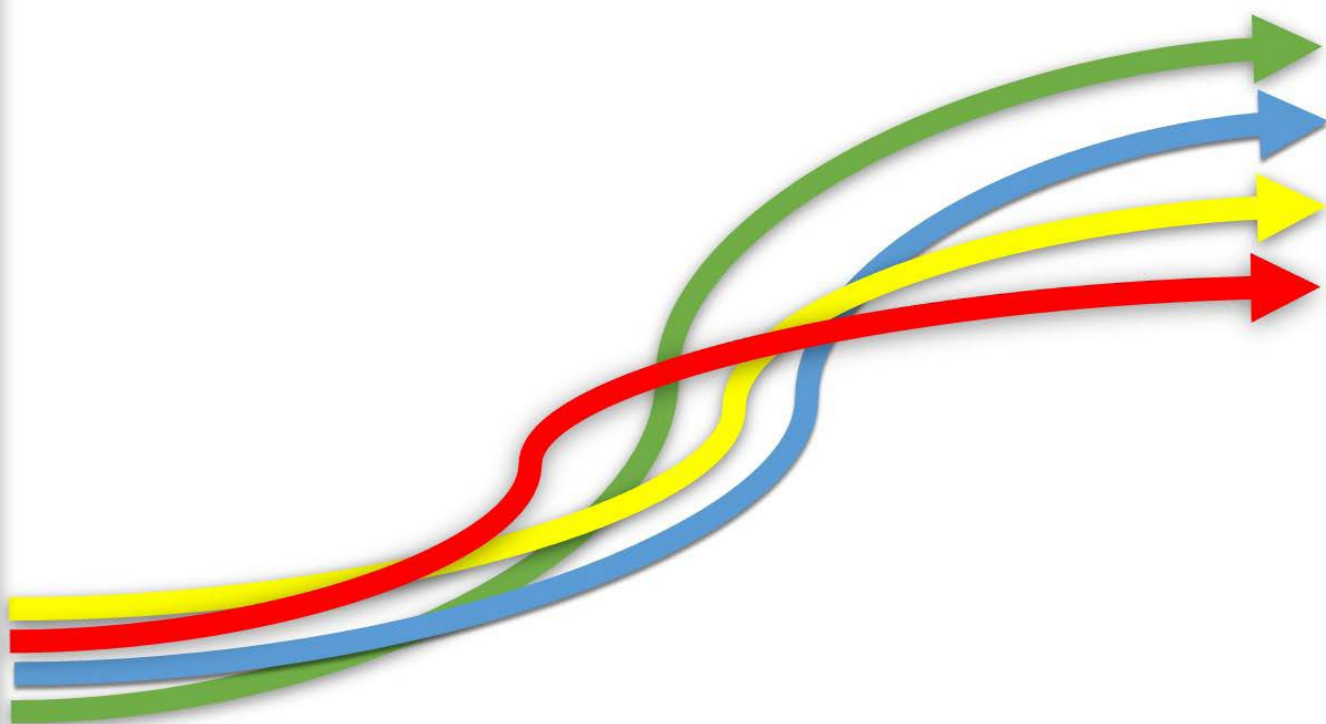


Catalysing and Characterising Transition

Authors: Geraint Ellis, Therese Hume, John Barry and Robin Curry



ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency (EPA) is responsible for protecting and improving the environment as a valuable asset for the people of Ireland. We are committed to protecting people and the environment from the harmful effects of radiation and pollution.

The work of the EPA can be divided into three main areas:

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- large scale industrial activities (*e.g. pharmaceutical, cement manufacturing, power plants*);
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- the contained use and controlled release of Genetically Modified Organisms (*GMOs*);
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- Providing advice and guidance to industry and the public on environmental and radiological protection topics.
- Providing timely and easily accessible environmental information to encourage public participation in environmental decision-making (*e.g. My Local Environment, Radon Maps*).
- Advising Government on matters relating to radiological safety and emergency response.
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- Generating greater environmental awareness and influencing positive behavioural change by supporting businesses, communities and householders to become more resource efficient.
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The EPA is managed by a full time Board, consisting of a Director General and five Directors. The work is carried out across five Offices:

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- Office of Environmental Enforcement
- Office of Evidence and Assessment
- Office of Radiation Protection and Environmental Monitoring
- Office of Communications and Corporate Services

The EPA is assisted by an Advisory Committee of twelve members who meet regularly to discuss issues of concern and provide advice to the Board.

EPA RESEARCH PROGRAMME 2014–2020

Catalysing and Characterising Transition

(2014-CCRP-DS.6)

EPA Research Report

End of project report available for download on <http://erc.epa.ie/safer/reports>

Prepared for the Environmental Protection Agency

by

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ACKNOWLEDGEMENTS

This report is published as part of the EPA Research Programme 2014–2020. The EPA Research Programme is a Government of Ireland initiative funded by the Department of Communications, Climate Action and Environment. It is administered by the Environmental Protection Agency, which has the statutory function of co-ordinating and promoting environmental research.

Many different groups of people helped us produce this report and influenced the thinking behind the research. We need to particularly acknowledge the crucial role of Dr Therese Hume, who was employed as the Research Fellow on the project between 2015 and 2016 and who did the majority of the background research and wrote much of the content of the project report. Thanks are also due to Dr Christina Kelly for assistance in editing the final report. We are also very grateful for the funding provided by the EPA and the patience they have shown in waiting for the final report, which was delayed because of some personal circumstances of the project leader. In addition to this, we would like to pay particular thanks to the members of our project steering group [Jeanne Moore (National Economic and Social Council; NESC), Hendrikje Reich (Deutsche Gesellschaft für Internationale Zusammenarbeit; GIZ), Frank McGovern (EPA), Ian Hughes (DJEDI), Gemma O'Reilly (EPA) and Phillip O'Brien (EPA, chairperson)], who provided encouragement and guidance for the execution of the project and were the valuable touchstone for the emerging findings. The research also benefited from the input of interviewees and attendees to the two project workshops held in Cork and Dublin. Many thanks to you all.

DISCLAIMER

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The EPA Research Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

EPA RESEARCH PROGRAMME 2014–2020

Published by the Environmental Protection Agency, Ireland

ISBN: 978-1-84095-852-2

September 2019

Price: Free

Online version

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Executive Summary

This synthesis report presents the main findings from a desk study on *Catalysing and Characterising Transition* (CCTransitions), which was funded by the Environmental Protection Agency (EPA). The project had the aims of providing a review of theoretical concepts that inform how we understand sustainability transitions, reviewing a number of international case studies of such sustainability transitions and examining how specific technologies have been promoted to facilitate transition. The project also sought to look at examples of how transition in Ireland could be benchmarked against other international examples and to provide a wider analytical framework for applying these ideas in an Irish context. The report summarises the findings of each of these objectives and how they were achieved via a desk study supported by interviews and two project workshops.

The report begins by reviewing the idea of transition, highlighting its origins in science and technology studies and outlining four broad perspectives on transition: the multi-level perspective, transition management, strategic niche management and technological innovation systems. Each of these perspectives provides a unique way of understanding the different challenges involved in mobilising the far-reaching transformation in society needed to overcome the persistent problems of un-sustainability. A common principle here is that desirable societal change cannot be defined primarily on the basis of a definable end state, but should be regarded as primarily a process of redirecting and steering a wide range of elements (markets, energy technologies infrastructure, governance, individual behaviour, collective action) towards a more sustainable configuration.

