Transforming Birmingham –
a city system approach

Assessing the future of whole energy systems: priorities for decarbonisation, resilience and efficiency

Monday 26th June, 10am to 4pm
G36 Civil and Mechanical Engineering Building, University of Birmingham

Workshop Summary

- It is evident from the workshop discussions that there is some awareness that a major transformation is underway in the energy system of the UK.
- The main limitations identified in understanding energy use were: Governance, Finance, Optimisation, the issue that resource supply is less than demand, the hidden cost of energy, liveability and technology and data.
- Suggested model outputs include energy and carbon outputs, energy "exchange" balance sheet, metrics associated with the energy trilemma (energy security, social impact and environmental sensitivity).
- There are major problems in terms of capacity and there are difficulties related to placing significant additional demand on the existing infrastructure system.
- There is also recognition that the linkages between different sectors are poorly understood. There is a need to investigate these linkages and interactions in detail.
- Transformation is seen as an opportunity and that it will be beneficial to bring together different sectors which will ultimately gain from energy efficiencies, reduced carbon emissions (and other air pollutants) with lower customer energy bills, reduced fuel poverty and improved air quality.

Introduction

On Monday 26th June 2017, the newly-formed Transforming Birmingham group convened a workshop to discuss energy system modelling approaches across the UK and to focus on the next steps for developing an integrated, energy system that is flexible and resilient enough to deal with future challenges of a changing climate, a growing and ageing population, new technologies and renewable energy sources to decarbonise at a city-scale.

Approximately 20 people from academia, energy agencies, business and non-governmental organizations participated. This event was motivated by widespread recognition that further research is required to better inform the whole systems perspective of future energy systems modelling.

Drawing from the energy modelling and business modelling expertise, as well as knowledge from the other communities, the workshop sought to glean insights on and evaluate the implications of bringing together energy system models with waste, air quality, legacy housing stock, new build and transport issues. In addition, social, economic and environmental aspects were also considered.

Presentation: *Assessing the future of whole energy systems: priorities for decarbonisation, resilience and efficiency*
Dr. Susan Lee introduced the workshop and highlighted the objectives of the EPSRC/ESC-funded scoping study as well as the objectives of the workshop namely to critically assess modelling approaches with a view to identifying priorities for not only carbon reduction but also considering the resilience and efficiency of systems within the context of the urban environment and its wider hinterland. Ultimately, this work would inform a much larger study building on this knowledge and provide a framework for new approaches to help improve policy decision making in the future.

Workshop Themes

The attendees were divided into three groups (6/7 people per group) with a mix of backgrounds. There was a whole group discussion at the end of each session. The group discussions included presentations by a member from each group and summarised on flip charts as well as individual comments noted on post-it notes. All the points raised were drawn together and summarised.
Discussions at the workshop were divided into three thematic sessions:

Session 1: *How energy use is represented within different sectors*
What are the limitations and why? Identification of three main issues within each group.

Session 2: *Potential integration across different sectors*.
What model outputs would be required from a whole energy-systems model at the city and city-region-scale to address deployment challenges e.g. business models, policy barriers, technological limitations?

Session 3: *Future research directions in whole energy system modelling*
Accounting for resilience, efficiency and the low carbon agenda at different scales
How do we allow for transformative change? What are the key research questions?

Further details about session discussions are as follows:

Session 1: *How energy use is represented within different sectors*

How is energy use represented?
This session highlighted the different views of energy use across sectors. The economic focus is on globalised cost and price of fuel and this is reflected in the transport sector where energy is currently measured in terms of the amount of petrol/diesel fuel used (km per litre); it was noted, however, that in the future, it will be electricity (kWh). Energy is also often viewed as equivalent to carbon but this should change with the use of more renewable energy. If the amount of carbon is reduced this doesn't necessarily mean that energy use will also reduce. Energy is also seen as a concept by many users and a convenience. They are not thinking of energy per se. For instance, in the transport sector, energy provides the means to move from point A to point B.
Energy and heat are often considered together but there are different forms and uses so heat needs to be considered separately. New technology could be transformative in the transport of heat and the distance travelled. There is also thermal storage in buildings that is not always utilised. Energy use is often considered from the suppliers' perspective rather than the users'; the focus should be more on what the customer wants.
Energy use is presented at different scales e.g. the city-scale. Is this a useful scale to consider when much of the energy supplied to a city come from external sources (e.g. 40% from within the city and 60% from elsewhere (Mini Stern Report, Birmingham)? It is also important to consider at which part of the energy cycle, energy is being used so that demand management can meet expectations. There needs to be some representation of the embodied materials within energy provision as well as cross-linking across sectors to identify energy use efficiencies.

