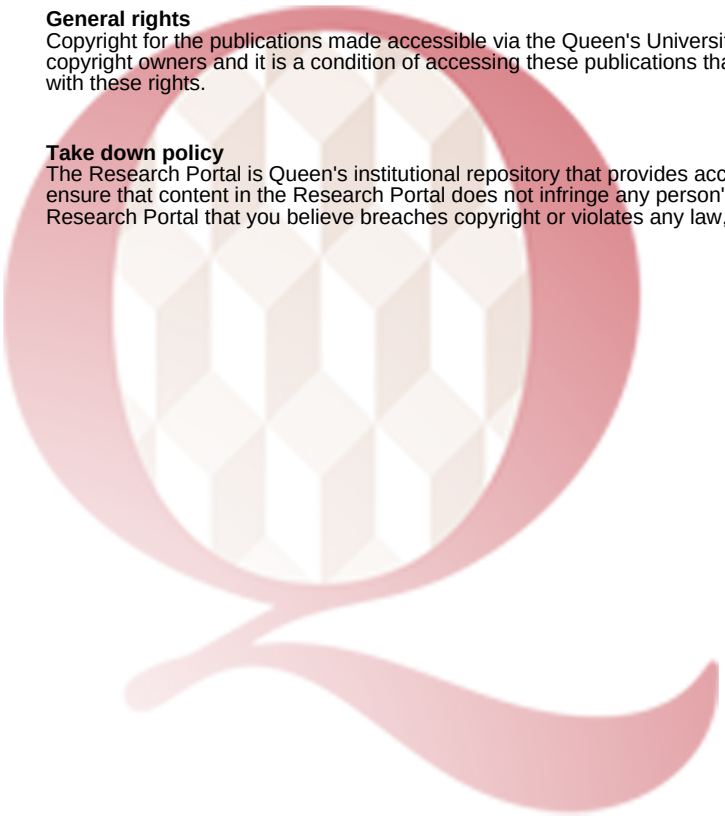
Catalysing the Irish Energy Transition: Capacities and Challenges

Hume, T., Ellis, G., Barry, J., & Curry, R. (2016). Catalysing the Irish Energy Transition: Capacities and Challenges. Paper presented at International Sustainabilty Transitions Conference 2016, Wuppertal, Germany.



Catalysing the Irish Energy Transition: Capacities and Challenges

[1]Therese Hume, Geraint Ellis, John Barry, Robin Curry

CCTransitions Project[2] , Queen's University, Belfast, Northern Ireland

Abstract

The transition to a "low carbon, climate resilient and environmentally sustainable economy by the end of the year 2050" has been conceptualised as the "national transition objective" in the Irish Climate Action and Low Carbon Development Bill, passed in late 2015. This has raised a myriad of questions over how this can be operationalised and resourced and whether it can maintain political momentum. This paper assesses the utility of framings informed by the transitions (MLP) and technological innovation systems perspectives in analysing transformative societal processes, by examining their application in an Irish case study on policy and technology. Through a qualitative exploration of the broader societal and policy context of the energy sector and a more detailed examination of the innovation systems of selected niche technologies (bioenergy and electric vehicles), the Irish case study sought to identify potential catalysts for a sustainability transition in the energy sector in Ireland: where these exist, how these are being built or enabled, and barriers to change. Following a discussion on the theoretical approaches used, a description will be given of how these were applied in the conducting of research on transition in Ireland and the key findings which emerged. A critical reflection will then be made on the utility of these perspectives (as applied) to contribute to broader processes of societal transformation in Ireland.

Keywords: sustainability transition, multi-level perspective, technological innovation system, Ireland

1. Introduction

> "The ambitious energy transition outlined in this document requires the active engagement of Ireland's citizens, communities, businesses, academics and experts, and local and national State agencies. It will also require better public awareness of the nature and scale of the challenges we face, and a robust consensus about the broad policy measures required to meet those challenges. "(DCENR 2015:7)

Ireland's "national transition objective", in the Irish Climate Action and Low Carbon Development Bill[3] is defined as the transition to a "low carbon, climate resilient and environmentally sustainable economy by the end of the year 2050" (DECLG 2015:5). Central to addressing this challenge is a *radical* transformation of Ireland's energy system, acknowledged in the Energy White Paper, published in December 2015 (DCENR 2015:7), and in the National Innovation Strategy, as a 'society-wide challenge' (DJEI 2015). In this context, a team from Queen's University Belfast has been undertaking a project on

[1] **Emails**: thume@itsligo.ie ; g.ellis@qub.ac.uk; j.barry@qub.ac.uk; r.curry@qub.ac.uk

[2] CC Transitions is a research project funded by the Irish Environmental Protection Agency (www.epa.ie) and based in Queen's University Belfast (https://www.qub.ac.uk/research-centres/TheInstituteofSpatialandEnvironmentalPlanning/Impact/CurrentResearchProjects/CCTransitions/)

[3] The bill provides for sectoral mitigation plans in the areas of transport, electricity generation, the built environment, and agriculture that will be monitored and reported on annually.

'Catalysing and Characterising Transition[4] (CCTransitions), funded by the Irish Environmental Protection Agency (EPA). A core aim of the CCTransitions project was to investigate ways to characterise and benchmark the 'state of transition' of the Irish energy system in a manner that could provide insights to inform policy. This paper provides an overview of some of the findings of this project, in particular examining how insights from transitions and technological innovation systems (TIS) literatures could be used to address these aims.

The project has assumed that the Irish Government's discourse of a 'radical transformation' in the energy system necessitates a range of complex, society-wide change processes with technical, cultural, social, economic and behavioural elements. From this perspective, and as acknowledged in the White Paper cited above, transforming the energy system involves change processes in a wide range of societal systems, not only those where energy is more directly produced and consumed (such as electricity, mobility/transport, heating and cooling, food, and shelter), but also in those where change might be engendered or facilitated, such as political, education, research and financial systems. Such change processes can involve diverse groups of actors and occur at different geographic scale levels. Given the complexity of the systems involved, and interdependencies and complex connections between them, coupled with the levels of uncertainty that exist, this paper explores and assesses how theoretical insights could aid in analysing the Irish energy system. The paper highlights potential catalysts and capacities needed for transformative change and provides a critical reflection on the ways in which energy transition has been framed, allowing a number of broader conclusions to be drawn on the state of transition in Ireland[6].

We begin with a discussion of the theoretical elements that were adopted and applied in the Irish research, followed by a brief discussion of methodology and an account of findings. Examples will be given of theoretical perspectives and their application to exploring the broader societal and policy context of the Irish energy system and the innovation systems of selected 'niche' technologies, electric vehicles (EVs) and bioenergy. The paper highlights potential catalysts and capacities needed for transformative change in Ireland's energy system and provides a critical reflection on the ways in which energy transition has been framed, allowing a number of broader conclusions to be drawn on the state of transition in Ireland.

2. Framing Aspects of Society-Wide Transition

Given that the need for a more systemic and holistic view to address society-wide challenges has increasingly been articulated(e.g.OECD:2015:6), a key assumption in the CCTransitions project is that it is possible to characterise 'state of transition' of a complex socio-technical energy system in a manner that can inform policy. The obvious dangers are those inherent in any attempt to simplify a complex system: reductionism, the prioritisation of some views and values over others, reification of what is essentially the subjective use of a framing

[4] Ref: 2014-CCRP-DS.6. This is an 18-month desk study was to investigate ways to characterise and benchmark the 'state of transition' of the Irish energy system in a manner that could provide insights to inform policy. For more details, see: https://www.qub.ac.uk/research-centres/TheInstituteofSpatialandEnvironmentalPlanning/Impact/CurrentResearchProjects/CCTransitions/

[6] Other important work on Irish energy transition has involved modelling approaches (e.g. see SEAI roadmaps 2010/2011, Finn 2012, Deane et al 2013) and there has also been valuable work on sustainable consumption and social practices, in particular a wide body of work linked with the Consensus Project[6] (Davies et al 2013). There has also been work on transport (e.g. Morrissey et al 2016a,b), and on community energy (e.g. Carragher et al 2011). The National Economic and Social council (NESC) have published a series of papers addressing climate challenges (e.g. NESC 2012, NESC 2014). We view our work as complementing these approaches.

device, or of giving a false impression of 'objectivity'. However, as it is patently impossible to view or conceptually 'map' a complex system in its entirety, it is also assumed here that despite these dangers, critical use of particular theoretical perspectives as frames to manage complexity and inform action can provide different types of insight, but that these caveats underlie insights from this research.

Providing a strict or definitive demarcation of the boundaries of the energy system is difficult, as how energy is produced and consumed provides a foundation for and is influenced by a wide range of societal systems (including individual and collective behaviour and belief systems) that should not be discounted in discussions of energy systems transition. For these reasons we began by adopting a broad perspective on the Irish energy system informed by the Multi-Level Perspective (MLP, in particular, adopting insights from De Haan 2010, Frantzeskaki and De Haan 2009, and De Haan and Rotmans, 2011). As such, we view a society-wide **energy transition** as the emergent result of multiple changes in "dominant structures, cultures and practices" [8] (De Haan 2010, De Haan and Rotmans, 2011:93) of *interlinked* societal systems which (directly or indirectly) shape the production and/or consumption of energy[9]. The implications of this view are that if the **energy system** is viewed as being primarily concerned with the societal function 'energy' (including how it is produced and consumed, and involving technical, cultural, social, economic and behavioural elements), then it is important that this is viewed in the broader context of its interfaces and linkages to other societal systems.

