Innovation Priorities for UK Bioenergy: Technological Expectations within Path Dependence

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UK policy goals for bioenergy

- ‘Sustainable bioenergy’ has an increasingly important role, e.g. reducing GHG emissions, expanding renewable energy and moving towards a low-carbon economy.
- To fulfill UK obligations under the RED, policy aims to obtain 15% of energy from renewable sources by 2020, fulfilling more than half that target through bioenergy.
- More ambitious targets: Climate Change Act 2008 mandates GHG reductions of at least 34% by 2020 and 80% by 2050 – below the 1990 baseline.
  To fulfill those targets will depend on policy incentives stimulating bioenergy innovation.
- Bioenergy is promoted for other benefits, e.g. energy security, technology export, waste management, etc.

Environmentally sustainable biomass?

Sustainability dependent on innovation?

- Bioenergy depends on traditional production processes and/or biomass imports from sources which have been criticised as environmentally unsustainable.
- Excessive increases in biomass imports 'could have counterproductive sustainability impacts in the absence of compensating technology developments or identification of additional resources' (Thornley et al., EPSRC study).
- UK government emphasises technoscientific innovation to ensure expansion of sustainable bioenergy.
- Strategy identifies 'low-risk innovation pathways', as well as 'future hedging options' for dealing with many uncertainties.

Qs for analysis

- This paper will analyse how the UK bioenergy strategy

  justifies support measures for some innovation pathways; and
  anticipates their future benefits, alongside potential disadvantages.
- Overall question:
  How does the UK strategy attempt to broaden future options for fulfilling policy goals? Put in terms of analytical concepts: How do technological expectations mobilise support for pathways which lie within or go beyond path dependence?

- Analytical perspectives: technological expectations and path dependence – as dual implicit aspects of bioenergy policy.

Technological expectations

- Expectations = ‘real-time representations of future technological situations and capabilities’.
- Expectations ‘guide activities, provide structure and legitimation, attract interest and foster investment’. Expectations mobilize resources ‘in national policy through regulation and research patronage’ (Borup et al. 2006).
- Actors strategically use expectations to influence other actors’ views on technological futures in order to favour their own interests.
- Promises are used to convince funding organisations to invest money and attract other practitioners to join a development.
- Promises can attracting resources and gain protection for a pathway, but also return as obligations.
  A claim or a promise may turn into a required action.

Reciprocal expectations

- Literature has focused on technology innovators who build expectations to attract resources and/or political support.
- Generally neglected are the reciprocal dynamics: public authorities raise innovators' expectations for support measures and then face greater pressures to make long-term commitments and/or choices among options.
- Industrial interests may seek 'large scale investment in improvement options that only fit into the existing system and which, as a result, stimulate a "lock-in" situation' (Kemp and Rotmans, 2005).

Path dependence in energy

- Lock-in has been conceptualised as synonymous with (or resulting from) path dependence.
- Energy systems have been a prime case: ‘Energy systems, not just individual technologies, are largely characterized by path dependence: decisions taken in the past limit the options available today’ (Lovio et al, 2011).
- Drive for low-carbon systems opens up extra choices. Innovators may promote new pathways destabilising current ones or else complementing them, especially to recoup past investment.
- It pays to hit the market first – in other words, ‘to build a low-carbon lock-in’ (Lovio et al., 2011).
- Thus lock-in may happen by design, not simply by default from path dependence.

Research methods

- Documents: thirty documents from several bodies – government departments, other state bodies, consultancy reports, Research Councils, research institutes and Parliamentary hearings, and industry organisations.
  Analysis focused on expectations for economic benefits and environmental sustainability.
- Interviews: Document analysis provided a stronger basis for interview questions, which investigated in depth the process of selecting priorities for bioenergy R&D.
  Interviews have been carried out with 20 individuals from the same bodies which originated the documents.

