Final Reporting*: Getting the right spatial & social mix: improved methods for planning community Renewable Energy facilities*

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Outline

Summary

The original ambitions of this pilot project were i) to assemble a network of stakeholders within renewable energy (RE) in Scotland, ii) to examine key social and supply factors in relation to RE, and iii) to extend current methods for modelling supply and demand. The project objectives have been met, but not through the original set of deliverables and milestones. From the first discussions, the project took a distinctly *community* perspective because of the large number of land / community-level policy initiatives in Scotland. In the first workshop the interactions of RE supply, demand and technology factors were examined. Key drivers & challenges were identified and new methods for identifying policy solutions to challenges using fuzzy concept mapping were suggested by the project team. In the second workshop the difficulties in governance and overall planning (for example of land use) were discussed, and the paucity of information systems to support such decisions at different scales was noted. For example, community need for robust business cases, regulator need for an overview of how different RE initiatives fit together and local authorities need to understand how supply and demand rates are being satisfied by different proposals. A cognitive mapping exercise was used to identify and investigate the relationship between different factors associated with RE supply, demand, finance & technologies. It identified drivers and challenges to the uptake and demand for RE and RE facility planning. The project recommendations are as follows:

1. An open web-based decision tool to support multi-scale spatial planning (from community to govt.) is needed for actors in RE across scales of interest and responsibility (from citizen via regulator to minister).
2. Critical factors within the control of policy[1] to RE uptake that could have a positive impact are increases in Energy price, Green governance, Planning support for RE and Financial support. The increased financial risk associated with RE (i.e. returns on costs) was found to have a negative influence in RE uptake.

The project team have developed novel methods in 2 areas: i) in location-allocation approaches that better support spatial planning through algorithms able to handle competition for resource supply, spatially distributed RE demand and different types and sizes of facility; ii) in fuzzy concept mapping by extending them to include graph partitioning methods in order to identify clusters of highly related factors (that could, for example be considered by policy together) and by including optimisation routines to identify policy routes to specific outcomes.

[1] Varying oil price was the strongest driver but is beyond policy control.

1. Initial Objectives and Considerations

This pilot project was concerned with the planning of land-based biomass Renewable Energy (RE) facilities: biomass, anaerobic digesters, gasification, combined heat and power. The original aims of this feasibility study were:

1) to assemble an network of stakeholders (academics, environmental scientists, planners, public bodies and commercial stakeholders;
2) to develop novel methods and support biomass RE facility site selection;

and to do this through a Scottish case study. Critical gaps in current research, practice and knowledge related to RE facilities planning were identified. These included the dearth of robust spatial statistical methods that could provide synoptic overviews of the impacts of different RE facility initiatives (for example, to optimally locate multiple RE facilities), and the lack of data and information to allow patterns of community receptiveness and participation in RE planning to be quantified. As a result, the initial overarching aim was to develop and extend tools for the spatial planning of RE facilities.

At the start of the project, the project team and partners had extensive discussions. In these, the key areas in the Scottish land and renewable policy landscape were identified as well as a number of important considerations specific to the planning of biomass related RE. These suggested important additional aspects for the project team to consider:

1) The leading role taken by the Scottish Government (SG) in RE: e.g. developing resilience to climate change and initiatives towards a low carbon climate resilient economy. The Agri-renewables strategy for Scotland has set ambitious renewable energy targets: the equivalent of 100% of Scotland's electricity demand is to be generated by renewable resources by 2020; a target of 500MW of community and locally owned RE by 2020 and 11% of heat to be delivered by RE sources. The SG has a diversification agenda to move away from wind power.
2) The focus on community-level initiatives in Scotland which has a strong community, land reform agenda with real targets for community land ownership and promoting community empowerment.
3) The multiple definitions of *Communities:* communities of interest and communities of place, and differences between urban areas and rural ones. These are supported by land reform acts linked to localism agendas that support local decision-making and control.
4) The need to consider agriculture and land use in the context of resilient RE feedstocks supply. While biomass from woodland is secure, uncertainties exist over supply from agriculture due to timings (crop residues) and supply from animals due to funding (changes to CAP).
5) There are critical infrastructure considerations. Current demand for grid access cannot be satisfied and this is having negative impacts on RE developments. For example, some farmers have adopted an Agri-RE strategy but cannot get an access window to connect / feed into the grid. The cost of grid connection is an issue. This raises a critical question: who is responsible for and who pays for the grid? Planners need advanced knowledge about where they should invest> It was noted that if a single agency was responsible then grid access becomes a finance and engineering problem.
6) There are questions and concerns about the uptake of RE opportunities and the need for future proofing, These related to i) the future availability and location of agricultural feedstocks (as above), ii) the need for 'economies of community scale' where for example communities could create and connect to their own local grid before a connection to the main grid, iii) increases in RE demand, iv) access to finance. The future proofing of rural community energy would be enhanced by empowering communities to make decisions, through the co-production of (RE) knowledge and community engagement, suggesting the need for a decision tool for RE siting.