As an island highly dependent on fossil-fuels (SEAI 2016a), with an open economy and a large national debt, it is vital to examine particular vulnerabilities of Ireland's energy system to broader external (landscape) forces (Frantzeskaki and De Haan 2009). Taking the Irish energy system as the 'societal system' of interest (De Haan and Rotmans 2011), and bearing in mind the difficulties in setting system boundaries discussed above, we view **landscape** as encompassing the broader legislative context (including EU and UN targets); the global and local physical environment; and financial and other geopolitical forces affecting Ireland's energy system. The energy **regime** is seen as the "dominant structures, cultures and practices" of the energy system (De Haan and Rotmans 2011:92). This effectively comprises a mesh of inter-dependent 'regimes', most notably in electricity, heating/cooling and transport, where most existing targets and policies are focused (see for example SEAI 2015a). Energy consumed is also highly dependent on broader systems of consumption and materials flow (Maguire and Curry 2008), while GHG emissions are also driven by the way in which food is produced and land is used. In order to catalyse (low or zero carbon) transition in the energy system, 'persistent problems' (Schuitmaker 2012), most notably 'carbon lock-in' (Unruh 2000), need to be considered and addressed in a holistic and coordinated manner. Finally, **niches** are viewed as 'protective spaces' where novel technologies and practices emerge (Geels and Schot 2007, Smith and Raven 2012), including experiments that demonstrate possibilities and drive learning. Where successful, these can be replicated or scaled up, thus, over time influencing and/or replacing the dominant regime. Niche experiments can be more socially-focused (e.g the array of 'transformative social innovations' examined by Haxeltine et al 2013), more technology-focused (renewable

[8] Again following (De Haan 2010, De Haan and Rotmans 2011), the term 'structures' is used to refer to the formal, physical, legal and economic aspects of functioning which restrict and enable practices; 'cultures' to the cognitive, discursive, normative and ideological aspects of functioning involved in the sense-making of practices; and 'practices' to the routines, habits, formalisms, procedures and protocols by which actors maintain the functioning of the societal system.

[9] As the energy function of society is so pervasive and fundamental (energy keeps us alive), we view an energy system as essentially synonymous with a 'sustainability transition' "radical transformation towards a sustainable society, as a response to a number of persistent problems confronting contemporary modern societies" (Grin et al 2010:1).

energy technologies) or policy-oriented (e.g. see Van Der Loo and Loorbach 2012). Examining the unfolding dynamics of niche development can enable capacities for niche formation (shielding), nurturing and empowerment to be examined, at different levels (Smith and Raven 2012).

Particular areas of niche experimentation clearly develop quite differently, require different types of support, and rely upon different mechanisms for learning, dissemination of knowledge and to build legitimacy. In order to understand such dynamics, we attempted to identify where capacities for change were needed in key technologies by using a framework based on the 'systemic instruments' approach (Weiczorek and Hekkert 2012, Weiczorek et al 2013) used as a 'fine-grained' diagnostic tool. We focused on bioenergy and electric vehicles (EVs), identified as 'exploratory projects' by NESC (2012), and in Low Carbon Roadmaps formulated by the Sustainable Energy Authority of Ireland (SEAI, 2010a,b, 2011a). Innovation systems analysis provides a heuristic attempt "to analyse all societal subsystems, actors, and institutions contributing in one way or the other, directly or indirectly, intentionally or not, to the emergence or production of innovation" (Hekkert et al 2007: 414). *Technological* innovation systems (TIS) analyses focus on specific areas of technological innovation. Analysis is conducted through examining processes or functions: entrepreneurial activities, knowledge development, knowledge dissemination, guidance of search, market formation, resources mobilisation, and creation of legitimacy that need to run smoothly for the TIS to perform well (ibid). Using the 'systemic instruments' approach (Weiczorek and Hekkert 2012), four structural dimensions: actors, institutions, interactions and infrastructure are considered for each function. Functions might fail due to the presence or capabilities of actors; the presence or quality of the institutional set up; the presence or quality of the interactions or the presence or quality of the infrastructure. Thus problems can be more precisely identified using sets of diagnostic questions that can be scored by policymakers, enabling policy instruments to be more accurately targeted (ibid).

There have been a number of attempts to integrate TIS and transitions approaches, for example Markard and Truffer (2008) and Weber and Rohracher (2012). These acknowledge the complementarity of the approaches in providing useful insights for policymakers. For Weber and Rohracher (2012), the innovation systems perspective offers important building blocks to explain transformative change, but needs to be complemented by elements from transitions approaches, to enable overall processes of transformation to be more clearly viewed. This provides a useful approach to combine and transcend insights [13] from innovation systems and transitions perspectives, in order to characterise a set of transformation systems 'failures' that can be used to assess or provide a justification for the provision of capacities to facilitate or drive transformative change. Failures include directionality failure (where innovation lacks sufficient vision, coordination, regulation or targeted resources to address specific societal challenges)[15]; demand articulation failure (to address user needs)[16]; policy coordination failures regarding the need for horizontal,

[13] These include the contribution of innovation systems approaches in providing rational justifications for policy intervention and system adaptation, and the contribution of transitions approaches in provide reflection and critical discussion about the formulation and set-up of goal-oriented system transformation policies.

[15] Weber and Rohracher define 'directionality failure' of a technological innovation system as comprising a number of components:

- the "lack of a shared vision regarding the goal and direction of the transformation process;
- Inability of collective coordination of distributed agents involved in shaping systemic change;
- Insufficient regulation or standards to guide and consolidate the direction of change;
- Lack of targeted funding for research, development and demonstration projects and infrastructures to establish corridors of acceptable development paths. "(2012:1045)

[16] User acceptance issues are considered by Wieczorek and Hekkert (2012) as part of the TIS legitimation function.

vertical and temporal policy co-ordination[17] and reflexivity failures, addressing capacities to monitor, anticipate and involve actors from different spheres in processes of self-governance, experimentation and learning. Here they cite 'hybrid forums' as useful, bringing

> "experts and laypersons together with legislators and citizens. [..] these serve as **coordination devices for collective sensemaking, imaginization and enactment** (Morgan, 1993; Weick, 1995). They also provide mechanisms for **translating complex and culturally embedded practices across contexts and communities through dialogue** (Sawyer, 2003; Tsoukas, 2009). "
>
> (Garud and Gehman 2012:989, emphasis added)

The agency (or self-perceived agency) of particular groups of regime or niche actors is an interesting factor to consider here. While providing *spaces* for deliberation and knowledge exchange by multiple stakeholders (including civil society) is an important element of participation, how power dynamics within the system work are equally important to consider: effectively, who gets to decide and the public accountability of decisions.

An MLP analysis for society-wide energy transition can be used to map unfolding transition dynamics through examining the interplay between levels such as the effect of landscape forces on the regime or on the formation of niches; through examining regime actors response to landscape forces; and on the relationships (competitive or collaborative) between regime and niche actors. Examining the composition of regimes and persistent problems, together with an account of landscape forces and niche activity provides a foundation upon which the presence or absence of conditions for regime change can be identified (Frantzeskaki and De Haan 2009, Loorbach and Rotmans 2010, De Haan and Rotmans 2011). This can also lead to the identification of possible transition pathways and expose inherent dangers[18](e.g. Smith et al 2005, De Haan and Rotmans 2011, Geels and Schot 2007). Geels et al (2016) provide useful examples of how these pathways can be influenced by landscape and regime characteristics that shape action possibilities. For instance, Germany had primarily a 'substitution' pathway where the fossil fuel regime was displaced through the existence of a strong and diverse group of niche energy actors, who exerted pressure on the regime. In the German case, broader landscape factors "created positive affordance structures for RET[renewable energy technology] -deployment by new entrants" (ibid: 910). These included a strong and organised civil society with active cooperatives, citizen groups, activists, and socially engaged scientists; a collaborative tradition for stakeholder interaction in a 'coordinated market economy'; a strong environmentalist tradition, including a strong Green Party at both Lander and National levels; substantial manufacturing sectors; and the creation of jobs and new industries (ibid). An additional factor in Germany, noted by Kivimaa and Kern (2016), was active regime 'destabilisation' through a social and political consensus on the phasing out of nuclear energy, in the wake of the Japanese Fukushima disaster.

By contrast, the UK has had a pathway that has involved existing actors, and RET deployment was more difficult due to societal structures preferring a "working with

[17] i.e. coordination between sectors, different levels of government / implementing agencies, or regarding appropriate timing of actions.