What are limitations in understanding energy use and why?
Several limitations arose in discussions, including human behaviour as well as economic and environmental limitations. These are shown under the main limitations highlighted by each group with additional limitations discussed at the end of the section. The top three limitations from each group are shown in Table 1.

Table 1 Three main energy use issues by group (not prioritised)

Issue	Group 1	Group 2	Group 3
1	Governance	Resource is less than demand	Linking to Governance
2	Finance	Hidden cost of energy	Liveability
3	Optimisation	Public perceptions	Technology and Data

Session 2: *Potential integration across different sectors*

What model outputs would be required from a whole energy-systems model at the city and city-region-scale to address deployment challenges e.g. business models, policy barriers, technological limitations?

A range of outputs were suggested with the requirement that system boundaries should to be defined for a particular model metric. Different temporal and geophysical scales need to be studied. There also needs to be an equitable approach to consider the whole system and avoid conflict with other cities e.g. Birmingham vs Oxford "Them" and "Us" should be avoided. Location and the radicalness of the transformation would also impact model outputs. Different users have different output needs which should be considered too. The energy system consists of additional players to solely energy generators and consumers who also need to be taken into account. This could lead to energy being supplied from a range of "everyday" sources.

Integration is likely to occur over time as energy availability and demand from different sectors are brought together, leading to coupling of sectors and ultimately their removal as the whole system becomes integrated

Session 3: *Future research directions in whole energy system modelling*

A number of different topics and issues were discussed, accounting for resilience, efficiency and the low carbon agenda at different scales. These topics also related to potential transformative changes and model requirements as well as research questions to be addressed. These include the distinction between transition and transformative change across sectors, the unpredictability of infrastructure, and dependencies between sectors. One point made is that we can't really allow for transformative change as it is transformative and we don't know what it is. The energy trilemma (energy security, social impact and environmental sensitivity) also needs consideration as the three topics are often presented as conflicting aspects of energy production

Accounting for resilience, efficiency and the low carbon agenda at different scales

Resilience: can be positive against shocks to the system but it could be negative to changes in the system (i.e. not responsive to change). Efficiency: not always a good measurement, an appliance may be very efficient but generation of electricity isn't (energy supplied should be accounted for – social agenda). The low carbon agenda is only one part of social agenda portfolio approach

How do we allow for transformative change?

We need to consider the difference between transformative and transitional change. A massive transformational change is expected but will it be noticed? Radical and unforeseen changes need to be accounted for and the system needs to be as flexible as possible. It will be challenging to model specific transformative change. Outputs need to be aligned to desired outcomes. Modelling should be measuring the impacts of transformative change rather than to predict changes. Step-changes are important in that the change may be faster than the asset duration or the investment cycle. Also, changes at both the domestic and international level (e.g. Brexit) can have a major impact. Public perceptions are also an issue (e.g. the nuclear accident in Fukushima, Japan influenced nuclear power decision making across the world).

What are the key research questions?

These covered topics such as the economic, social and environmental sustainability as well as considerations about energy storage, the inclusion of more components of green energy, measuring transformative change and the metrics to be used.

Future plans:

Building on the workshop discussions, the participants will be encouraged to discuss their energy modelling requirements further. A website about the Transforming Birmingham group will be established on the University of Birmingham website. An email list of interested parties is also being set up. An academic position paper will build on the findings of this workshop and a literature review will assess the usefulness of existing energy systems models for whole city-system modelling.

Appendices

A: List of participants
B: Further details of each of the sessions.
C: Contact details

Appendix A: List of Participants

Surname	First Name	Company
Argent	Steve	Arup
Baines	Richard	EBC (MS) Ltd.
Bouch	Chris	University of Birmingham
Braithwaite	Peter	University of Birmingham
Bryson	John	University of Birmingham
Cavada	Marianna	University of Birmingham
Coles	Suzanne	Energy Systems Catapult
Crean	Chris	Friends of the Earth
Fitch	Mark	PA Consulting
Heaton	Chris	Energy Technologies Institute
Leach	Joanne	University of Birmingham
Lee	Susan	University of Birmingham
Murrant	Dan	University of Birmingham
Powell	Robin	Chase Community Solar Ltd.
Quinn	Andrew	University of Birmingham
Radcliffe	Jonathan	University of Birmingham
Sciacovelli	Adriano	University of Birmingham
Williams	David	University of the West of England

Appendix B: Details of the workshop sessions

Session 1: *How energy use is represented within different sectors*

Main limitation issues:

Governance

- Governance around local energy and supply
- Energy is politicised on many different levels so energy governance is a limitation
- Breaking down silos: within Local Authorities (LA's); sectors (energy, transport); public/private; regulation
- Who has regulatory authority? Many sectors are regulated and this is a major driver.