These considerations provided the context and basis for the first workshop.

2. Outcomes of Workshop 1

In January 2016 a stakeholder workshop was held at the SRUC in Edinburgh. It was attended by representatives the from SG, The Scottish Heatmap, the Forestry Commission, Local Energy Scotland, Scottish Natural Heritage, Resource Efficient Solutions and from academia (SRUC, The Hutton Institute). The aim of the workshop was to identify the factors related to RE supply, demand and finance & technologies as well as the interrelationships between factors. The aim was to determine whether any commonly identified factors were acting as drivers to the uptake and demand for RE and RE facility planning and, particularly, whether any factors were acting as blockages to RE uptake. The attendees were split into 3 groups to consider factors related to supply, demand and technologies and were steered / chauffeured through a Fuzzy Cognitive Map exercise to identify the RE drivers, blockages and their relationships. The result of this process was a series of cognitive maps of factors, their links and causal relationships between factors weighted using a scale of -5 (*very strong negative impact*) to +5 (*very strong positive impact*). These were identified and scored by each group. The maps were converted to graphs that allowed them to be quantitatively analysed. The Supply map and its associated graph are shown in Figure 1 below.

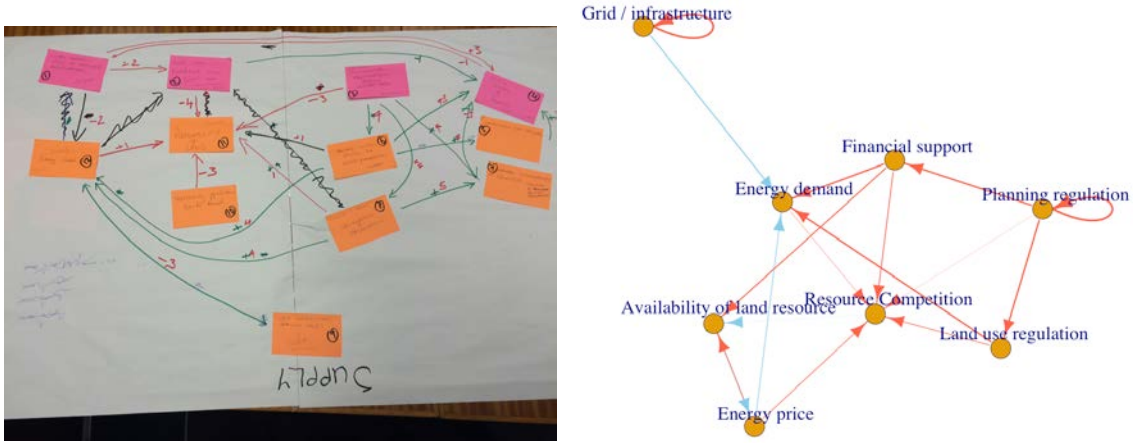

Figure 1. An example of a raw cognitive map of supply factors (rhs), and the cognitive map (lhs), with positive influences red, negative ones in blue and arrow width indicating the strength of influence.

The 3 maps were combined and the initial factors were re-coded to 12 common factors. The new factors and the initial ones are listed in the Appendix. The interrelationships between the 12 factors are summarised in the matrix in Figure 2.

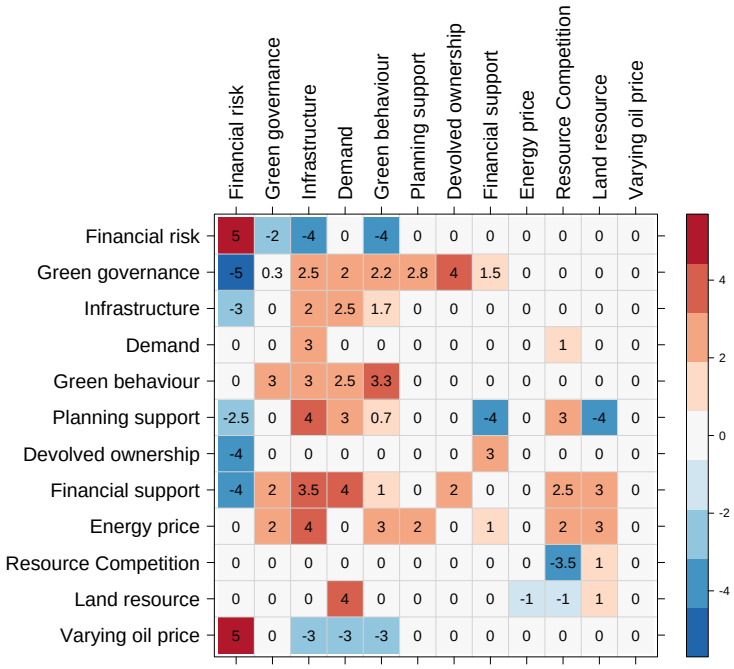

Figure 2. The matrix of factors, to be read left to right, with deeper reds indicating the most positive influences and the deepest blues the most negative ones.