[18] For example, the dominance of landscape legislative forces could imply a "top down" externally imposed transition pathway with an inherent danger of backlash, evident, for example, in social acceptance issues arising from a national drive to comply with EU legislation, such as has been the case with wind energy and water charges in Ireland.

incumbents" pattern; and a top-down, autocratic political system, characterised by close-knit policy networks, which tended to be closed to new entrants, hindering broader stakeholder engagement. The UK pathway has also been shaped by the country's broader 'liberal market economy', characterized by a neo-liberal ideology that has framed a preference for market-based and non-technology specific policy instruments which also created barriers for new entrants. In contrast to Germany, the UK has had a weaker civil society, particularly in the energy domain; and a weaker environmental tradition than Germany (Geels et al 2016). In the case of the UK, Kusemko et al argue that a "reasonably dominant ideological commitment to placing markets rather than government at the center of delivering policy objectives such as energy security and/or sustainable energy system change" has contributed to relative inertia in energy governance (2016:99). Their work raises the need for a deeper examination of how domestic political institutions and historical energy infrastructures influence change[20], and they stress the need to be precise about the "domestic political context within which processes of governing for sustainable change take place" (ibid:104). Certain of these characteristics can be assessed using the MLP and aspects of Weber and Rohracher's 'failures' framework, but also raise the need for analysis incorporating the broader political context for transition (Kusemko et al 2016).

3. Methodology

Following the above considerations, we adopted the MLP as a broad structuring device for an analysis of the Irish energy system. This included landscape forces, the geopolitical context, persistent regime problems, the diversity and spread of niches, and the development of particular niche areas. The framework based on the TIS systemic instruments approach described above (Weiczorek and Hekkert 2012) was also used to drive further data gathering on bioenergy and electric vehicles, two technologies identified as exploratory projects by the National Environmental and Social Council (NESC 2012). As this was primarily a desk-based study, most research was done using documentary sources. These included academic papers; 'grey' literature such as newspaper articles, government documents, national and international reports; web-based material and online databases (e.g. Eurostat, IEA policy databases). Sources also included a report from a collaborative weekend workshop attended at the Cloughjordan eco-village aimed at accelerating change in transition towards community energy in Ireland, and attended by a diverse range of community energy actors. We also interviewed a small number (12) of relevant actors including policymakers (in innovation and energy), industry actors (small and large scale biomass, renewable energy agencies, electric vehicles) and NGO and civil society actors.

We hosted two workshops, the first for researchers and the second a mix between policymakers other civil society/NGO and industry actors, where we posed a series of questions for discussion. These had two purposes – firstly, to act as pilot 'spaces for reflection', providing opportunities for network formation and knowledge exchange where groups could meet and reflect on energy transition challenges from a range of perspectives; and as a further source of qualitative data, as groups reflected on particular questions. Informed by examples in and insights from the transitions literature (e.g. Roorda et al 2015, Schuitmaker 2012), the first workshop was aimed at bringing Irish transitions researchers together to explore how insights from diverse perspectives could be brought to bear on the challenge of energy transition. This included a broad mapping of the Irish energy system, identifying key actors at different levels (see Fig 1) and a reflection on persistent problems in the Irish energy system. Using a simple back-casting exercise, the workshop also explored

[20] For example, countries such as Denmark demonstrate how public participation has shaped society-wide energy transition (Lockwood 2015).

potential quantitative and qualitative benchmarks for monitoring how Ireland is moving towards transition. The second workshop explored other perspectives on the Irish energy challenge, drawing on the insights from key policy-makers. This included a reflection on persistent problems and on the capacities (existing, or requiring re-orientation or creation) to address these.

4. Energy Transition in Ireland

4.1 Carbon Lock-in: Challenges and Opportunities

The extent of carbon 'lock-in' in Ireland is evident in its high dependency on imported fossil fuels, primarily in transport but also in heating/cooling and to a lesser extent in electricity production. Factors such as high car dependence, a scattered rural population and poor public transport have contributed to the fact that in 2014, the transport sector was responsible for the largest share of final energy consumption (42%) and the largest contributor to energy-related CO_2 emissions (37%) (SEAI 2015a, see also Heisserer and Rau 2015). Most domestic heat is via single-household oil boilers, and lack of district heating infrastructure renders change challenging, although there are more immediate possibilities for the use of biomass in industrial heating systems (ibid). Ireland's forestry cover has greatly increased in recent years (DAFM 2014) and this, if care is taken to ensure sustainable use (Mc Cormack 2015, Coford 2014), can provide an additional source of heating energy and create rural employment (SEAI 2015c). Whilst agricultural emissions are expected to increase due to an expanded dairy production (EPA 2016), this does create opportunities for biogas, although this in itself is not without problems.

Ireland's location is well disposed for the development of wind and marine energy, particularly wave energy[21]. Wind generation capacity in the island of Ireland grew from 145 MW at the end of 2002 to 2,825 MW in December 2014 (Eirgrid 2015). Renewable generation[22] accounted for 22.7% of gross final electricity consumption in 2014, most of this from wind[23] (SEAI 2015a:47). Ireland now has the fourth highest wind capacity per capita in the world (REN21 2016:21), but this rapid growth has raised social acceptance and legal issues (NESC 2014, Barrett 2015). The provision of grid infrastructure involves developing monitoring and management capabilities and experimentation with future scenarios and system performance issues raised by customer-driven demand side management and increased use of volatile renewable energy sources (Eirgrid 2015). Here Ireland provides a useful test-bed for Europe, as it has a largely independent grid system coupled with a strong indigenous research capacity in ICT.

4.2 Landscape

As a small open economy and an island on the edge of Europe with a high degree of dependency on imported energy sources, Ireland is particularly vulnerable to global oil and gas price and availability, an issue flagged up many years ago by a Forfas report (Forfas, 2006). Being an island, imported and exported goods need to be transported via air or sea, compounding this vulnerability, as costs of imported and exported goods in Ireland's economy are largely dependent on the price of oil. Ireland's electricity system is highly reliant on the import of gas, mostly via one terminal in Scotland (SEAI 2016a) and electricity

[21] This is at a relatively early stage of development, but there are a number of research centres exploring this e.g. MAREI, University College Cork and the Marine Institute.
[22] Mostly from wind, hydro, landfill gas, biomass and biogas.
[23] In 2015, 24% of all electricity generated in Ireland was from wind, according to IWEA http://www.iwea.com/_windenergy_onshore

systems in Northern Ireland and the Republic of Ireland are highly inter-dependent[24]. Ireland is required to comply with EU renewable energy (heat, transport and electricity) and GHG emissions targets. To enable 2020 renewable energy targets to be met, a series of accelerated actions need to be taken (SEAI 2016b) and 2020 targets for emissions reduction are unlikely to be achieved even with additional measures being taken, mainly due to projected increases in agricultural (47%) and transport (29%) emissions (EPA 2016). Identifying and addressing the root causes of the need for accelerated effort to meet energy targets, and failure to meet emissions targets requires deeper reflection on the existing state of the energy system. As energy and climate governance becoming increasingly intertwined, questions also arise regarding the compatibility or coherence of policies driving emissions reduction (in energy) whilst driving emissions increase (in agriculture[25]).

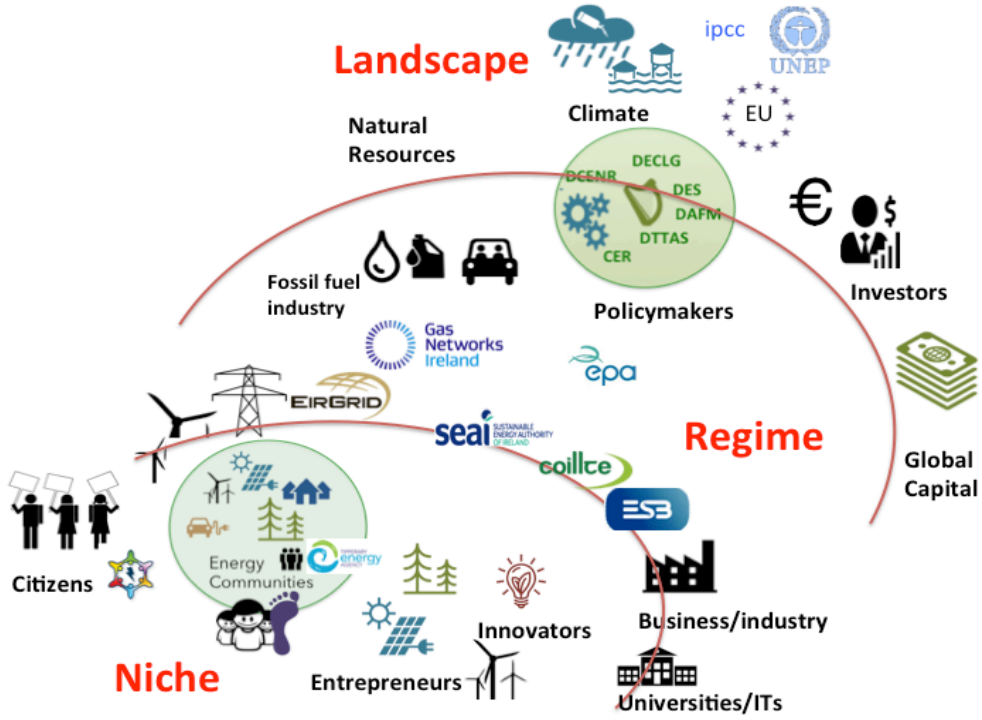


Fig 1 An outline schematic of the Irish energy system compiled from Workshop 1 showing actors at different levels.