Following this, the report examines the energy transition experiences of the Netherlands, Sweden, the

UK, Germany, Denmark, Norway and New Zealand. The key dimensions of the transition experience in each country are reviewed, highlighting for each country the broader landscape forces, dominant actors and scope of niche innovation. This demonstrates the possibility of diverse pathways towards transition, depending on the structural conditions, vision and actors involved. The report also seeks to draw some general insights from these international experiences, noting the complexity of forces, agents and scales that can act as drivers for or barriers to a country's transition. In particular, the benefits of a strong and widely shared sustainability vision and the way in which incumbent, vested interests can frustrate progress are noted.

The report also reviews the drivers for and challenges to the deployment of three technologies that have been considered to be relevant to the Irish energy transition (namely bioenergy, biofuels and electric vehicles) in other European settings, identifying key points for consideration in an Irish setting. The context of the Irish energy system is then described, using the concepts of landscape, regime and niche from the multi-level perspective to typify the interdependencies, challenges and opportunities for transition.

A further section of the report reviews the challenges to benchmarking the Irish transition against other countries' progress and critically develops suggestions for what could be usefully done in an Irish context. Finally, the report seeks to synthesise the findings of the project and makes recommendations for how the perspective of transitions can be operationalised in an Irish context, with an emphasis on enhancing the Irish national capacity for transition research, and initiating a national transition management process.

1 Introduction

This synthesis report presents the main findings from a desk study on *Catalysing and Characterising Transition* (CCTransitions), which was funded by the Environmental Protection Agency (EPA) in response to a competitive call on climate research. The research began in January 2015 and was undertaken by an interdisciplinary team of researchers from Queen's University, Belfast.

The project was funded amid a growing recognition of the systemic challenges to the shift towards a low-carbon society as a way of mitigating future climate change risks, covering a wide range of sectors, behaviours and markets. The prime focus here is on the energy system, but interdependency with other systems, such as transport and food, is recognised. It is clear that the transformative changes demanded by climate change cannot be achieved through only technological solutions, because these changes have widespread implications for the economy, social practices, institutional arrangements and wider sociotechnical systems of which they are part. This presents very complex, long-term governance challenges and the EPA recognised that, in order to make better sense of this, a framework for integrating analysis from a wide range of disciplines, scale and sectoral perspectives needed to be developed to more effectively direct and shape future action. There was also a need to characterise the main attributes of a process of transformation, to be able to recognise when and where transformation is happening and to be able to develop relevant indicators to monitor progress and identify barriers. These are the main aspirations of this research.

As a desk study, this report has been able to sketch out only some key principles, but it does articulate a future agenda for tackling these challenges and realising opportunities.

The research follows a wide range of existing activity undertaken by public, private and non-governmental organisation sectors to transform Ireland to a low-carbon society. It is impossible to acknowledge all of these activities, although many are referenced in the main report (available on <http://erc.epa.ie/safer/reports>). Current initiatives create a diverse and complex context for steering towards a goal of a low-carbon society, with multiple actors acting at different geographical scales and over long periods of time. In order to deal with this complexity, it is useful to adopt a conceptual model that helps to identify the key actors, drivers and processes in what can appear to be a chaotic system. This can help us understand the range of factors that needs to be encompassed in shifting to a low-carbon society and the nature and scope of the challenge, as well as identify opportunities to catalyse change. The approach adopted here draws on the developing field of sustainability transitions and transition management (TM), as detailed in the main report. We also examine international case studies of energy transition and attempt to map the state of transition of specific technological sectors in Ireland. The project has sought to identify how to benchmark Ireland's progress to a low-carbon economy and sets out an agenda through which transition can be consolidated and advanced. This work was organised through a series of discrete working papers, all of which are available on the project website (available on <http://erc.epa.ie/safer/reports>).

2 Research Approach

As noted previously, this research was funded as a desk-based study and, as a consequence, most of the report draws on existing academic work and secondary sources, such as policy documents, reports and guidance, produced by a wide range of organisations and individuals. Early stages of the project were underpinned by a number of systematic reviews of key areas of research. This ensured that the synthesis presented here reflects the state-of-the-art research at the time of writing. The research

also benefited from two stakeholder workshops: the first at University College Cork in April 2016 and the second at the Custom House in Dublin in May 2016. Reports from both of these workshops are available on the project website (<http://erc.epa.ie/safer/reports>) and as an appendix to the final report. The project also benefited from a series of interviews with 12 experts, mostly to support the case studies of different technologies in Ireland and the assessment of the capacity for innovation barriers to implementation.

3 Conceptualising Society-wide Transitions

The first stage of the research involved a review of the concepts and theoretical tools that theorise the scale and complexity of the type of social transformation discussed above. A systematic review of the academic literature on society-wide transitions was undertaken by following established protocols (Petticrew and Roberts, 2008) and building on an earlier review by Markard *et al.* (2012). This identified more than 850 relevant papers, many of which share a core conceptual understanding of society-wide transitions and add a variety of other perspectives that help explain different aspects of social, economic and environmental transformation. A brief summary of the key elements in this literature is provided in this chapter.

3.1 Origins and Evolution of the Transition Perspective

The field of transition studies emerged from the area of science and technology studies, through attempts to characterise the nature and dynamics of developments in technology (Kemp, 1994; Rip and Kemp, 1998) using an evolutionary approach, drawing on disciplines such as cultural studies, anthropology, geography and politics (Grin *et al.*, 2010, p. 52). The theory was developed through the provision of narrative explanations for historical transitions in sociotechnical systems, such as transport systems and mobility, public sanitation, lighting, electricity provision and large-scale agricultural changes (Smith *et al.*, 2010). The review by Markard *et al.* (2012) identifies four broad perspectives that have been taken in transition studies: TM, strategic niche management (SNM), the multi-level perspective (MLP) and technological innovation systems (TIS) tracing the origins of these perspectives in the literature. Examining these provides a useful starting point for understanding concepts that are used to inform subsequent elements of this study. As TIS provides a useful framework to examine the factors influencing the adoption of particular technologies, it will be examined in more detail in Chapter 5.

3.2 The Transition Perspective on Change in Sociotechnical Systems

A dominant theme in the transition literature is that the shift to a low-carbon economy can be viewed as a process of redirecting and steering a wide range of factors (markets, energy technologies infrastructure, governance, individual behaviour, civil society action) towards a more sustainable configuration rather than being about achieving a definable and predetermined end state (Berkhout, 2002). Such a process cannot be guided by a fixed blueprint, given the timescales involved (usually at least 25–30 years), as there will inevitably be uncertainties and surprises, ambivalent goals, political myopia, social resistance, institutional or cultural inertia and a danger of “lock in” (technological, policy or behavioural), among other factors (Kemp *et al.*, 2007a). Transition is thus more likely to be progressed by using a long-term vision as a framework for formulating short-term objectives and policy evaluation orientated towards achieving that longer-term transition (Rotmans *et al.*, 2001).

Much current research in the area relates to the need to analyse what have been described as persistent problems (Schuitmaker, 2012) of unsustainability (Barry, 2012), which exist within different types of co-evolving societal systems (e.g. electricity, transport and food), and to develop appropriate governance mechanisms to guide them towards a more sustainable configuration. These persistent problems are often complex and deeply embedded and reproduced as side effects of existing systems, and so are particularly difficult to respond to. Thus, sustainability transitions can be viewed as complex, multi-causal, multi-level, multi-domain, multi-actor and multi-phase processes (Loorbach, 2010), involving profound changes to existing structures, cultures, norms and practices (de Haan and Rotmans, 2011, p. 93).¹

¹ Structures refer to the formal, physical, legal and economic aspects of functioning that restrict and enable practices; cultures refer to the cognitive, discursive, normative and ideological aspects of functioning involved in the sensemaking of practices; and practices refer to the routines, habits, formalisms, procedures and protocols by which actors maintain the functioning of the societal system (de Haan, 2010; de Haan and Rotmans, 2011).