UK Bioenergy Strategy (2012) expectations vs risks

- Technological expectations for techno-innovation combine environmental sustainability (e.g. renewable energy, GHG reduction and/or waste conversion) with future economic benefits of two basic kinds – reducing the costs of GHG savings, and gaining or capturing economic value.
- Anticipates that a new technological pathway may pose risks – e.g. failing to provide GHG reductions in cost-effective ways, or locking out novel pathways that later offer greater environmental benefits.
- The most cost-effective pathways to fulfill 2020 targets may not correspond to optimal ones for reducing GHG emissions – and may marginalise or delay the latter pathways.

‘Low-risk innovation’ pathways in policy

- Thus effort to identify ‘low-risk innovation’ pathways for expanding bioenergy. For example:
  Financial incentives will expand biomass co-firing with coal, as a predictably time-limited infrastructure.
  Yet this pathway reinforces electricity-only generation, while losing links to CHP which could use the waste heat.
- Also effort to promote longer-term future ‘hedging options’ (advanced biofuels, gasification, hydrogen fuel storage).
  Technoscientific development should be able to demonstrate incremental step-wise progress, as a basis for decisions on further investment, thus minimising financial risk.

Industry involvement in priorities

- Innovation funding priorities are shaped not only by industry lobbying, but also by various arrangements closely linking state bodies with companies. Their representatives mainly comprise the government's Technology Strategy Board.
- As an incentive for such involvement, innovators face great uncertainty about the necessary investment before a technological pathway can reach a commercially viable stage. Industry seeks means of 'de-risking' research and innovation.
- UK Research Councils offer a great influence over priorities to companies co-funding R&D.
- Energy Technologies Institute: energy companies co-fund near-market technological scale-up , as means to minimise or share financial risks in commercialising technoscientifc results.
- R&D depends on innovation to identify difficulties in scale-up.

Input substitution patterns

- Resulting from those state-industry arrangements, support measures favour specific bioenergy pathways.
- These provide mainly input-substitutes within current high-carbon infrastructure, even through path creation such as advanced biofuels and gasification.
- Given the technical delays and difficulties of those pathways, such priorities can be better explained by technological expectations, especially for economic benefits (e.g. technology export or share of IPRs).
- Examples of implicit pathway-choices:
  Biofuels/ICE vs bio-hydrogen fuel cells
  Gasification: even biomass-CHP is envisaged as large-scale plants, distant from domestic consumers.
- Higher financial risk: bioenergy-CCS

Alternatives gain little support

- Meanwhile little support goes to alternatives, despite policy statements promoting decentralised bioenergy, e.g. through small-scale CHP.
- Biomass-CHP and bio-hydrogen (for electric vehicles) could greatly enhance GHG reduction – but may jeopardise the capital value of earlier investment.
- Micro-CHP could involve consumers in behavioral changes which further reduce energy usage and enhance GHG savings.
- Anaerobic digestion was promoted as an opportunity for decentralised systems, but AD investment increasingly follows large-scale centralised model.