4.3 Regime

> "Unravelling persistent problems reveals the structural properties of regimes through which enduring problems are reproduced, and thus how resistance to system innovations or transitions manifests itself on the actor level"
>
> (Schuitmaker 2012:1030).

[24] These vulnerabilities have been highlighted by Britain's vote to exit from the EU, prompting immediate response from the Irish Climate Minister, and raise the need to consider capacities within the energy system for the anticipation and assessment of risk and contingency planning. [http://www.merrionstreet.ie/MerrionStreet/en/News-Room/Releases/Statement_from_Denis_Naughten_T_D_Minister_for_Communications_Energy_and_Natural_Resources.html [statement released on 24-6-2016, accessed 28-6-2016]

[25] This has been (controversially) considered by the EU in reduced 2030 targets, 30% reduction by 2030, which is less than other states. This has been widely criticizes by environmental groups in Ireland and by the Catholic Church[http://ec.europa.eu/ireland/news/ireland-s-eu-2030-emissions-targets-published_en]

Taking a broad view of the energy regime, key actors (identified in literature and workshops) include government agencies, the electricity production companies, the TSO (Eirgrid), ESB networks, the state forestry company (Coillte), fuel companies and car manufacturers, the media, the education system and the general public. Sustainable Energy Agency (SEAI), the state renewable energy agency, is the main actor responsible for driving, monitoring and seeking possibilities for change, primarily through supporting the development of renewable energy technologies, but also through awareness raising, education and supporting energy communities. For example, the urgent need to meet targets, highlighted by the EPA above, has been addressed through the identification of a series of accelerated actions (SEAI 2016b).

Following Schuitmaker (2012) an attempt was made to 'unravel' persistent problems in the regime in order to provide a more fundamental picture of what was inhibiting change, through the workshops and interviews. The most fundamental problem identified was a lack of awareness and engagement by the general public: "we are not even talking about these issues", as one workshop participant put it. Furthermore, a poll conducted by SEAI[27] at the time of the COP21 negotiations showing that only 49% of people surveyed believed that climate change is a serious problem. The survey also highlighted a significant underestimation of the contribution of the residential sector to energy related emissions. Reflecting this, in the lead up to the 2016 election there was a call by academics for a citizens convention to address issues such as climate change and decarbonisation of the energy system[28], climate change being described by one newspaper as 'the elephant in the room"[29]. Lack of public awareness was also reflected in political party manifestos- a survey of party policies in the lead-up to the 2016 Irish general election showed large variations in terms of detail and commitments[30]. A related issue was a breakdown of trust in Irish institutions, manifest through major social acceptance issues in large scale wind installations and grid expansion projects[31]. Two major factors were seen as contributing to this: 'top down' imposition of change on communities where there was inadequate public consultation and participation in decision-making, and a lack of 'trusted information'. Some policy actors also commented on the prevalence of mis-information.

Workshop participants made regular links between these problems and deficiencies in the education system. Although exceptions clearly exist, there was believed to be low levels of carbon and energy literacy and the need to educate for active citizenship through 'life-long learning'. The lack of state commitment to education for sustainable development (ESD) is evident in the fact that the publication a national strategy was delayed until 2014 (DES 2014), despite the fact that an imperative to create this (the UN Decade of Education for Sustainable Development) had existed since 2005. A lack of basic skills-training was also cited; although there has been some work done in this area (e.g. DTI 2009, DJEI 2013). Other contributory factors included the way that climate change has been addressed in the national media: both through a general lack of coverage[32] and through rules for balancing opinion in national media that did not reflect the weight of scientific evidence[33]. Research on

[27] This also showed a significant underestimation of the contribution of the residential sector to energy related emissions. http://www.seai.ie/News_Events/Press_Releases/2015/Only-half-of-citizens-convinced-that-climate-change-is-a-serious-problem.html

[28] http://www.irishtimes.com/news/politics/election-2016-citizens-convention-urged-on-climate-change-1.2532909

[29] Irish Times editorial: http://www.irishtimes.com/opinion/editorial/election-2016-the-elephant-in-the-room-1.2545746

[30] http://www.irishtimes.com/news/politics/ge16-which-parties-have-best-climate-change-policies-1.2545875

[31] This is also reflected in protests against water and waste charges.

[32] An exception being the series of Eco-eye programmes : www.earthhorizon.ie

[33] This, for example was believed to have led to a disproportionate representation of climate skepticism in Irish media.

Irish print media has found that policy-driven, economic arguments on carbon reduction are privileged with more 'socially-relevant' conceptualisations marginalised (Mc Nally 2015).

The growth of 'individualisation' was also identified. A point raised by some actors was that this was exacerbated through the dominance of neoliberal forces in the global economic landscape and the market orientation of society in general. This dominance has led to individual habits of consumption that do not factor in 'sufficiency'; and a largely individualistic society, where skills and models for cooperation and sharing are being eroded and 'forgotten'. These include the communication and conflict resolution skills for the 'social learning' needed to build resilient communities. These skills are also essential elements of Education for Sustainable Development (ESD) and 'green republican' and 'agonistic/contestatory' notions of citizenship and policy-making (Barry and Ellis, 2010). Some viewed the fact that economics, rather than society or environment had become the principal driving factor in policymaking, as a particularly persistent problem. Under-pricing of carbon was also noted as an issue. Individualisation was also linked to infrastructural problems, resulting through dispersed housing patterns and "rural and urban sprawl". This has contributed to fragmented services, dependence on the private car for transport[34], and the lack of more communal (e.g. District Heating) infrastructures for heating, rendering changes in heating mode more difficult.

Regarding policy, a lack of policy coherence (in particular regarding agricultural policy) was cited, despite the fact that many policy areas do reflect the need for low carbon transition to a certain extent [35]. Inconsistencies in energy policy, such as the issuing of gas and oil speculation licenses, despite commitments given in the Energy White Paper and the climate bill, were also noted. The need for structures to enable policy integration, and evaluation of all policies with respect to climate targets were observed, and the need for cross-cutting measures and a cross-sectoral approach. The 'siloe-ed' nature of government departments was also mentioned. However, in the experience of one actor interviewed (who "always gets asked about this"), policymakers often work together at all levels in cross-departmental committees. A further workshop participant stressed that thinking of government as monolithic is inappropriate, observing that: "some get it, and some don't", that there are niches within policymaking, alliances of actors, and the ability by some to recognise opportunities emerging in the external environment. This can be seen in the acknowledgement in the national innovation strategy of the need for government-wide approaches to address major societal challenges (DJEI 2015), and in earlier civil service reforms. A final issue identified was **'**short term-ism' in decision-making, particularly in finance, raising the need for a 'societal license' to legitimise planning for activities over longer timeframes, transcending individual governments.

4.4 Niche

Fig 2 illustrates the growth of renewable energy technologies in Ireland[36]. Two 'niche' technologies, bioenergy and electric vehicles(EVs) were examined in more detail. As explained above, these were explored using a framework based on the 'systemic instruments' approach (Weiczorek and Hekkert 2012, Weiczorek et al 2013). When

[34] Although these now emit less CO_2, due to a shift from petrol to diesel catalysed by the (arguably successful) banding of motor tax in 2008, it has been argued that this has now created a new "diesel lock-in" that has its own inherent problems.
[35] In addition to energy and climate policies, these include innovation and enterprise strategies that acknowledge the need to address 'society wide challenges (DJEI 2015) and transport policy [see www.smartertravel.ie].
[36] As discussed above, there has been a rapid expansion of wind energy. There is a small offshore wind industry (5 companies) but to date only one operation has begun construction, mainly due to planning and licensing issues[36]. Other renewable sources include hydropower (there has been an 18% increase in hydro-electricity generation, but this varies annually with rainfall SEAI 2015a), geothermal energy and bio-energy.

considering society-wide transition to a low or zero carbon energy system, both the context of use of these technologies and other social innovations driving systemic change also need to be considered and examples of these are also discussed below.