Core concepts in transition studies are articulated in the MLP (Kemp, 1994; Rip and Kemp, 1998; Geels, 2012), which is used as a framing through which complex situations can be understood (see Figure 3.1). The levels include:

- A micro-level of *niches* representing innovative local practices, local actors and technologies, which can be viewed as “a protected space where radical novelties emerge and have the opportunity to learn, develop and gain a critical mass of adopters” (Safarzyńska *et al.*, 2012, p. 1013).
- A meso-level *regime* relating to dominant technologies, practices, policies, rules, shared assumptions and discourse (Geels, 2002).
- A macro-level *landscape* comprising social and physical environmental or infrastructural features, which the dominant regime and niches are nested within and influenced by. This includes “external” factors such as demography, the macro economy and the prevailing political and consumer culture (Geels, 2002).

It is important to note that this view of the MLP does not necessarily imply a “nested hierarchy” view of the three levels, i.e. niches are not necessarily located within a specific regime, which themselves would be nested within a specific landscape. Rather, the three levels refer to different degrees of structuration of local practices and, as Geels (2010) suggests, should be understood heuristically. In this view, the levels refer only to differing degrees of stability.

Transitions are broadly seen as emerging through the interplay between these three levels, involving what Grin *et al.* (2010, p. 265) described as “mutually reinforcing flywheels”, where processes of change reinforce each other. For example, Geels and Schot (2007, p. 400) describe a scenario in which niche innovations build momentum and in which landscape forces put pressure on and destabilise the regime, providing a window of opportunity that enables niches to gain dominance. A summary of the type of dynamics that can emerge from the interplay of these levels is shown in Figure 3.2. The strength of regimes means that transitions do not happen easily, and the processes and dynamics of transition are inherently open-ended, contingent and non-linear. Transitions analyses can thus be used to identify leverage points for steering, which can be reviewed later as learning occurs. Using these concepts, it is possible to begin to identify some of the dynamics, inter-dependent sectors and actors that are central to an energy system such as that in Ireland, as shown in Figure 3.3.

Relationships between niche, regime and landscape levels are important in the unfolding of transitions and the transition paths or trajectories that may emerge, and these have been conceptualised in different ways. Examining the dynamics in particular situations thus provides a possibility to determine potential trajectories of change and to identify where change can be influenced. As discussed previously, transition may occur through a transformation of a dominant regime or through its displacement by an expanding niche. The type of transition is also influenced by where the major impetus for change occurs, for example

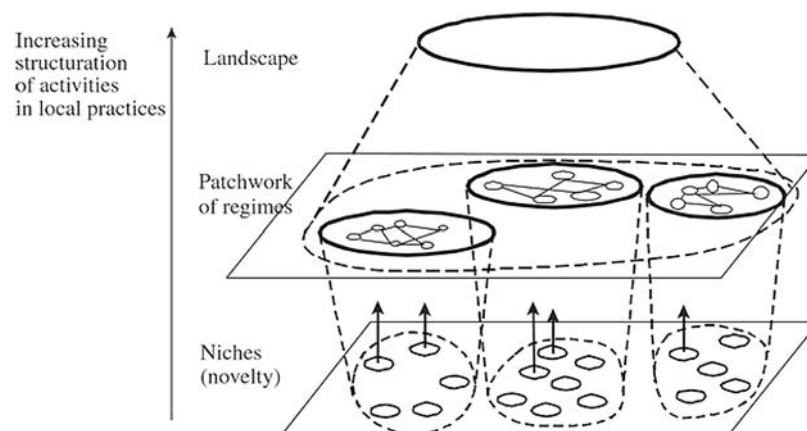


Figure 3.1. The MLP. Reprinted from *Journal of Transport Geography*, Vol. 24, F.W. Geels, A socio-technical analysis of low-carbon transitions: introducing the multi-level perspective into transport studies, pp. 471–482, copyright 2012, with permission from Elsevier.

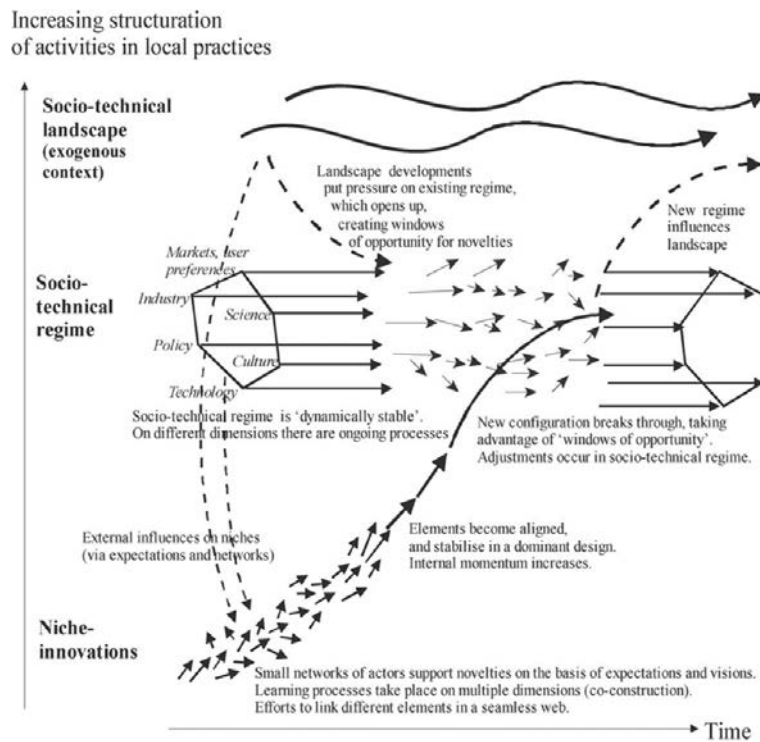


Figure 3.2. Transition dynamics. Reprinted from *Research Policy*, Vol. 36, F.W. Geels and J. Schot, Typology of sociotechnical transition pathways, pp. 399–417, copyright 2007, with permission from Elsevier.

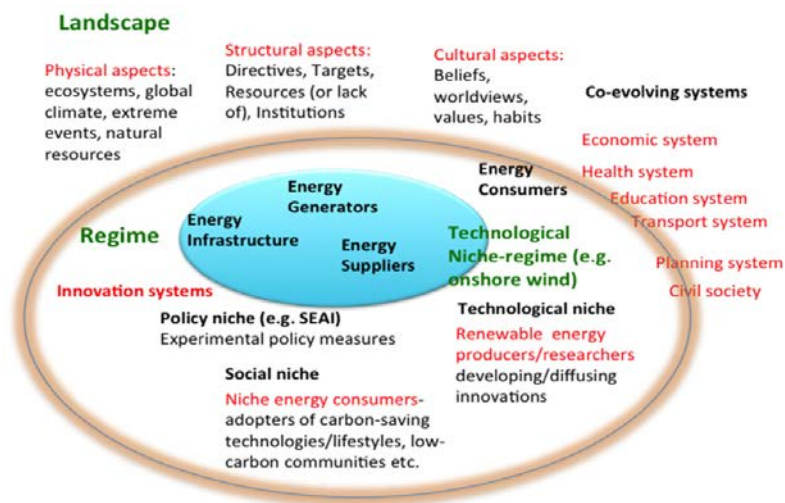


Figure 3.3. An MLP on an energy system. SEAI, Sustainable Energy Authority of Ireland.

the introduction of legislation or targets could drive a preferred energy transition from the top down, or grassroots civil society demands for particular climate-energy policies.