Finance

- Financing and risk apportionment – need to transform governance
- Value capture and apportionment – generate, sell, collect money
- Accounting practices and how energy is accounted for in business accounts
- Need to move away from selling fuel to selling energy services
- Energy "VAT" over an energy allowance
- Make energy more visible? e.g. a carbon tax

Optimisation

What feature do we want to optimise the system around?

- Re-design the grid system?
- More distributed generation – limit household grid impacts
- Industry/business not always energy efficient
- Heavy industry is getting more energy efficient but still not recovering enough waste energy
- Power station cooling - could this be used?
- Re-design the grid system?
- Which sectors – Transport, construction and waste management

Resource is less than demand

- Energy demand always seems to exceed harvestable energy within any area/region so it is always reliant on an outside source. How do we design this to be most sustainable? E.g. demand management, renewables etc.
- World energy consumption is increasing
- Energy from China
- Supply of energy - local to Birmingham and WM- Import from Hinterland

Hidden cost of energy

- Cost of energy use is not understood (specifically the bill)
- Energy is too cheap
- Energy – the more you use the cheaper it becomes with current pricing
- Travel – is not cost associated with energy
- Costs of energy in food production
- Public take energy for granted – used to relatively cheap available energy
- E.g. internet, public charging of appliances no "roaming" for energy

Public perceptions

- Incentivising behaviour
- Prioritise energy use
- Domestic sector perception of energy. Public take energy for granted – used to relatively cheap available energy
- People's aspirations do not always fit with a sustainable future

Liveability

- Improve quality of life and well-being
- "Domestic energy training", "House MOT"
- Customer and what wants rather than supplier
- Demand Side Management (DSM) leading to quality of life issues. Can we reduce demand?
- People – short-term issues
- Who will benefit? Poor? Those in fuel poverty?

Technology and Data

- Technology – diesel leading to dis-benefit – change in policy
- Manage transition and change
- Big data – Independent organisation; not "big brother"; available and reliable
- Transport of heat (distance travelled) – new technology could be transformative
- Cross-linking. Use of bi-products.

Several limitations arose in discussions, including human behaviour as well as economic and environmental limitations. Many people do not understand the cost of energy and this is often included in the cost of a particular service. In certain sectors e.g. the food industry, the food energy footprint is huge but people are only aware of the cost they pay for a particular food item. There is also a lack of awareness of the amount of money paid for infrastructure to supply energy. Under the current system the more energy you use the cheaper it becomes with current pricing. Regional demand outstrips supply so additional local sources need to be considered. Local energy systems are flexible and more resilient. With the National Grid a large generating station leads to a unit cost

Other Issues

- Can we use energy more smartly – reduce wastage of dissipated energy
- Unforeseen consequences
- Poor building design caused by embedded ways of working
- Power station cooling - could this be used?
- Scalability – to what extent is a city a useful scale to consider this? Mini-Stern report about 40% compared with 60% external.
- Different points in the cycle
- Capability
- Materials – embodied
- Scales – project
  – spatial scale (reuse, recycle etc.)

Session 2: *Potential integration across different sectors*

Suggested outputs include the following:

- Energy and carbon outputs
- Energy availability and demand of each sector.
- Transport energy consumption: km per litre
- Percentage of salary spent on energy/hour
- Air quality and health
- Trilemma metrics. Energy trilemma: decarbonisation, security of supply and affordability (IET, 2017)
- GDP – local/national/GVA
- Aligning outputs to desired outcomes
- Time
- Psychology heuristics
- Predict value from changed circumstances (policy/technology)
- Energy "Exchange" (Balance sheet)
- What extent are we self-sufficient?
- Unused capacity
- Forecast of demand for near future (3 to 6 months)

Other issues
Within this session, other issues were also considered and discussed.

For instance:

- Population growth does not always lead to economic growth.
- Energy systems need to have more flexibility and need to include energy storage.
- Measurements of energy imports and self-producing *smarter* networks will also be required.
- Who might be interested in the model outputs?
  - WMCA is the only authority in the "Birmingham" area
  - Energy users (large) within the area e.g. Jaguar Land Rover (JLR)
  - Hospitals/Health authorities – backup (criticality)
  - Violia – Multiple plants of waste treatment/ generation. Supply/generation
  - Big retail centres
  - Campus Universities
  - Data centres
  - Local Enterprise Partnership (LEP)
  - Regional Development Agency
  - Residential care homes/large community housing
  - Indirect benefits/interest in transport + heat due to health impacts
  - Distribution centres (storage& transport) potentially cooling
  - Fuel poverty lead to higher health demands