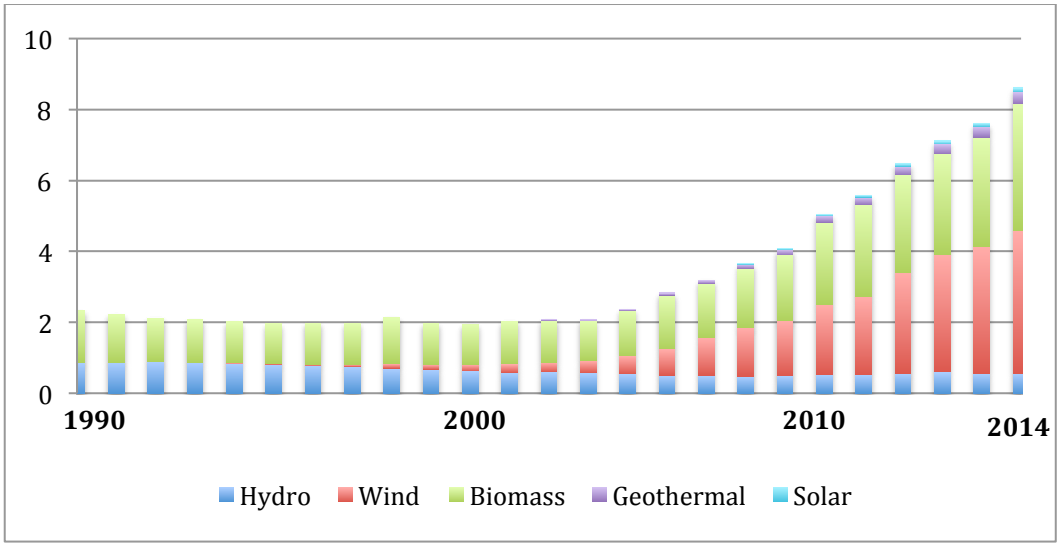


Fig 2: Renewable energy contribution as a % of gross final energy consumption (SEAI 2016)

4.4.1 Bioenergy

As bio-energy is a diverse and complex area covering a wide range of processes, supply chains and technologies, we focused on biomass (small and large-scale use of wood energy), and biogas. Ireland has had a relatively strong research base in bioenergy, there is a draft bioenergy strategy (DCENR 2014) and the area is well networked (Biobase 2015) with two main (related) industry organisations: Irbea[38] and Cré[39] (covering Anaerobic Digestion and composting). These act as advocates, build legitimacy, disseminate knowledge and support entrepreneurs. In solid biomass for industrial heat, the state forestry company, Coillte is a key player. There is also a network of private forestry owners spread out across the country who provide smaller scale and local heating solutions. Examples exist where woodland co-operatives, county councils and regional development groups have worked together to drive entrepreneurial activity at a local scale (DCC 2010). The potential role of bioenergy in contributing to the rural economy has also been identified by SEAI(2015c) .

Biomass boilers and CHP have been identified as instrumental in meeting Irish 2020 RES-H targets. In order to achieve this, 300,000 homes, 3,000 services/public sector buildings or 200 large industrial sites would need to install renewable heat options such as biomass boilers, solar thermal, or biomass CHP systems before 2020 (ibid:4). However, a major barrier to further development of industrial biomass use for heat has been uncertainty for investors as a result of delays in a renewable heat incentive (RHI), due at the end of 2016, and expected to be focused on industry. User acceptance and technical issues regarding domestic biomass boilers (SEAI have withdrawn grants for these) have raised the need to build evidence and skills bases. Given the scale of uptake required and the time required for new installations, it is highly unlikely that heat targets will be met (Coillte 2015). Whilst there are no significant major social acceptance issues with biomass plants, the forestry resource needs to be carefully and sustainably managed (Coford 2015, Fitzpatrick 2015) and

[38] www.irbea.ie
[39] www.cre.ie

increased provision of training, particularly for private forest owners, and further development of producers groups and local networks are believed to be key to this (DAFM 2014). The biogas industry is beginning to take off despite earlier barriers (Fitzduff 2014) but social acceptance issues are also beginning to emerge, particularly for larger plants, and these, as well as infrastructural issues (Murphy 2015), need to be addressed if biogas is to expand (as envisaged in agricultural policy). For small scale producers such as for CHP plants, a number of barriers to grid access have emerged, such as competition for grid access with solar projects.

4.4.2 Electric Vehicles (EVs) in Ireland

According to SEAI (2016b), an increased uptake of EVs is needed as part of an accelerated effort to meet 2020 (RES-T) transport targets, and they believe that with added supports and demonstration projects, adoption rates could be further encouraged. In the view of industry actors, Ireland has an EV infrastructure with a good diversity of charger types and high rate of chargers per head of population. There is a small, but strong research base in EVs and smart grid, involving universities, car manufacturers, ICT companies and statutory agencies (including EU projects and other international collaborations). However, despite this, adoption of EVs in Ireland has been very slow. Only 562 electric cars were sold in 2015, 0.23% of new car sales (SEAI 2016b:6). A number of problems have contributed to this, but the main one relates to user acceptance. There is a poor public perception of EVs (though this may be changing), 'range anxiety' (Morrissey et al 2016a,b)– possibly due to the (perceived) extent of the charging network, and less choice of vehicles than in mainland Europe[41], including second hand vehicles. Actors in the industry have thus argued for a strong longer-term policy vision and cite the short-sighted nature of Irish politics as a barrier to change. The Government is currently formulating a vision and convening a high level Working Group on EVs.

4.4.3 Conclusion

These pilot studies, structured using the TIS/ systemic instruments approach, helped identify where barriers existed, action might be needed or future problems might arise. Using this framing also exposed where data was lacking, and where further research might be needed. Earlier work that had adopted this approach to structuring a review of literature (Curry et al 2016) enabled an international comparison of response to challenge . However too strong a focus on technology can obviate other possible contributions in addressing and approaching energy system transition. For example, due to the heavy reliance on the private car in Ireland, the assumption is sometimes made that electric vehicles will act as a primary driver of low carbon transition in transport. Thus, government response to the need to meet transport targets has been somewhat limited, as articulated by the (new) energy and climate minister:

> "Transport is going to be a huge challenge for us [..]Until the technology is developed for e-cars to be extensively available, there is not a lot we can do about it. The biofuels commitment will deal with a certain part of it." [42].

This is despite the fact that a *mobility* transition could involve diverse and interlinked change processes at different scale levels, such as modifications in planning practices, enhancement

[41] As Ireland is right-hand drive, it does not have access to the same range of cars that are available in other European countries.

[42] : the new energy and climate minister, Denis Naughten quoted in the Irish Times 20-6-16 [http://www.irishtimes.com/news/politics/ireland-won-t-throw-towel-in-on-climate-targets-says-naughten-1.2691362]

of school transport systems, community lift sharing, or a broader 'modal shift' from car to public transportation, cycling and walking, all of which are within the control of diverse sets of actors.

4.5 Socio-technical and Social Niches

There are many international examples of the use of transitions approaches at city, regional ('smart sustainable districts') or community scale levels[43], which provide insights into how collaborative processes can be used to address local challenges in innovative ways. These involve the use of transitions approaches at city, regional or community scale levels (e.g. Roorda et al 2015, Roorda and Wittmayer 2014, Nevens et al 2013, SRTP 2015[44]). In Ireland there are a diverse (and growing) range of community energy projects. Many of these are incentivised by SEAI who provide a range of financial supports and have established a 'sustainable energy community' (SEC) network to enable knowledge sharing and mentoring. Energy communities include Inis Mór (the largest of the Aran Islands), who aim to be fossil fuel free[45] by 2022, and a number of local authorities, such as Dun Laoghaire and Rathdown in the greater Dublin area. There are also innovative organisations with more socially oriented business models such as community energy cooperatives (e.g. Templederry Wind Farm); and social enterprise businesses to support energy communities (e.g. Tipperary Energy Agency who provide advice, audits, project management in addition to technical installation services). However despite this well-networked, dynamic (and growing) community energy sector, many barriers still exist, including difficulties with grid access, financial viability, and support structures (FOE 2014). Two niche experiments were examined in more detail and these specifically addressed some of the persistent problems identified. The first, Cultivate, provides learning capacities for transition including reflective spaces for collaboration and facilities for knowledge exchange; and the second demonstrated a grassroots response to social acceptance issues raised through large-scale wind developments (the People's Energy Charter -PEC).

Cultivate[47] (an NGO established in 2000) works to develop sustainability in Ireland through education, action, networking and facilitating dialogue. Initially based in Dublin, it played a key role in developing the Cloughjordan eco-village[48] (Kirby 2014). A key aspect of the village project is that transition is not only demonstrated through using technologies to lower GHG emissions, but also through building community resilience and aiming to enhance the quality and vibrancy of community life. As such, governance has been important, and work on this has included the development of an approach aimed at enhancing coherence, connectivity, communication and reciprocity in the community (ibid). Over the years, Cultivate have hosted many facilitated events linking diverse actors in deliberation and discussion of sustainability-related questions. In 2016, a series of 'transitions accelerators' (in community energy, food and social justice) were held to bring pioneers together to enable reflection,

[43] Climate-KIC - Knowledge and Innovation Communities (KICs) created in 2010 by the European Institute of Innovation and Technology (EIT) www.climate-kic.org . ARTS Project : http://acceleratingtransitions.eu : Stockholm (Sweden), Brighton (UK), Genk (Belgium), Budapest (Hungary) and Dresden (Germany).