Incorporating ideas from complex adaptive systems theories and in common with theories of innovation, unfolding transitions can be viewed as going

through four broad phases. These are commonly conceptualised as: "(1) pre-development phase, during which structural change is not yet visible; (2) take off, when the process of structural change gains momentum; (3) acceleration phase of these processes; and (4) stabilization phase, after which a new dynamic equilibrium is achieved" (Safarzyńska et al., 2012, p. 1016).

In summary, the MLP, aided by insights from complex adaptive systems theories, provides a framework that can be used to describe particular types of sociotechnical systems, such as an energy system. Major actors, structures, cultures and practices in the regime can thus be identified, key landscape influences can be mapped and described, and accounts can be given of existing niches. Analyses of processes of change help identify possible phases and trajectories or roadmaps for transition and also where, for example, lock-in might be occurring or where change might be blocked or driven in a less desirable direction. These analyses thus provide insights to inform the timing and nature of policy interventions, and can be incorporated in the design of reflexive governance processes.

3.3 Governance and Transitions

These perspectives on transitions clearly have substantial implications for governance processes and mechanisms to operationalise change. Two particular frameworks are identified here: SNM and TM.

3.3.1 Strategic niche management

Building on constructive technology assessment, SNM was developed as a governance mechanism to encourage and steer technological innovation through creating spaces for experimentation, using open

learning processes (Hoogma *et al.*, 2002; Geels and Schot, 2007). Steering is enacted by a range of “niche” actors, including users or societal groups, for example new actors might be added to broaden the range of insights contributing to specific learning processes or practical experiments. Key elements of SNM include the clear articulation of expectations and visions, the building of social networks and the central role of learning processes.

3.3.2 Transition management

Transition management combines aspects of reflexive governance and complex adaptive systems theory and can be defined as a “deliberative process to influence governance activities in such a way that they lead to accelerated change directed towards sustainability ambitions” (Loorbach and Rotmans, 2010, pp. 238, 239). Analyses of transitions are used to stimulate and support problem-structuring processes, help build reflexive capacity and inform social learning to create the conditions for change to occur. An operational cycle of activities typically includes the following elements (Loorbach and Rotmans, 2010, pp. 238, 239) (see Figure 3.4):

1. The establishment of a “transition arena” and an integrated systems analysis to structure the problem. This brings together diverse actors relevant to the issue in order to stimulate debate and enable structured evaluation and assessment.

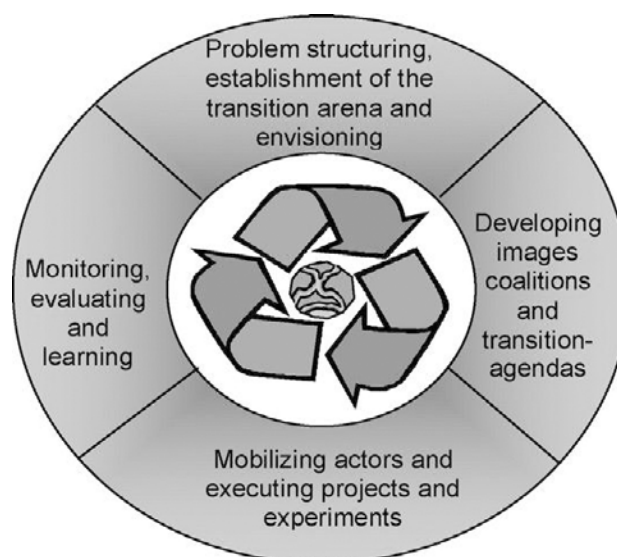


Figure 3.4. The cycle. Reprinted from *Governance*, Vol. 23, D. Loorbach, *Transition management for sustainable development: a prescriptive, complexity-based governance framework*, pp. 161–183, copyright 2010, with permission from John Wiley and Sons.

2. The creation of a transition agenda through envisioning processes.
3. Mobilising networks, carrying out transition experiments.
4. Monitoring, evaluating and learning from these experiments, ensuring that the learning feeds back into the next cycle.

Through these cycles, different types of governance activities provide a recursive framework for implementation, ensuring co-ordination at different levels (Loorbach, 2010; Loorbach and Rotmans, 2010, p. 238):

- strategic activities take into account a long time horizon and relate to structuring a complex societal problem and creating alternative futures;
- tactical activities at the level of subsystems relate to the build-up and break-down of system structures (e.g. institutions, regulations, physical infrastructures);
- operational activities relate to short-term and everyday decisions and actions where actors either recreate system structures or choose to restructure or change them;
- reflexive activities relate to the evaluation of the existing situation at various levels.

3.4 Critical Reflection on Transition Studies

Although these transition perspectives provide a high level of conceptual clarity, they have attracted a range of criticisms and challenges, which are reviewed in detail in the main report. These include the suggestion that transition studies neglect issues of power and asymmetrical agency (e.g. Shove and Walker, 2007; Swyngedouw, 2007; Smith and Stirling, 2010; Smith *et al.*, 2010; Meadowcroft, 2011;

Kern, 2012) and that this leads to a naive apolitical perspective of sociotechnical transition, where only system changes that do not disrupt the dominant political and economic status quo are deemed to be both legitimate and possible. This increases the risk of TM being co-opted by prevailing vested interests or being too narrowly circumscribed by the “tramlines” of the dominant regime, leading to “path dependency” as opposed to “path creation” in innovations (Garud and Gehmann, 2012), or a lack of attention being paid to grassroots and non-technological dimensions of innovation.

It has also been argued (Geels, 2010) that the complex nature of sustainability transitions requires further consideration of the importance of narrative and discourse. This is linked to the contribution of a “post-normal science” approach and how this can add value to the sociotechnical transition perspective (Funtowicz and Ravetz, 1993), including bringing in new stakeholders, integrating, rather than excluding, normative points of view, and extending appropriate expertise beyond those normally viewed as the appropriate experts. There have also been suggestions that transition perspectives can lead to top-down governance frameworks (Haxeltine and Seyfang, 2009), where others suggest that transitions could emerge from the bottom up, through civil society movements and social innovations (Avelino and Kunze, 2009; Cato and Hillier, 2011).

Other criticisms aimed at transition studies include a failure to fully account for the spatial dynamics of transitions (Smith *et al.*, 2010; Coenen *et al.*, 2012; McCauley and Stephens, 2012; Raven *et al.*, 2012), and by emphasising technological innovation, many transitions approaches may sometimes overlook a focus on energy efficiency and conservation or more radical ideas around energy descent planning (Hopkins, 2008).

4 International Case Studies

The complex context for transitions, involving an interdependent dynamic between niche, regime and landscape levels, inevitably means that each community, region or nation will face very different challenges for transition and will develop their own bespoke approaches. Nevertheless, a review of how other countries have approached this task can be very instructive and for this reason the project included a number of international case studies. The aim of these was to provide comparative examples of how other countries have conceptualised and operationalised processes of energy transition.

The extent of this review was constrained by the availability of documentation on relevant countries and case study selection was guided by this, coupled with an attempt to highlight innovative practice from within and outside Europe. Following the advice of the project steering group, the following countries were used as case studies: the Netherlands, Sweden, the UK, Germany, Denmark, Norway and New Zealand. A very brief account of each country is provided in this chapter, with more detail provided in the main report.