The matrix allows the perceived barriers and drivers to RE to be identified. A number of factors were found to have a positive influence:

- Increasing **Energy price** has a positive effect on a number of factors including Green governance, Infrastructure, Green behaviour, Planning support for RE, Financial support of RE, Resource competition and Land resource.
- Increases in **Green governance**: would have positive effects on Infrastructure, Demand, Green behaviour, Planning support, Devolved ownership and would reduce the Financial risks associated with RE development.
- Increases in **Planning support** for RE: would increase Infrastructure, Demand, Green behaviour and Resource competition and would decrease Financial risk, Financial support and the Land resource.
- Increasing **Financial support** for RE would increase Green governance, Infrastructure, Green behaviour, Devolved ownership and the Land resource available to RE.

However, increased **Financial risk** was found to have a negative influence on Green governance, Infrastructure to support RE and Green behaviour of the population.

3. Outcomes of Workshop 2

In March 2016 a second workshop was held at the James Hutton Institute, Aberdeen and was attended by representatives from a small set of key stakeholder groups; the Forestry Commission (as a land owner and biomass provider), Local Energy Scotland (as a facilitator of community energy projects, supporting both planning and brokering funding), SEPA (as the regulator charged with locally interpreting policy guidance over RE planning), Resource Efficient Solutions (as the SG agency with responsibility for supporting policy initiatives in RE), and academics with interdisciplinary expertise in energy issues (from both policy and activist viewpoints). The aims of the workshop were:

1. To identify any policy gaps and the requirements needed to support low carbon resilient economies in Scotland (current and new; policy coordination and interaction; outcome focussed, etc).

2. To identify the features and outline specification of a Renewable Energy (RE) decision tool to support multi-scale decision making, from community to national scales (route maps for communities, community benefit trade-offs, etc).

The workshop identified a number of significant research gaps (as described in the next section) and **research opportunities related to the following points:**

- Community energy initiatives and proposals do not link with energy use (evident in the community energy fund initiatives).
- Understanding the spatial distribution and equity of current community benefits (CARES have the data) with the spatial distribution of socio-economic factors (deprivation, fuel poverty, etc. would identify geographical and social gaps in current provision.
- The extent to which current community energy initiatives relate to current and projected energy use is unknown. Work is needed to identify geographical and usage gaps in current and projected provision.
- The nature of SG influence through policy:
    - If energy policy was devolved then grid connectivity would be driven by energy companies (Scottish Power, SSE and others);
    - There is no immediate link between devolved energy policy and bulk buying. So if public policy by the SG encouraged LAs to have biomass plants – as in Aberdeenshire - then the LA becomes a bulk biomass buyer.
- How to improve RE storage capabilities and promote (grid) connections?
- How to promote RE ownership and RE stakeholders to have a positive impact on governance and buying?
- Extend the 'heat map' to a) support fine scale analyses b) include socio-economic factors. A map of heating networks would also be useful.
- Identification of future energy and environmental planning constraints. For example soils in relation to above ground solar - currently only peat areas are considered (e.g. routing of cables to avoid peat soils) and strategic assessment are lacking.

4. Findings, Recommendations and Next Steps

A. The following research gaps should be addressed to support RE facility planning in Scotland:

1) Clear planning policy guidance with multi-scale objectives is needed to address current gaps in understanding:

- Demand factors are multiscale, they change over scales, and that the bulk are activities are commercially driven rather than community (e.g. housing developments);
- Currently, little consideration is currently given to heat and power in planning *cf* water and waste infrastructures;
- There are difficulties in interpreting SG policy and then advising planning authorities regarding planning applications. Regulatory interpretation varies (e.g. in different SEPA offices) in the absence of clear guidance.

2) Research is needed to determine what the new community and locally produced renewable target should be and how it should be measured.

- Scotland met the 500 MW target in September 2015;
- Can a target be set that mixes capacity with community related benefits e.g. funds generated, fuel poverty targets, equity of provision.

3) Research is needed to identify what can be influenced through policy in Scotland. For example:

- Grid Connectivity: If energy policy was devolved then grid connectivity would be driven by energy companies (Scottish Power, SSE and others);
- Bulk buying of biomass: There is no immediate link between devolved energy policy and bulk buying. So if public policy by SG encouraged LAs to have biomass plants – as in Aberdeenshire - then the LA becomes a bulk biomass buyer;

- RE Storage: How to improve RE storage capabilities and promote (grid) connections?
- RE ownership: How to promote RE ownership and RE stakeholders to have a positive impact on governance and buying?