[44] Climate-KIC - Knowledge and Innovation Communities (KICs) created in 2010 by the European Institute of Innovation and Technology (EIT) www.climate-kic.org
ARTS Project : http://acceleratingtransitions.eu : Stockholm (Sweden), Brighton (UK), Genk (Belgium), Budapest (Hungary) and Dresden (Germany).

[45] http://www.aranislandsenergycoop.ie

[47] www.cultivate.ie

[48] www.thevillage.ie : Cloughjordan was established in 2009 with a primary objective to "demonstrate truly sustainable development, in as holistic a way as practicable, in order to serve as a model and an educational resource for Ireland" (Kirby 2014). Cloughjordan is a member of the Global Ecovillage Network (GEN) and it and Cultivate are involved in a number of European projects.

knowledge exchange and mutual learning, including the identification of barriers to change and potential ways of addressing these.

A core principle in the formation of the PEC was the need for public participation in energy decision-making, and this grassroots initiative involved people who saw the need for a community-led (rather than externally imposed) energy future. Networking with other environmental and energy groups, and working through the Environmental Pillar (who sat on the NESC, where government departments were also represented), arguments were made for more extensive and inclusive policy consultation in the lead up to the Energy White Paper. This provided a demonstration of where structures that could enable levels to be linked played a valuable role in enabling persuasive niche actors to provide input into policy. In this case, the need to address social acceptance issues, coupled with an energy minister "who listened", effectively resulted in a 'stretching and transforming' (Smith and Raven 2012) of the policymaking process, as a much more extensive and inclusive consultation process was conducted. However, whilst progress on participation was undoubtedly made in the publication of the Energy White Paper, implementation details are lacking, there has been a change in government[49], and, as noted by one niche actor, much more extensive capacities are needed if truly inclusive participation is to be achieved.

5. Capacities for Change

To explore what capacities might be needed to address persistent problems identified, we examined categories of 'transformation system failure' described by Weber and Rohracher (2012), focusing on directionality, reflexivity and policy coordination. In Ireland, whilst the Energy White Paper (DCENR 2015), Climate and Low Carbon Action Bill (DECLG 2015), and other policies such as Innovation2020 (DJEI 2015) have set a broad *direction* for change, they lack implementation detail, including how "active engagement of Ireland's citizens, communities, businesses, academics and experts, and local and national State agencies" (DCENR 2015:7) in the decarbonisation of Ireland's energy system, might be achieved. Capacities for foresight, though these do exist to an extent [50], are also required due to Ireland's particular vulnerability to landscape forces that raise the need to take a much longer-term view of energy choices. Particular issues highlighted by actors interviewed and workshop participants in our study, such as lack of trust, awareness and knowledge, also raise the need to identify where governance capacities to incorporate participation, reciprocal communication and learning could be improved or created.

Weber and Rohracher cite the importance of *reflexive arrangements* (Hendriks and Grin 2007) for interconnecting overlapping arenas of public discourse, creating new "interfaces between existing innovation policy arenas and other types of policies, actors and discursive spheres [51] " (2012:1041). Social niches examined above demonstrate how particular interfaces have been used or created in the Irish context. In particular, the PEC case illustrated the effective use of networking amongst diverse 'niche' actors, and of structures enabling communication across levels. Dialogue and how it is structured are important here and the work of organisations such as Cultivate demonstrate the use of 'social technologies'

[49] Where the minister lost his seat.

[50] There is a strong well-networked research base in energy modelling (Finn 2012) in Irish universities and in the SEAI, and good relationships between academics and energy policymakers. Research on the Consensus project has included work on foresight techniques to envisage future sustainable social practices (Davies et al 2013). The TSO, Eirgrid, also have a scenario planning department to enable future scenarios to be envisaged, enabling the building of resilience in the electricity network.

[51] Reflexivity failure is defined as "the ability of the system to monitor, to anticipate and to involve actors in processes of self-governance" (Weber and Rohracher 2012: 1044)

in the creation of deliberative spaces for the reflection and knowledge exchange needed to drive society-wide sustainability transition. Informed by examples in the literature (e.g. Roorda et al 2015), the workshops held by CCTransitions, the second involving policymakers and civil society actors reflecting on persistent problems and capacities to address these, have provided useful templates to enable issues to be explored from diverse perspectives and knowledge to be exchanged.

The need for policy *co-ordination* – both in terms of communication between departments, and in the implementation of policies at local levels was also identified in workshops and by actors interviewed. Where capacities for horizontal, vertical and temporal co-ordination of policies (Weber and Rohracher 2012) could be built on or created were also identified. One suggestion made was 'climate-proofing' processes for policies. The need to consider the overall 'policy mix' was also acknowledged. This is described by Kivimaa and Kern (2016) as a combination of creative innovation and energy policies with measures aimed at 'regime destruction', such as carbon taxes to dis-incentivise the use of fossil fuels. A further suggestion made was an extension of Public Participation Networks, established in 2015 to improve links between civil society and local government, to cover energy issues. However more extensive mechanisms to enable participation were also believed to be needed, to ensure that people living in rural areas, single parents or people with restricted mobility could also be included in governance processes. Organisations such as SEAI, energy agencies, NESC and the environmental pillar also work (or could work) to implement or inform policy or provide information at different levels. However, the need for more extensive and locally accessible support (such as that given by Community Energy Scotland[53]) was also cited to further enable the development of community energy projects.

6. Conclusion

The frameworks we used provided us with a useful range of perspectives with which to view the Irish energy system, each having value in bringing certain issues into focus. To provide finer-grained insights for policymakers where a clear aim of driving the development and diffusion of a particular technology has been established, the TIS-based 'systemic instruments' approach provides a useful framework for analysis, enabling the identification of barriers, benchmarks and indicators. Using this approach, however, the dominant focus on technology can shift attention away from other broader societal change processes needed for low carbon energy system transition. The MLP proved useful in characterising this broader context for change: landscape forces; persistent issues that may shape responses to these; and innovative social and sociotechnical experiments explicitly addressing the need for socio-energy transition and transformation (Scoones, Leech and Newell, 2015). It also had utility in mapping the interplay between levels and describing the dynamics of change processes, including where these are enabled or blocked. This provided examples of how change could be catalysed by interlinked networks of actors, operating at different levels.

In order to more specifically address particular issues exposed by this analysis, such as the need to engage citizens in energy transition, additional theoretical input was required[55]. Transformation systems failures (Weber and Rohracher 2012) provide a useful set of heuristics to identify and assess capacities for foresight, direction, coordination, reflexivity and participation. These begin to address aspects of the deeply political nature of sustainability transitions, through enabling deeper consideration of how socio-political

[53] http://www.communityenergyscotland.org.uk
[55] See Barry et al (2015).

capacities to enable society-wide energy transition can be operationalised in a reflexive manner, including those for public participation, education and citizen engagement. Provision of such capacities, as SPRU have suggested, would involve a structural transformation in arrangements between the state, the market, civil society and science to include space for experimentation and societal learning, a more constructive role for foresight and the development of new types of trans-disciplinary knowledge (SPRU 2016:4).

Irish experience with wind energy, water charges and waste in Ireland has demonstrated the danger of backlash and "lock-in" to unsustainable practices engendered through poorly conducted or undemocratic processes. Such backlash raises the danger of "unintentional transition" (Hodbod and Adger 2014) where Ireland's energy regime could be subject to unplanned, externally imposed and radical change[58], due to its particular vulnerabilities to external forces, as discussed above. To avoid this and, more importantly, to fulfil Ireland's global responsibilities, our study suggests a need to more deeply consider, through active processes of experimentation and learning, how and where capacities for change can most be effectively be built (or enhanced) in what will most likely be highly messy processes of social (and technical) learning and innovation.

References

Biobase (2015) *The Irish Bioeconomy Factsheet*, Biobase 2015, [accessed http://www.biobasenwe.org/media/95578/BBNWE-Factsheet-IE_Sept15_Final.pdf 17-4-2016]

Barrett Eva (2015), '"In Sowing the Wind How Ireland Could Reap the Whirlwind" - A Case Against Irish Wind Development(s)' (2015) 33 Journal of Energy and Natural Resources Law 1, 59 –81.

Barry, J. and Ellis, G. (2010), 'Beyond consensus? Agonism, contestation, republicanism and a low carbon future', in Devine-Wright, P (ed), Renewable Energy and the Public: From NIMBY to participation. (London: Earthscan), pp. 29-42.

Barry, J., Hume, T. Ellis G, Curry R. (2015) *Society Wide Transitions*, CC Transitions Working Paper 1, [available online https://www.qub.ac.uk/research-centres/TheInstituteofSpatialandEnvironmentalPlanning/Impact/CurrentResearchProjects/CCTransitions/ProjectOutputs/]

Carragher Vincent, Moles R. O'Regan B. (2011) Development of a Community-Based Ecological Footprint, EPA, [accessed

http://erc.epa.ie/safer/iso19115/displayISO19115.jsp?isoID=3024 22-7-2016]

Cloughjordan (2016) *Proceedings of a workshop on Catalysing Community Energy: Harvest Document*, Cloughjordan Ecovillage and Cultivate (2016).