4.1 The Netherlands

The Netherlands is a frontrunner in terms of environmental issues, primed by its vulnerability to rising sea levels and flooding. They were also a leader in TM, with the Fourth Dutch National Environmental Policy Plan (NMP4) (VROM, 2001), which was introduced using an interactive dialogue between science and policy in order to explore possibilities for systemic change (van der Loo and Loorbach, 2012). This led to the transitions approach becoming central to Dutch long-term environmental policy. Seven transition paths and an innovation agenda were set up around themes such as new gas, sustainable mobility, built environment, electricity, energy-supplying greenhouses and supply chain efficiency. By 2007, environment-oriented technology policy (ETP) had become a key programme in the government, involving all relevant departments and having been integrated in the National Energy Policy (Van der Loo and Loorbach, 2012). However, notwithstanding successes in stimulating innovation and in embedding

the acceptance of energy transition as a longer term policy issue, it has been argued that the ETP has been unable to challenge the incumbent energy regime (van der Loo and Loorbach, 2012), with key industrial incumbents, such as Shell, having key roles in the transition process. This has led to issues of democratic legitimacy and poor engagement of wider society. Despite the innovative transition process, the Netherlands remains one of the most carbon-intensive economies in Europe, with, in 2011, per capita emissions 30% higher than the European Union (EU) average and per capita consumption of energy 45% higher than the EU average (Donat *et al.*, 2014).

4.2 Sweden

Sweden has had strong, long-term sustainability strategies dating back to its hosting of the first conference on the global environment in Stockholm in 1972 and it was the first country to implement a carbon tax in 1989 (Anshelm and Hultman, 2015). Swedish energy policy has been strongly influenced by external shocks (particularly the oil crises of 1972 and 1979) and its ability to exploit its vast forestry resources (IEA, 2013; Di Lucia and Ericsson, 2014). Sweden has a long track record of addressing the persistent problems of the fossil-fuel based energy regime; for example, financial instruments introduced in 1991 almost doubled the price of coal, thus making fuels, such as biomass, much more attractive, and this resulted in its increased use in district heating systems (Di Lucia and Ericsson, 2014). As a result of this, Sweden is considered to be among the global leaders in terms of low carbon intensity and a high share of renewables, with 2014 Eurostat figures indicating that Swedish greenhouse gas (GHG) emissions were 19% below 1990 levels (EEA, 2015a). Despite these figures, however, Sweden is a big consumer of energy [236 British thermal unit (Btu) per person in 2011, compared with 127 Btu in Ireland; IEA, 2013] and, if outsourced emissions are taken into account, for example by using a consumption-based approach to emissions calculation, Swedish emissions have actually increased by 15–20% since 1990 (Anshelm and Hultman, 2015; Mundaca *et al.*, 2015). One of the

major reasons for lower emissions figures despite high energy use is that Sweden's electricity supply is almost carbon free, as it is dominated by hydro and nuclear energy. Bioenergy is a particularly strong sector, supported by sustained research and development (R&D) efforts, the creation of markets through fossil fuel taxation and the construction of extensive district heating systems. However, although this demonstrates success in deploying renewable energy, challenges remain in other areas including transport, industrial energy efficiency, household energy efficiency and agriculture.

4.3 United Kingdom

Although the UK has provided some key examples of leadership in climate action, particularly its Climate Change Act 2008 (and related initiatives such as the Low Carbon Transition Plan and the Committee on Climate Change UK Renewable Energy Roadmap), unlike many other European countries, it has a less stable policy environment for sustainable energy and relies more on market mechanisms to induce a shift to renewables (Kern *et al.*, 2014). Although the UK has far-reaching emissions and renewables targets (e.g. a legally binding goal of an 80% reduction in CO₂ emissions by 2050), it has sought to implement this within a system long dominated by a market logic that sees policy objectives best delivered where there are actors freely interacting within high-level policy frameworks (Foxon, 2013). A consequence of this has been a reinforcement of the dominance of the six major electricity suppliers following privatisation in 1990 and liberalisation in 1998. These now provide over 99% of electricity within a centralised system based on large-scale transmission and an aligned institutional framework that suppresses new market entrants and innovation. In this context there is a very limited community energy sector and high levels of opposition to new energy infrastructure (Strachan *et al.*, 2015). Despite a core political consensus on climate policy, the 2015 Conservative government has reversed some aspects of policy in terms of renewing the country's commitment to nuclear industry, seeking to exploit the country's shale gas reserves and downplaying renewable targets on the basis of economic efficiency (Gillard and Lock, 2016). Although this position is coming under increased pressure in the face of public disquiet and landscape forces (EU targets, energy security, etc.), transition

may also have been frustrated by a fragmentation of energy-related powers across national and devolved governments (Cowell *et al.*, 2016). The UK reduced its GHG emissions by 26% between 1990 and 2012 and primary energy consumption fell by 7% during the same period (EEA, 2015b). In 2016, final energy consumption from renewable sources reached 8.9%, in comparison with a target of 15% for 2020.

4.4 Germany

Germany has experimented with policy approaches for encouraging investment in renewables for over three decades and in 1980 coined the term "energiewende" to characterise the shift away from fossil fuel and nuclear energy towards a sustainable energy system based on renewables. It first introduced support for renewables in 1991, which was strengthened in 2000 and further accelerated in 2011 following the Fukushima Daiichi nuclear disaster, after which the federal government committed to shutting down the remaining nuclear plants by 2022. This also marked an increase in targets, with the adjusted aim of renewables providing 50% of total electricity use by 2030 and 60% by 2050, and emission reduction targets of 55% by 2030 and 95% by 2050 (Donat *et al.*, 2013). The energiewende goes beyond a shift to renewables and encompasses energy efficiency measures, with a target of reducing primary energy consumption by 20% by 2020 and 50% by 2050 compared with 2008. As a result of a long-term engagement with climate protection and renewables, Germany's GHG emissions fell by 23.8% between 1990 and 2013 and it had the highest ratio between carbon productivity and gross domestic product (GDP) per capita of the G20 countries (1999–2005) (Vivid Economics, 2009).

Over many decades, Germany has had a strategy of aggressively promoting renewable energy, particularly through its adoption of a feed-in tariff, which has been very effective in stimulating small-scale investments (Hoppman *et al.*, 2014). This has led to an increase in renewables from 3.1% in 1990 to 25% in 2013 and, perhaps even more significantly, over 50% of renewables capacity is now owned by private individuals (40%) and farmers (10%), with only 6.5% owned by the major energy companies (Trendresearch, 2011). This has created a strong economic–political feedback in favour of renewables,

with high levels of support, to the detriment of key incumbents in the fossil fuel and nuclear sectors (Kungl, 2015; Strunz, 2014). This range of capacities has evolved from decades of experimentation with different policy approaches and led to Germany being a key source of policy diffusion in the renewables arena (Nordensvärd and Urban, 2015).

4.5 Denmark

Denmark offers many useful insights into the process of energy transition. Since the 1970s it has transformed its energy system from one that is 100% dependent on imported fuels for power plants to one that is self-sufficient and a net exporter of energy today. Since 1990 it has promoted its wind energy sector, which now leads the world, with the highest per capita use of wind energy and the highest share of wind as a percentage of the national supply, at over 40% (Lund and Mathiesen, 2009). This is supported by innovative approaches to ensuring public support (in the Renewable Energy Act 2008) and a strong export industry in the manufacture of turbines. This transition has also involved shifting from a centralised system based on 20 large-scale plants to a more decentralised one, now with 400 smaller scale plants. Denmark ranks very highly on key indicators of energy sustainability, including energy security, energy intensity and energy consumption per capita, and despite the growth of its economy and population, it uses the same amount of energy as in 1970 (Sovacool, 2013). This has been helped by a consensual society and political culture, with a strong “common interest” discourse, strong capacity in the public sphere and a system of energy governance that facilitates public value (Lockwood, 2015). There are high levels of transparency and good links at each level of government, for example the transition has been strongly supported by local climate action plans promoted by municipalities (Damsø *et al.*, 2016). There is broad consensus among political parties on energy and climate strategies, which has allowed stability in policy over several decades; the most recent example of this is the Energy Agreement 2012–2020, which was signed by all political parties and which committed the country to a 100% renewable electricity system by 2050. Denmark’s success in moving towards sustainability has also led to green

growth being a key economic strategy, with a green transition fund to support new business models and product innovation and a green pioneer fund to promote engagement at a community level (Sovacool and Blyth, 2015).