B. A multi-scale decision support tool is needed to support RE facility planning across the different stakeholders, agencies and authorities.

Throughout this project it has been apparent that many involved in RE in Scotland would welcome a tool to support decision-making. The workshop considered the specification and characteristics of such a tool.

- It should have a clear biomass RE focus. This is a clear gap in current tool provisions, which typically display the locations of RE facilities (e.g. Local Energy Scotland, Energy Archipelago) or resources (e.g. Scotland Heat Map) but have no analytical capability;
- It should have a clear focus and scope, e.g. relating to development levels the tool supports;
- It should be open, online, with (linked) data to be able to join up all the factors;
- It should provide multi-scale information and support different stages of RE facility development as for example different processes relate to different applicants (e.g. developer vs. farmer vs. community);
- It should support fine-scaled decisions about:
    - the trade-offs e.g. between food and fuel, to be evaluated at regional level. This is especially important for the "squeezed middle" between high and low value land;
    - decisions over viability relating to the minimum sized unit (capacity) for a viable resource;
    - benefits such as off-set flooding risks and scenario testing to show potential benefits and inform the decision making process.
- It should support Community empowerment by putting the raw materials of decisions in the hands of more people;
- It should be able to identify locations where there is the greatest potential for buyout based on current resources (supporting communities of place or interest);
- The tool should support new RE targets (see above) e.g. to assess and quantify the RE capacity with community related benefits, equity of provision, and so on.

In short, the tool should accommodate the factors describing benefits and burdens of the decisions that are made around energy.

5. Publications

Papers to Scientific Journals

Comber A, Dickie J, Elston D and Miller D (in prep), Identifying optimal locations for multiple, differently sized facilities: extending the p-median problem to consider resource catchments

Comber A and Dickie J (in prep). What to put where? Extending the p-median problem to consider multiple facilities, multiple sizes and associated resource needs

Comber A and Dickie J (in prep). Biomass renewable energy factors: extending fuzzy cognitive mapping approaches with graph partitioning and optimization.

Dickie J and Comber A (in prep). An assessment of the drivers and challenges to the demand and uptake of biomass renewable energy using a fuzzy cognitive mapping approach.

Conference papers

Comber A and Dickie J (2016). Getting the right spatial mix: optimising the size, type and location of renewable energy facilities. Paper accepted for *Spatial Accuracy 2016*, Montpellier 5-8 July 2016.

Comber A and Dickie J (2016). Biomass renewable energy factors: extending fuzzy cognitive mapping approaches with graph partitioning and optimisation. Paper accepted for *AGILE 2016*, Helsinki 14-17 June 2016

Appendix: Factor descriptions

The standardised and original descriptions for factors associated with biomass renewable energy. The asterisk (*) indicates actors whose links (scores) were reversed during the relabeling to reflect a shift from a positive to a negative emphasis or *vice versa*.

Factor	Description
Financial risk	Earn money without (or limited) risk*; Low risk and high return*; Reduced risk and uncertainty*
Green governance	Governance - culture - change vs. habit; UK wide and devolved energy policy benefiting communities through regulations and incentives; Positive behaviour change e.g. CCF; Overarching climate change commitments COP Paris; Current UK energy policy
Infrastructure	Heat and electricity storage / access to storage (+ transportation of stored energy); Transportation; The gas grid/ district heating. The gas grid is less attractive than district heating (but also an opportunity); Grid connectivity (gas and electricity). Ability to connect and export increases; Grid connections, capacity issues and cost; Meso level infrastructures
Demand	DSM (Demand side management); Scottish energy market; Scaling up energy demand - collective
Green behaviour	Exposure to precedents / uptake; Behavioural inertia and lock-in*; Lack of energy literacy*; Increased trust
Planning support	Planning regulations - increase in local energy friendly planning regulations; Statutory environment - More restrictive*; Positive planning policy
Devolved ownership	Ownership - long term, partnerships, simplification, ESCos, stakeholders complexity, reducing complexity, heat and electricity
Financial support	Bulk buyer, PPA, fall back and flexible; Case of raising finance at appropriate timescale; Demand-supply driven by support mechanisms increase; Positive policy change - financial support
Energy price	Global market - Price of resource increase; High $100 a barrel oil price
Resource Competition	Land-use - Food vs. fuel sites. Current use. Local; Competition for resource; Increasing population needs food; Availability of land - increase
Land resource	Scottish quantity of resource - Increase; sustainability of resource - (definition of specified requirements); Climate and land legislation and regulation
Varying oil price	All energy price volatility (non-renewable)