Coford (2015) *Mobilising Ireland's Forest Resource,* Coford Wood Mobilisation Group, Department of Agriculture, Food and the Marine Dublin 2015 [accessed http://www.coford.ie/media/coford/content/publications/projectreports/Mobilising%20Irelands%20forest%20resources%20-%20Digital%20March2015.pdf 17-4-2016]

Coillte (2015) *Renewable Heat: A lost Opportunity?* , Des O'Toole, Business Development Manager, Coillte blog, [accessed www.coillte.ie 17-1-2016]

CSO(2011) *Census 2011: Town and Country* , Central Statistical Office, Ireland [accessed online http://www.cso.ie/en/media/csoie/census/documents/census2011vol1andprofile1/Profile1_Town_and_Country_Entire_doc.pdf 17-4-2016]

[58] A fairly obvious example here would be oil or gas shortages – though these aren't exactly unpredictable.

Curry R., Hume, T. Ellis G, Barry, J. (2016) *Barriers, Incentives, Indicators*, CC Transitions Working Paper 3,[available online https://www.qub.ac.uk/research-centres/TheInstituteofSpatialandEnvironmentalPlanning/Impact/CurrentResearchProjects/CCTransitions/ProjectOutputs/]

Davies, A., Fahy, F., Rau, H., Devaney, L., Doyle, R., Heisserer, B., Hynes, M., Lavelle, M.J. and Pape, J. (2013) CONSENSUS: Consumption Environment and Sustainability EPA, Dublin.

Deane, P. et al., 2013. Technical support on developing low carbon sector roadmaps for IrelandLow Carbon Energy Roadmap for Ireland. , (021), pp.1–125. Available at: papers2://publication/uuid/CE7C43F1-5449-4120-9C71-AB63D8680D4B.

DAFM (2013) *Forests, products and people: Ireland's forest policy – a renewed vision*, Forest Service, Department of Agriculture, Food and the Marine, Government of Ireland 2015

DAFM (2014) *Forestry Programme 2014 – 2020: IRELAND* , Forest Service, Department of Agriculture, Food and the Marine 28/11/2014, Ref: IRL-DAFM-FS.022

DAFM (2014b) Ireland's Forests Annual Statistics, Forest Service, Department of Agriculture, Food and the Marine, 1/11/ 2014

DAFM (2015) *Foodwise 2025*; Department of Agriculture, Food and the Marine, Government of Ireland 2015

DCC(2011) *Development of the Green Economy in County Donegal*. Donegal County Council, April 2011

DCENR (2010) *National Renewable Energy Action Plan*, Department of Communications, Energy and Natural Resources, Government of Ireland 2010 [accessed http://www.dcenr.gov.ie/energy/en-ie/Renewable-Energy/Pages/Action-Plan.aspx 17-4-2016]

DCENR (2014) *Draft Bioenergy Plan*, Department of Communications, Energy and Natural Resources, Government of Ireland 2014

DCENR (2015) *Energy White Paper*, Department of Communications, Energy and Natural Resources, Government of Ireland 2015

DECLG (2012) '*Our Sustainable Future: A Framework for Sustainable Development in Ireland*, Department of the Environment, Community and Local Government, Government of Ireland 2012

DECLG (2015) *Climate Mitigation and Low Carbon Development Bill*, Government of Ireland 2015

De Haan, J. & J. Rotmans(2011) 'Patterns in Transitions: Understanding complex chains of change.' *Technological Forecasting & Social Change* 78: 90-102.

DES (2014) *Education for sustainability: the national strategy on education for sustainable development in Ireland 2014-2020*, Department Of Education and Skills , Government of Ireland 2014, [accessed http://www.education.ie/en/Publications/Policy-Reports/National-Strategy-on-Education-for-Sustainable-Development-in-Ireland-2014-2020.pdf 24-6-2015].

DJEI (2012) *Delivering our Green Potential*, Department of Jobs, Enterprise and Innovation, Government of Ireland, Dublin 2015

DJEI (2015) *Innovation2020 : National Innovation Strategy*; Enterprise2025; Department of Jobs, Enterprise and Innovation, Government of Ireland, Dublin 2015

DTI (2009) *Developing the Green Economy in Ireland*, Department of Trade and Industry , Government of Ireland 2009 [accessed www.forfas.ie 8-8-2015]

Eirgrid (2015) *ALL-ISLAND Generation Capacity Statement 2015-2024* , Eirgrid group [accessed http://www.eirgridgroup.com/site-files/library/EirGrid/Eirgrid_Generation_Capacity_Statement_2015.-2024.pdf , 17-4--2016]

Ellis G, Hume, T., Curry R Barry, J. (2016) *Case Studies of Technologies in Ireland*, CC Transitions Working Paper 2,[available online https://www.qub.ac.uk/research-centres/TheInstituteofSpatialandEnvironmentalPlanning/Impact/CurrentResearchProjects/CCTransitions/ProjectOutputs/]

EPA (2016) *Greenhouse Gas Emissions Projections to 2020: An Update*, Irish Environmental Protection Agency 2016, [accessed http://www.epa.ie/pubs/reports/air/airemissions/2020_GHG_Projections_2016_Bulletin.pdf 16-4-2016]

Finn, C. (2012) *Modelling the Long Run Transition to a Low -Carbon Economy: The Contribution and Limitations of Model and Roadmaps*, Background Paper No. 4 for the NESC report on Irealnd and the Climate Change Challenge, NESC, Dublin.

Fitzduff, Kevin and Burke, Morgan (2014) Opportunities and challenges of developing anaerobic digestion. *Engineers Journal*, 1/9/2014 [accessed online http://www.engineersjournal.ie/2014/09/01/opportunities-challenges-developing-anaerobic-digestion/ 16-4-2016]

Fitzpatrick John J (2015) 'Environmental sustainability assessment of using forest wood for heat energy in Ireland', *Renewable and Sustainable Energy Reviews* 57 (2016) 1287–1295

FoE (2015) *Community Energy*, Friends of the Earth, 2015, [accessed

http://www.foe.ie/download/pdf/executive_summary_community_energy_leaflet.pdf

Forfas (2006), A Baseline Assessment of Ireland's Oil Dependence: Key Policy Considerations, [accessed http://ecolo.org/documents/documents_in_english/Ireland-oil-report-06.pdf]

Frantzeskaki, N. & de Haan, H., 2009. Transitions: Two steps from theory to policy. *Futures*, 41(9), pp.593– 606.

Garud, R. & Gehman, J. (2012) Metatheoretical perspectives on sustainability journeys: Evolutionary, relational and durational. *Research Policy*, 41(6), pp.980–995

Geels, F.W. & Schot, J., 2007. Typology of sociotechnical transition pathways. *Research Policy*, 36(3), pp.399–417.

Geels, F.W. et al., 2016. The enactment of socio-technical transition pathways: A reformulated typology and a comparative multi-level analysis of the German and UK low-carbon electricity transitions (1990-2014). *Research Policy*, 45(4), pp.896–913. Available at: http://dx.doi.org/10.1016/j.respol.2016.01.015.

Haxeltine, Alex; Wittmayer, Julia and Avelino, Flor; Kemp, René; Weaver, Paul; Backhaus, Julia and O'Riordan, Tim (2013) Transformative social innovations : a sustainability transition perspective on social innovation (Paper presented at the international conference Social Frontiers : The next edge of social innovation research, at GCU's London Campus on 14th and 15th November 2013).

Hekkert, M.P., Suurs, R.A.A., Negro, S.O., Kuhlmann, S., and Smits, R.E.H.M., 2007, 'Functions of innovation systems: A new approach for analysing technological change', *Technological Forecasting and Social Change*, 74(4), 413-432

Hendriks CM, Grin J (2007), 'Contextualizing reflexive governance: the politics of Dutch transitions to sustainability, *Journal of Environmental Policy and Planning*, 9: 3–4: 333–350.

Hodbod, J. & Adger, W.N., 2014. Integrating social-ecological dynamics and resilience into energy systems research. *Energy Research and Social Science*, 1, pp.226–231.

Kirby, Peadar (2014), *Cloughjordan Ecovillage: Modelling the transition to a low-carbon society* [accessed http://www.thevillage.ie/wp-content/uploads/2014/11/Cloughjordan-Ecovillage-Modelling-low-carbon-society.pdf 17-4-2016]

Kivimaa, P. & Kern, F., 2016. Creative destruction or mere niche support? Innovation policy mixes for sustainability transitions. *Research Policy*, 45(1), pp.205–217. Available at: http://dx.doi.org/10.1016/j.respol.2015.09.008.

Kuzemko, C. et al., (2016). Governing for sustainable energy system change: Politics, contexts and contingency. *Energy Research and Social Science*, 12, pp.96–105. Available at: http://dx.doi.org/10.1016/j.erss.2015.12.022.