4.6 Norway

Norway is unique in that it couples its role as a major oil and gas producer with a strong commitment to climate mitigation. Oil and natural gas production comprise the main sector in the Norwegian economy, while abundant access to hydropower means that most of the power used is generated from renewable sources (IEA, 2011a; Norwegian Ministry of Petroleum and Energy, 2015). Because much of the energy sector and infrastructure is publicly owned it tends to be highly centralised and institutionalised, with shared values, norms and regulations, characterised by a widespread support for market logic (Ballo, 2015). In 2018 battery electric vehicles in Norway reached a 30% market share², the highest internationally (McCarthy, 2015). Incentives for the uptake of electric vehicles (EVs) include exemptions from road toll charges, reduced taxes, free access to public parking and use of bus lanes. There has also been funding for infrastructure developments and, in some cases, free charging (Holtmark and Skonhoft, 2014; Figenbaum *et al.*, 2015). Figenbaum *et al.* (2015) describe the SNM of the sector as a series of measures carried out in a number of distinct phases since the 1970s: concept development, testing, early market, market introduction and market expansion. These measures ranged from research funding and a public test programme at the earlier stages, to a variety of incentives to promote the adoption mentioned above. These policy measures have been highly successful in promoting the adoption of EVs; however, Holtmark and Skonhoft (2014) suggest that the growth in their use and ownership may lead to more individuals driving, at the expense of public transport.

Like Sweden, Norway has a long-standing commitment to environmental protection, being the first country in the world to have a ministry at cabinet level with special responsibility for environmental matters (from 1972) and the first to declare that it aimed to be carbon neutral by 2050. Public funding for research

2 <https://elbil.no/english/norwegian-ev-market/> (accessed 4 June 2019).

into and development and deployment of clean energy more than tripled from 2007 to 2009 (IEA, 2011a). However, Norway has very high GHG emissions on account of its northerly location and dispersed settlement patterns, which generate a large demand for heating and transport services, and its large and emission-intensive process industry (IEA, 2011a).

4.7 New Zealand

New Zealand provides an example from beyond the EU and is not bound by the same renewable energy and climate change targets as the other countries reviewed here. It is also different from the other case studies because of its relative geographical isolation, which means that it is unable to balance its electricity demand through imports and exports. New Zealand also has a relatively low population density and a total population of only 4.5 million, although this has increased by 25% since the early 1990s. The country is well endowed with natural resources and has been able to generate 80% of its electricity from renewable sources, mostly from hydropower and geothermal sources (Kelly, 2011). New Zealand has established a target of 90% electricity from renewables by 2025, with high potential from biomass and marine energy. There is a need for further grid investment and back-up generation from non-fossil fuel sources to go beyond this figure and to counteract challenges arising from the highly liberalised nature of the electricity market and a relatively low level of investment in research in energy technologies (IEA, 2011b).

Furthermore, New Zealand is unlike the other case studies presented here in that, similarly to Ireland, almost half of its GHG emissions come from its agricultural sector, much of which serves an export market. The transport sector is 99% dependent on fossil fuels, as a result of the low population density, with only 1000 registered EVs in November 2016 (Ministry of Transport, 2019). The government has set two national targets for reducing GHG emissions: a 10–20% reduction in emissions relative to 1990 levels by 2020 and a long-term target of a 50% reduction in net GHGs relative to 1990 levels by 2050 (Palmer and Grinlinton, 2014; Ministry for the Environment, 2019). New Zealand is also a signatory to the 2015 Paris Agreement and ratified this in October 2016; this commits the country to reduce its GHG emissions by 30% below 2005 levels by 2030.

Although New Zealand has previously been innovative in environmental governance, such as in its Resource Management Act 1991, it has recently taken a very conventional approach to climate change policy. This faces difficulty of cross-government co-ordination, in relationships with financial policies, and in embracing the wider involvement of economic and civic society stakeholders, with successive governments having terminated some climate change initiatives (Birchall, 2014a,b,c). Sims *et al.* (2016) suggest that there is a need for a far more strategic approach to energy transition, a more transparent approach to how emissions targets should be met, a stronger scientific evidence base and regular opportunities for revisiting policy, climate change measures and targets.

4.8 Reflections on the International Case Studies

The review of these case studies points to a number of general insights that may provide a valuable reflection in an Irish situation, although strong contextual factors discourage any notion that these cases should be regarded as a “blueprint” (Laes *et al.*, 2014). Relevant factors are as follows:

- Transitions are not merely the outcome of technological investment or robust policy direction, but are strongly influenced by broader political cultures and patterns of governance. The countries that have progressed most with energy transition tend to have the longest-standing commitment to such principles. These countries appear to have benefited from strong and widely shared enduring visions of their energy futures, which seems to have been successful in inducing more fundamental change over long periods of time. Indeed, consistency in long-term, bold goals is a very strong element of transition, while, conversely, policy reversals (e.g. as seen in the UK) can be destabilising of sustainable transition pathways.
- When key factors do align, it is possible that fundamental transitions can occur relatively quickly, with major changes to the Danish energy system discernible in less than 5 years from 1973.
- Although no government is able to bind future political leaders to the same transition path, there are commitment devices (Laes *et al.*, 2014, p. 1143), including strong advocacy coalitions,

public participation around specific policies and explicit consensual decisions, that help consolidate the direction of travel.

- Transitions also appear to have more traction when state institutions retain high levels of agency, for example through regulatory instruments or ownership of key assets, such as the electricity transmission network.
- State institutions require strong and consistent social and market support for far-reaching changes, particularly from strong civil society organisations.
- Even with strong visions of the future, it is possible to underestimate the power of incumbents and vested interests, emphasising the need to focus on long-term common interests and to ensure a broad representation of stakeholders in key policy debates at different levels of governance.
- In terms of backing key technologies, a prudent approach is one of polycentricism (Sovacool, 2013), emphasising engaging multiple stakeholders at different geographical scales and in a diverse range of technologies and

approaches (e.g. energy efficiency and promotion of renewables).

- Although strong transition pathways can emerge around technological innovation, the role of social innovation should also be supported.
- The process of policy learning can be integral to transition, signifying a more reflexive approach to governance, and so structures and processes that encourage and support frontrunners and pioneers need to be identified.
- There is a need for close co-ordination and integration of transition efforts. This can be seen at a horizontal scale, in ensuring that national and local government pursue compatible strategies and, at horizontal levels, with policies from different parts of government requiring co-ordination. A particularly important issue here is the alignment of climate and energy objectives and integration of innovation policy, market support mechanisms and R&D investment.
- There are also many potential pitfalls of unforeseen lock-in that can arise from transition pathways.