Anaerobic digestion

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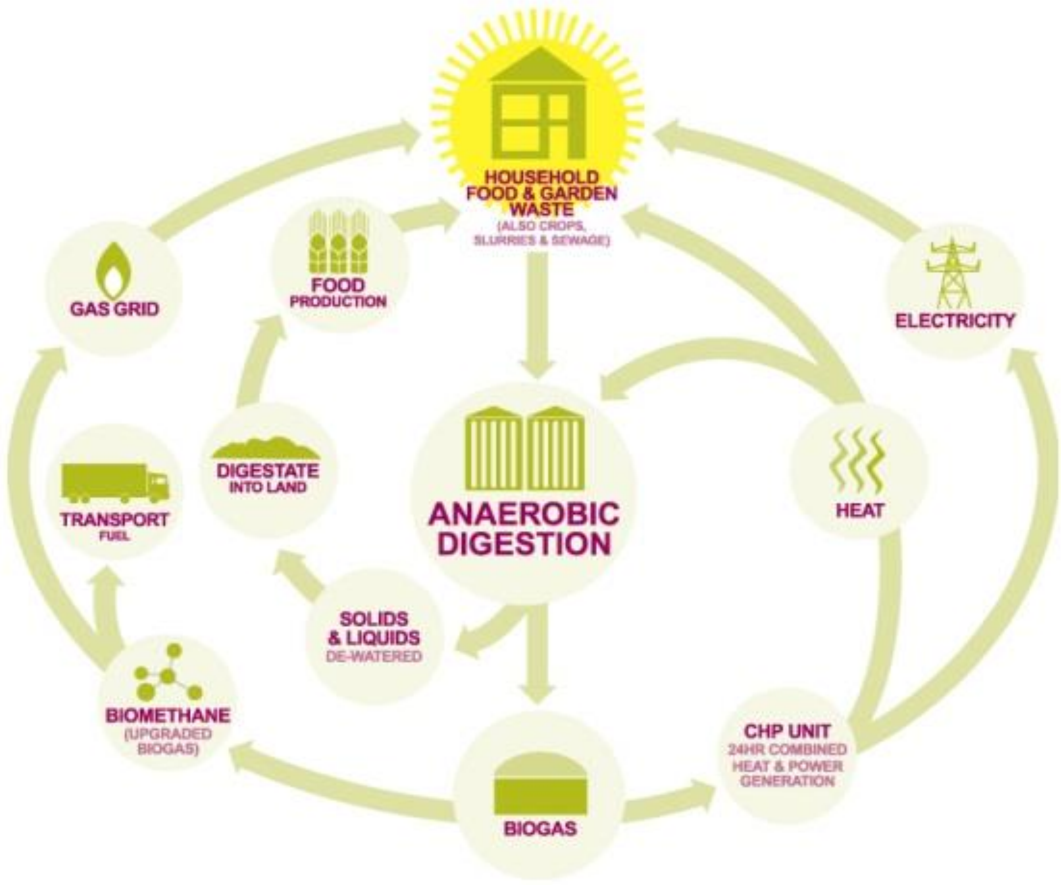

Policy assumptions

- State support measures generally promote bioenergy innovation as input-substitutes for supplying centralised infrastructures, especially current ones, or as means to reduce their GHG emissions (e.g. through BE-CCS).
- Those priorities involve several policy assumptions.
- Cost-effective GHG reduction is conceptually linked with inherent efficiencies of large-scale systems.
- National economic benefits are conceptually associated with large companies selling novel technology or licensing patents; likewise associated with large-scale infrastructures creating employment.
- Input-substitution, remaining largely invisible to consumers, is seen as politically more reliable than changes needing consumer knowledge or cooperation.

Reciprocal expectations

- Although environmental policy stimulates innovation in bioenergy, support measures generally complement past infrastructural investment, minimise extra infrastructural costs and so limit future options for maximising GHG reductions.
- These priorities result partly from the UK state's relatively weak capacity to implement innovation, especially after two decades of liberalising the energy sector.
- State and industry generate reciprocal expectations which turn into requirements, e.g. for de-risking R&D, for providing support measures and for demonstrating technical progress, as steps toward fulfilling future mandatory targets.
- Expectations for specific economic benefits drive and thus favour some innovation pathways more than others.

Path-dependent infrastructure

- Driven by large companies, ‘low-carbon bioenergy’ been directed and integrated into a path-dependent infrastructure for centralised production and delivery via national supply-grids.
- Incumbent energy companies seek new low-carbon lock-ins to minimise investment risk – contrary to ‘risk’ as understood by policymakers.
- Although novel technologies per se may have flexible applications, their design largely complements current infrastructures.

Conclusion

- In this case, technological expectations mobilise support for novel path creation within a fundamenta l path dependence.
- UK bioenergy strategy seeks to avoid lock-ins, yet only some are explicitly called lock-ins.
- A fundamental path dependence is implicitly accepted by default, or is even sought as beneficial – as complementing current centralised infrastructures and energy consumption patterns.
- By contrast, government policy has encouraged expectations for bioenergy to decentralise energy systems along with community benefits and/or involvement; but such pathways have remained marginal in support measures.
- Bioenergy will provide an input-substitute within energy-intensive infrastructure, largely dependent on fossil fuels.