Tutorial 1: Energy context

Q1. Identify two distinct challenges underpinning the development of sustainable energy systems and in each case outline an aspect of the challenge that would benefit from modelling.

Some examples:

1. The need to accommodate disparate views. Modelling allows the trade-offs between options to be made explicit to different stakeholders.
2. The need to operate hybrid systems whereby different systems must cooperate. Modelling supports the elaboration of an effective control strategy.
3. The need to ensure that energy efficiency measures do not cause problems elsewhere. In the case of building insulation, modelling allows an assessment of energy demand reduction alongside issues such as indoor air quality and construction hygrothermal behaviour.
4. The need to balance local and global effects. Modelling can be used to ensure that a decentralised approach to power production does not inappropriately reduce global emissions by moving them to local breathing zones.

Q2. Identify 4 reasons (other than global warming) for taking action to reduce fossil fuel consumption.

Some examples:

1. poor air quality associated with the various gaseous and particulate emissions;
2. diminishing fossil fuels causing price rise because of scarcity;
3. security of supply due to over reliance on imports from politically volatile countries;
4. maintenance of sustainable growth as new energy supply systems are introduced.

Q3. Why might the harnessing of renewable energy difficult?

1. There are many policy, technology and socio-economic barriers to deployment.
2. The practical resource is not vast relative to total energy demand.
3. Matching a large portion of demand will require the industrialisation of the environment on a large scale.
4. High capture levels require: increased transmission network capacity; active distribution network management; and energy storage and/or standby capacity.

Q4. Why is it hard to take action to reduce energy demand?

Because a significant reduction in demand will require lifestyle changes that are unlikely to be acceptable to citizens (e.g. not flying or buying 'stuff'). The maxim 'do a little, save a lot' is misleading.

Q5. List 5 energy efficiency measures that might be applied to the built environment.

Some examples:

1. turn down the heating system thermostat;
2. replace gas boilers with electric heat pumps;
3. upgrade the fabric (e.g. insulate, apply phase change material etc.);
4. draught proof and recover heat from ventilation air;
5. introduce passive solar features (e.g. phase change material, daylight utilisation etc.).

Q6. What is micro-generation?

A scheme in which small scale generators (such as combined heat and power plant, ducted wind turbines, photovoltaic components etc.) are deployed locally and used alongside conventional energy supply connections (gas and electricity) to match the energy demands of a single building or community.

Q7. Why do we need to model energy systems?

To support design decisions relating to:

1. conformance with legislative requirements;
2. the provision of requisite levels of comfort;
3. the attainment of indoor air quality standards;
4. to embody high levels of new and renewable energy technologies;
5. to incorporate innovative energy efficiency and demand side management solutions; and
6. to lessen environmental impact.

Q8. Explain the 4 fundamental aspects of an energy system that ideally need to be represented within a high resolution simulation model and give an example in each case.

A high resolution model should represent the following characteristics.

1. Dynamic effects – the underlying state-space equations correspond to regions with different time constants and the interacting energy flows have driving influences that vary at different rates. Example: the time constant of wall conduction is typically 30 minutes or more, while advection flow in the adjacent room will fluctuate at the second scale.
2. Systemic effects – all flow-paths are connected and influence each other. Example: solar radiation drives natural convection.
3. Non-linear effects – the defining parameters (e.g. material conductivity, heat transfer coefficients *etc*.) depend on the variables of state (e.g. temperature, moisture content etc.) that, in turn, cannot be determined without first knowing the parameters. Example: boiler efficiency varies as a function of the return temperature.
4. Stochastic affects – due to uncertain parameter values, boundary conditions, occupant behaviour and control system response. Example: occupant response to space overheating.

Q9. Identify the basis of 4 main model types.

1. National statistics.
2. Performance tracking via 'big data'.
3. Matching supply and demand.
4. Energy systems simulation.

Q10. What are the 2 main dynamic modelling methods?

1. The response function method which can be configured in either the time or frequency domain. In the latter case, a simple method suitable for manual application known as the Admittance method can be formulated.
2. Numerical methods whereby conservation equations are established for each of many small finite volumes that represent the discretised problem and then solved simultaneously to give the variables of state over time.