5 Barriers to and Incentives for Innovation for Transition

Following the review of conceptual frameworks for transition and international examples, a review was carried out of the development of bioenergy, biofuels and EVs in different national settings, technologies that have been highlighted as having significant economic potential for experimentation in Ireland (NESC, 2012). The aim here was to identify the broad conditions that can foster or inhibit the development of these technologies. A technological innovation systems (TIS) approach involves mapping the specific organisations, institutions and infrastructures that together make up the innovation system for the technology, in addition to examining the state of the main functions of the innovation system, such as knowledge development and diffusion, entrepreneurial experimentation and market formation (Hekkert and Negro, 2011). Other issues that can influence technology take-up, including social acceptance and market failures, are also discussed in the main report.

5.1 Bioenergy

In terms of bioenergy, the focus here is on biogas production from farm waste using anaerobic digestion, which can be used as a strategy for reducing agricultural GHG emissions. The main report traces the development of this technology from the 1970s, with a focus on Denmark, the Netherlands and Germany, and covers topics ranging from learning experiments to a growing commitment to the technology as a response to climate change, with significant government support. It is possible to identify a range of landscape drivers that have pushed the adoption of biogas (such as waste problems, climate change), the type of incentives used (e.g. feed-in tariffs) and a number of barriers that have constrained its further development, such as access to grid infrastructure. Each of the countries reviewed shows a different set of drivers of success: in Denmark this seems to be based on experimentation, strong “niche” networks and knowledge diffusion, supported by policy, whereas in Germany a strong transition vision and a series of policy instruments were effective. In both of these cases, the fact that biogas production

also offered a solution to the problem of farm waste was also a strong incentive for developers.

5.2 Biofuels

The second case examines the growth of biofuels in Sweden, where government and car companies worked with actors in forestry and agriculture in a series of experiments to develop alternative fuels (mainly methanol and ethanol). This presented a range of opportunities for energy transition, as it allowed a shift to low-carbon alternatives for the transport sector without far-reaching changes to mobility and its existing infrastructure. The main report provides a detailed account of how Sweden has adopted this technology during the post-war period and contrasts this with the approach taken in the Netherlands. The Swedish example highlights the effectiveness of using a mix of policy measures (both incentives and regulations) to ensure an adequate infrastructure to enable the diffusion of the technology, the value of established networks and the involvement of key regime actors (such as car companies). However, the case of biofuels also demonstrates the danger of locking in to a particular technology, where potential unintended side effects can arise, such as land use displacement. The figures for the registration of vehicles using biofuels appear similar to the figures for registration of ethanol vehicles in Sweden in terms of how they peaked and dropped, possibly in response to these concerns, and compounded by the drop in the price of crude oil. This underlines the importance of monitoring policy impacts, understanding the key drivers of technology uptake and reflecting on policy as broader contexts change.

5.3 Electric Vehicles

The third case examined EVs, which can play a key role in energy transition by contributing to air quality and significantly reducing GHG emissions, if renewable sources of electricity are used, while also helping to balance the load on electricity systems. The main report reviews the development of EV technology and focuses particularly on the case of Norway,

where over 33% of new cars registered in 2015 were fully electric. A key insight here is how support mechanisms, including incentives, infrastructure development and R&D, aided the adoption of the technology, by helping to overcome key barriers such as consumer perception, cost and other issues. This case also illustrates the importance of an advocacy organisation to disseminate knowledge and allow potential users to test-drive cars. However, a side effect of the increase in EVs in Norway appears to be an increase in overall car ownership, with EVs tending to be adopted as a household's second vehicle for shorter journeys. This highlights the risk that car use might continue to displace alternative modes of transport, such as walking, cycling or public transport, and thus in the long run could hinder a more fundamentally sustainable mobility transition. As EVs are only as sustainable as the electricity supply they use, it is important that the wider adoption of EVs is monitored in the context of their contribution to the overall mobility and energy transitions.

5.4 Development of an Evaluative Framework for Sustainable Technologies in Ireland

Drawing on the TIS and transitions literature, these case studies indicate how we can map the uptake of particular technologies within their overall societal

context. This takes into account the state of the innovation system, including systemic instruments (Weber and Rohracher, 2012) or transformational failures (Wieczorek and Hekkert, 2012), as well as broader long-term perspectives. The main report reviews the criteria taken into account in developing an evaluative framework that can be deployed to evaluate a number of sustainable technologies in Ireland and how they may be able to contribute to a society-wide sustainability transition. Three specific areas were identified as important to consider in the Irish case studies:

1. technology: technological readiness level and sustainability, including suitable indicators;
2. context of use: extent of learning networks, changes in social practice, and social acceptance, including the extent of stakeholder involvement and level of participation in development and planning processes;
3. policy learning, policy coherence and integration of existing capacity for this to assess and how reflexivity is built into policymaking processes at different levels.

This was elaborated into an evaluative framework, incorporating aspects of both transition and TIS approaches, for assessing the Irish case studies discussed in the following chapter.

6 The Context for the Irish Energy Transition: A Transitions Perspective

This chapter builds on the insights from previous elements of the study and combines this with research undertaken by other bodies to highlight some of the potential catalysts for and barriers to energy transition in Ireland. This chapter reviews the broad context for change in the Irish energy system, focusing on the key landscape forces (climate change, energy insecurity, etc.) and the key regimes (transport, electricity, agriculture) and it briefly discusses the national policy that influences the direction of transition. This facilitates the identification of key actors, as well as a discussion of the nature of key persistent problems that can hamper sociotechnical innovations and how these are being addressed. This section of the study is primarily informed by a review of the academic, policy and grey literature, as well as 12 semi-structured interviews with key stakeholders. The resulting analysis formed a key input into the two workshops held as part of the project.³

This chapter is closely informed by the conceptual framework outlined above, particularly the MLP to sketch the wider context for change. The Irish energy system is viewed as underpinning a number of key co-evolving societal systems, including transport, electricity and heating/cooling. Each of these is characterised by dominant structures, cultures and practices and is situated within a broader landscape. Persistent problems appear within these regimes when locked-in elements fail to evolve or adapt to landscape pressures (such as climate change). Social and sociotechnical innovations can be conceptualised as developing in protective spaces or niches – these are places where “radical novelties emerge” (Geels and Schot, 2007, p. 400). Mapping the dynamics of interaction within and between these levels can give insight into where change can be catalysed and where it is being blocked. Therefore, we can apply this framework to describe the characteristics and dynamics of the Irish energy system in terms of broader landscape pressures, the structures and practices that make up the energy regime, the way

that policy is encouraging or hampering innovations and the scope for niche innovation.

6.1 Energy in Ireland

The main report provides an overview of the wider context for transition in Ireland, highlighting particular issues of energy security, dependence on imported fossil fuels and carbon lock-in. This situation has evolved over decades and centuries to provide structures, practices and infrastructure that have a strong inertia towards a carbon-intensive energy system. Other contributing factors are Ireland’s island status, climate, low population density and population distribution. These have all influenced the evolution of the transport and agricultural sectors, which remain key contributors to GHG emissions. Transport consumes a greater proportion of final energy than any other part of the economy (42%), is the largest contributor to CO₂ emissions (37%) and is 97% dependent on fossil fuels. Agriculture is the largest overall contributor to GHG emissions (33.3%) and this is projected to rise, particularly with the government’s policy objective of increasing dairy production (DAFM, 2015). Set against this is the substantial potential for developing wind and marine energy, underpinned by the target to have 40% of electricity come from renewables by 2020, although there are increasing issues of social acceptance (NESC, 2014).

