building fabric and controls
- A regionalised building stock model will allow scale up
- Will make full use of Heriot-Watt's existing Low Carbon Futures expertise applied to building overheating, particularly those of building models and statistical emulator

Networks, Markets and Resilience

- Primarily interested in supply-demand balance as a measure of energy security as well as capability of grids to handle flows
- Extend Edinburgh's electricity and gas transmission models to capture future energy flows and market dispatch
- Driven by time series from RCM and MSWS to develop probabilistic estimates of impacts
- Will trigger consideration of adaptation measures that enhance resilience and mitigation