- What is the readiness for new technology? E.g. electric vehicles would improve air quality but at the moment there are not sufficient infrastructure charging points
- Also, there are unforeseen circumstances with reducing car vehicles, the charging points being installed may not be used if the leasing of batteries becomes popular.
- Motivations for using a model:
  - Profit – Efficiency
  - "Green" reputational value
  - Resilience of supply/service
  - Collaborative arrangements to achieve mutual support
- Decision support
  - Any benefit in mutual support arrangement? Not just now but in the future-scenario
  - Timing and capacity of short-term demand (e.g. distribution centres at supply centres)
  - Policy decision about encouraging investment E.g. site for new technology development or policy on "Enterprise Zone" & energy systems "science park" designation
  - Investment Decision in new technology. E.g. new storage technology as backup for a large company
  - Resilience/Whole systems modelling
  - Local case studies
  - Needs national buy-in i.e. translatable to other cities/regions
  - Needs New infrastructure and building development HS2/Airport

Session 3: *Future research directions in whole energy system modelling*

A number of other factors also need to be considered:

- Dependencies between sectors
- Costs/Health across sectors
- Long-term planning
- Energy store of coal
- Flexibility and changes in demand

- Energy density (amount of energy stored in a given system or region of space per unit volume)
- Governance models leading to integrated approach
- The need to inform discussions
- Use of evidence to inform policy
- Allow for innovation policy makes
- Access to finance
- Cross-sectoral use of energy [scales]

How do we allow for transformative change?

- We need to consider the difference between transformative and transitional change
- It is hard to model specific transformative change
- Radical/unforeseen changes. Examples: Internet and mobile phone
- Need to be as open and flexible as possible
- Open regulation, supportive
- Joined-up governance across sectors. Built-in existing system
- Strategic outputs vs outcomes

There will be massive transformative change but will we notice?
Information flows quickly so changes permeate quicker.
Government funding to drive innovation – need to be targeted
Research funding needs to be blue-sky as well as application research
Flexibility in energy systems is required but there is a trade-off with reliability and security
Modelling to measure impacts of transformative change not to predict the changes themselves
The water and waste systems need to plan and allow for transformative change
The appropriate metrics are also needed to evaluate transformative change.
Hidden positives and negatives need to be included
Building a more holistic, fuller understanding
Governance. Demand management
Range of different stakeholders. E.g. Retailers. Effects on energy demand. Energy sector point of view.

Step-Change

- Change faster than asset life duration
- Change faster than investment cycle
- Change in concept form
- Carbon fuel to new sources + renewables. E.g. "storage", H_2, Heat transport, climate change
- Change in users' demographic e.g. ageing population
- Change in demand profile of services (changing face of high street, business and services)
- Change in International policy – Brexit
- Change in Domestic policy

Other considerations, changes need to be:

- Sustainable and affordable
- Political and economic (World Trade Organisation Regulations)

Public perception

- Major development "failures" which kill new ideas early
- User perception of "risk" affected by lifestyle and themselves
- People may not want a sustainable solution because they are comfortable with the current service
- Nuclear power. E.g. *Fukushima,*Japan
- Public failure – issues and resistance even if later successful
- People don't always make the most informed decisions

Other issues discussed included the following

- Insight to avoid lock-in
- Beta Max

- ESME- no regrets
- Resilience – cost return

Future research directions will depend on:

- Who will use the model and what they use the model for?
  There will be a range of different stakeholders. E.g. retailers. There will be different effects on energy demand. There is also the energy sector point of view.
- The "radicalness" of transformation and the location.
- Air quality and health which need to be included

The following research questions were suggested:

Research Questions

Economic sustainability

- How do you manage investment when transformative change could undermine investment?
- How do you make a 40-year franchise business case? What will the world be like in 40 years' time?(e.g. when waste is converted to energy you may lose fuel stores)

Social sustainability

- How do we introduce transformational change to an older demographic?
- Who controls the technology leading to change? Who controls this change?
- Trust leading to Governance.
- Education/Communication
- Whole systems approach requires better understanding and communication across sectors and governance
- Different sectors – common metrics/common ground. Communication and understanding

Environmental stability

- Indirect environmental impacts e.g. nuclear waste + model shift in transport

Also discussed were:

- Energy density/storage
- Green energy – more differences
- Business cases - old towards new
- Finance
- Measuring impacts of transformative change
- Metrics to evaluate transformative change
- Energy trilemma

Appendix C: Contact Details

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Other links:
City Region Economic and Development Institute
Birmingham Centre for Railway Research and Education
Birmingham Energy Institute