Lockwood , Matthew (2015), *The Danish system of electricity policy-making and regulation*, Energy Policy Group Working Paper 1504, Exeter University, 2015 [accessed

http://projects.exeter.ac.uk/igov/wp-content/uploads/2015/06/ML-Danish-model-of-regulation.pdf 6-7-2016]

Loorbach, D., 2010. Transition management for sustainable development: A prescriptive, complexity-based governance framework. *Governance*, 23(1), pp.161–183..

Markard, J. & Truffer, B., 2008. Technological innovation systems and the multi-level perspective: Towards an integrated framework. *Research Policy*, 37(4), pp.596–615.

Mc Nally, Brenda (2015) Media and Carbon Literacy: Shaping Opportunities for Cognitive Engagement with Low Carbon Transition in Irish Print Media, 2000 – 2013, Conference Paper [accessed online http://dcu.academia.edu/BrendaMcNally6-7-2016]

Morrissey, P., Weldon, P. and O'Mahony, M., Electric Vehicle Household Charging Behaviour in Ireland and Aims for a Carbon Neutral Electric Fleet by 2020, *World Review of Intermodal Transportation Research*, 2016

Morrissey, P., Weldon, P. and O'Mahony, M., Future standard and fast charging infrastructure planning: An analysis of electric vehicle charging behaviour, *Energy Policy*, 89, 2016, p257 – 270

Mullally, G. & Byrne, E., 2015. A tale of three transitions: a year in the life of electricity system transformation narratives in the Irish media. *Energy, Sustainability and Society*, 6(1), p.3. Available at: http://www.energsustainsoc.com/content/6/1/3.

Murphy, Jerry (2015) Greening the gas grid, *Engineers Journal*, 7/4/2015 [accessed online http://www.engineersjournal.ie/2015/04/07/bioenergy-model-ireland-greening-gas-grid/ 16-4-2016]

NESC (2012) *Ireland and the Climate Challenge: Connecting how much with* how to. , [accessed http://www.nesc.ie/assets/files/Ireland%20and%20the%20Climate%20Change%20Challenge_Connecting%20How%20Much%20with%20How%20To_Main_Report.pdf]

NESC (2014) *Wind Energy: The Challenge of Community Engagement and Social Acceptance in Ireland*, National Economic and Social Council 10 SLR Project Ref No 501.00319.00001, [accessed http://www.nesc.ie/en/publications/publications/nesc-reports/wind-energy-in-ireland-building-community-engagement-and-social-support/ 14-5-2015]

Nevens, F., Frantzeskaki, N.Gorissen, L. & Loorbach, D. (2013), 'Urban Transition Labs: co-creating transformative action for sustainable cities', *Journal of Cleaner Production* 50: 111-122.

OECD (2015) *System Innovation: Synthesis Report* [accessed

https://www.innovationpolicyplatform.org/sites/default/files/general/SYSTEMINNOVATION_FINALREPORT.pdf 28-7-2016]

Rau, H., Hynes, M. and Heisserer, B. (2015) Transport policy and governance in turbulent times: Evidence from Ireland, *Case Studies on Transport Policy,* doi:10.1016/j.cstp.2015.11.006

REN21(2016) Renewable Energy: Global Status Report [http://www.ren21.net/gsr-2016-products/ 20-7-2016]

Roorda and Wittmayer (2014) Transition management in five European cities – an evaluation, DRIFT, Erasmus University Rotterdam, Rotterdam.

Roorda, C., Wittmayer, J., Steenbergen, F. van, Frantzeskaki, N., Loorbach, D and Henneman, P. (2014). Transition Management In Urban Context – guidance manual. DRIFT, Erasmus University Rotterdam, Rotterdam.

Schuitmaker, T.J.,(2012). Identifying and unravelling persistent problems. *Technological Forecasting and Social Change*, 79(6), pp.1021–1031.

Scoones, I, Leach, M. and Newell, P (eds), (2015), The Politics of Green Transformations (London: Routledge)

SEAI (2010a) *Bioenergy Roadmap*, Sustainable Energy Authority of Ireland 2016. [accessed http://www.seai.ie/Publications/Statistics_Publications/SEAI_2050_Energy_Roadmaps/ 17-4-2016]

SEAI (2010b) *Ocean Energy Roadmap*, Sustainable Energy Authority of Ireland 2016. [accessed http://www.seai.ie/Publications/Statistics_Publications/SEAI_2050_Energy_Roadmaps/ 17-4-2016]

SEAI (2011) *Electric Vehicle Roadmap*, Sustainable Energy Authority of Ireland 2016. [accessed http://www.seai.ie/Publications/Statistics_Publications/SEAI_2050_Energy_Roadmaps/ 17-4-2016]

SEAI (2015a) *Energy in Ireland 1990-2014, 2015 Report*, Sustainable Energy Authority of Ireland 2016. [accessed http://www.seai.ie/Publications/ 17-4-2016]

SEAI(2015c) *A Macroeconomic Analysis of Bioenergy Use to 2020:An analysis using the Sustainable Energy Economy Model,* , Sustainable Energy Authority of Ireland 2016. [accessed http://www.seai.ie/Publications/ 17-4-2016]

SEAI (2016) Energy Data Portal, [data accessed online 22-7-2015]

SEAI (2016a) *Energy Security in Ireland : A Statistical Overview 2016 Report*, Sustainable Energy Authority of Ireland 2016. [accessed http://www.seai.ie/Publications/ 17-4-2016]

SEAI (2016b) *Ireland's Energy Targets, Progress, Ambition, and Impacts,* Sustainable Energy Authority of Ireland 2016. [accessed http://www.seai.ie/Publications/ 17-4-2016]

Shove, E. & Walker, G., 2007. CAUTION! Transitions ahead: Politics, practice, and sustainable transition management. *Environment and Planning A*, 39(4), pp.763–770.

Smith, A., Stirling, A. & Berkhout, F., 2005. The governance of sustainable socio-technical transitions. *Research Policy*, 34(10), pp.1491–1510..

Smith, A., and Raven, R. (2012), 'What is protective space? Reconsidering niches in transitions to sustainability', *Research Policy*, 41: 6): 1025–1036.

SPRU (2016) *Designing Innovation Policy for Transformative Change*, Briefing note for Policymakers, Science Policy Research Unit, University of Sussex 2016

SRTP (Stockholm Regional Transition Platform) (2015) SUSTAINABLE STOCKHOLM –TRANSFORMING FROM WHAT TO WHAT? , Report from Transition Platform Meeting, October 7 2015, Stockholm [accessed http://acceleratingtransitions.eu/transition-regions/transition-region-stockholm/, http://acceleratingtransitions.eu/publications/ 6-7-2016]

Unruh, G.C., 2002. Escaping carbon lock-in. *Energy Policy*, 30(4), pp.317–325.

Van Der Loo F. and Loorbach D. (2012) The Dutch Energy Transition Project (2000-2009) in Verbong G. and Loorbach D. (2012) eds Governing the Energy Transition, Routledge 2012

Weber, K.M. & Rohracher, H., 2012. Legitimizing research, technology and innovation policies for transformative change: Combining insights from innovation systems and multi-level perspective in a comprehensive "failures" framework. *Research Policy*, 41(6), pp.1037–1047.

Wieczorek, A.J. et al. (2013.) A review of the European offshore wind innovation system. *Renewable and Sustainable Energy Reviews*, 26, pp.294–306..

Wieczorek, A.J. & Hekkert, M.P.(2012). Systemic instruments for systemic innovation problems: A framework for policy makers and innovation scholars. *Science and Public Policy*, 39(1), pp.74–87.

Dr. Therese Hume is the research fellow on the CC Transitions project in QUB, currently on sabbatical from Institute of Technology Sligo. Having recently completed doctoral studies applying a transitions perspective to case studies of higher education in Ireland, and with many years experience teaching in the sector, her research interests lie in the broad area of learning for a sustainability transition, how this can be informed by theories of transition, and how space and capacity for learning can be created in diverse societal settings.

Professor Geraint Ellis is leading the CC Transitions project. A geographer and planner, he is currently Chair of Environmental Planning in the School of Planning Architecture and Civil Engineering and Director of Research for the Institute of Spatial and Environmental Planning at QUB. Geraint's research interests lie in the broad field of spatial planning and sustainability, with a particular emphasis on environmental governance, renewable energy,

marine spatial planning, environmental justice and equality issues in planning.

Professor John Barry is an interdisciplinary social science scholar based in the School of Politics, International Studies and Philosophy and is Chair of Green Political Economy at QUB. His research interests include: green political theory, politics and political economy of sustainability, greening the economy, environmental and sustainable development policy-making, environmental ethics, transition to a low-carbon/renewable energy economy, including normative dimensions, theories and practices of active citizenship, democracy and green politics, civic republicanism, and green political theory.

Dr. Robin Curry is an interdisciplinary scientist based within the School of Chemistry and Chemical Engineering at QUB. His research interests lie in fields ranging from construction and infrastructure development to product design, which involve the application and ongoing development of a range of methodologies to the measurement and assessment of resource efficiency and sustainability. These are resource, ecological and carbon accounting methodologies which are consistent with thermodynamics and ecological principles. A particular focus of his research is how to combine different methods to optimise their use for design and policy making.