A strong landscape influence on Ireland’s energy policy is its membership of the EU, which sets the broad framework for energy policy, markets and regulation. This has resulted in liberalisation of the Irish electricity market and closer integration with other EU energy systems; it also drives energy efficiency, reduces energy demand and supports innovation. Ireland ratified the COP21 Paris Agreement in November 2016 and as a result will have to adopt a new emissions target. As an island with high import dependency, as discussed previously, the Irish energy system is particularly vulnerable to outside influences, such as

3 See Chapter 2, with workshop reports available online at <http://erc.epa.ie/safer/reports> (accessed 1 October 2016).

oil and gas price increases. Despite an increase in wind capacity, the variable nature of wind means that a dispatchable source of power, such as natural gas, is extensively used for electricity production (as well as for domestic heating and cooking), and this situation has been projected to remain [see the Sustainable Energy Authority of Ireland (SEAI) electricity roadmap: SEAI, 2011].

Key actors in the Irish energy system are detailed in the main report and include relevant government departments, the SEAI, other regulators and energy producers. Electricity infrastructure is largely controlled by EirGrid, which is strengthening the ability of the grid to cope with increased levels of renewable energy and is exploring demand-side capabilities through its DS3 programme (EirGrid, 2015). Storage is a key element of demand-side management, and technologies that have the potential to be charged at times of high production, such as EVs, have thus been promoted. ESB Networks operates the distribution network and is responsible for maintenance, repairs and construction. It enables grid access for most electricity producers. A number of independent electricity providers, e.g. Electric Ireland, Airtricity and Energia, supply electricity to consumers. A significant proportion of electricity in Ireland is also generated using gas, most of which (93% of the total used) is imported via Moffat in Scotland. The heavy reliance on this channel is regarded as a weak point in the security of supply (SEAI, 2016).

A critical component of the overall energy system is the heating and cooling regime, with 23% of energy consumed by the residential sector and 11.5% by the commercial and public services sectors in 2014 (SEAI, 2015). Improvements in energy efficiency (e.g. improved building standards) have reduced the amount of energy required, and variations in the weather can influence energy demand (SEAI, 2015). Fossil fuels accounted for 71.4% of residential energy use in 2014, down from 82% in 1990. The composition of fuels has changed over time, shifting from coal and peat towards a greater use of oil (34% in 2014), gas (2.1%) and renewables (2.6%) (SEAI, 2015). In 2014,

transport was responsible for the largest proportion of total final energy consumption (42%) (SEAI, 2015) and remains almost entirely dependent on imported fossil fuels. Private cars dominate the transport sector.

In response to climate challenges, new practices and technologies have sought to gain a foothold within the Irish energy system and, although existing regimes have begun to adapt to some of these, significant challenges remain. Responses have included the increase in renewable energy and the infrastructure, policies, practices and innovation that support this. There has been a significant expansion of wind energy and the grid infrastructure to support this, though social acceptance issues still exist; energy efficiency measures in the built environment; and initiatives to foster investment and innovation in areas such as biomass and marine energy. Community energy projects have also been incentivised by SEAI, and these can be viewed as social innovations that foster the development of growing niche practices that may pressurise the existing energy regime. These range hugely in terms of scale, communities involved and technologies used, with over 300 projects having been supported by 2019⁴. However, barriers to community energy in Ireland include a lack of adequately funded support mechanisms at local government and community levels, as well as grid access issues (FoE *et al.* 2014).

Only a brief summary is presented here, and the main report is also only able to sketch some of the main dimensions of the complexity of the Irish energy system. However, a detailed understanding of how this operates as a complex sociotechnical system is still needed. Although existing models of the Irish energy system (such as the SEAI roadmaps and the Irish TIMES model; Ó Gallachóir *et al.*, 2012) have great value in providing an understanding of the technological and economic constraints and capacities of the Irish energy system, we should be aware of their limitations (Finn, 2012) and aim to augment them with analyses that enable more complex (especially social) aspects of the energy system and the core persistent problems that contribute to its unsustainability.

4 www.seai.ie/grants/community-grants/project-criteria-and-funding/ (accessed 4 June 2019).

7 The Irish Energy Transition: Technology Case Studies

A transitions perspective envisages change driven by niches representing innovative local practices, local actors and technologies. The National Economic & Social Council (NESC) (2012) identified six specific projects⁵ that could be taken forward to explore possibilities and experimentation in an Irish context. In conjunction with the steering committee, bioenergy and EVs were identified from this list as appropriate technologies to explore how Ireland facilitates such innovative practices, using the TIS framework discussed previously.

7.1 Bioenergy

As noted previously, bioenergy is a diverse and complex area covering a wide range of processes, supply chains and technologies. Bioenergy could contribute significantly to Ireland's energy transition; however, there is still a long way to go before this is achieved. Regarding the 2020 targets for renewable heat, SEAI estimates that the shortfall could be in the region of 2-4 percentage points of the 12% renewable heat (RES-H) target (see SEAI, 2016), suggesting that this could be overcome if 300,000 homes, 3000 services/public sector buildings or 200 large industrial sites could be encouraged to install renewable heat options, such as biomass boilers, solar thermal systems or biomass combined heat and power (CHP) systems, before 2020. However, given the scale of uptake required and the time required for new installations, it is highly improbable that targets will be met. The development of an evidence base for the operation of both technologies and business models would serve to document successes and failures and drive learning (as happened in the biogas sector in Denmark). For small-scale units, such as

CHP plants, a number of barriers to grid access have emerged, such as the "clogging of the list" with solar applications. Meeting transport targets would require a supply of between 440 and 500 million litres of biofuels to be secured for blending with fossil fuels for transport, in order to increase the biofuel consumption level to 8% by 2020, which, given land use considerations, raises questions on the sustainability of this option.

7.2 Electric Vehicles

Electric vehicles can play an important role in the decarbonisation of the transport fleet and, with added support and demonstration projects, uptake rates could be further encouraged. Ecars by ESB have been involved in research, demonstration and infrastructural projects from a relatively early stage, and there is a small, but strong, research base in EVs and smart grid technology, which has contributed to a number of major EU projects and other international collaborations. A number of problems have contributed to the low uptake of EVs, including public perception of EVs, the extent of the charging network, lack of information, range anxiety, and a lack of choice of vehicles, exacerbated by the fact that Ireland uses right-hand drive cars. Actors in the area have argued for a firm and strong vision that takes a longer-term approach and cite a short-term outlook in Irish politics as a barrier to change. In December 2016 the Irish government established a Low Emission Vehicle (LEV) Taskforce to identify options for decarbonisation of the transport sector, and this reported in 2018 with a set of recommendations.⁶

5 The six projects are (i) carbon-neutral agriculture, (ii) smart grid, (iii) EVs, (iv) electrification of heat, (v) biomethane and anaerobic digestion and (vi) carbon capability.

6 <https://www.dccae.gov.ie/en-ie/energy/publications/Documents/21/LEV%20Taskforce%20Phase1%20Progress%20Report.pdf> (accessed 4 June 2019).

8 Characterising the Transition: International Benchmarking

Following the Irish case studies, this chapter goes on to explore how the state of Ireland's transition could be usefully "benchmarked". Here, the term "benchmarking" is interpreted in a broad sense as the setting of a target, standard or exemplar of good practice and the process of measurement or assessment used to provide qualitative or quantitative indicators that could help determine the extent to which the benchmark has been reached. The main report considers whether or not it is possible to actually have meaningful benchmarks for transitions, given their complex, long-term and multi-dimensional character, and the dangers of oversimplifying the nature of transformation required. Given a number of provisos, the idea of a benchmarking process is taken forward on the assumption that the main purpose of such a process would be to promote learning, through identifying potential gaps in capacity, providing potential options for action and evaluating the outcomes of existing approaches. Here, it is assumed that a strategic transition monitoring, incorporating social, behavioural, economic, technical and political aspects, could inform, contextualise and help construct a more comprehensive and holistic view of transition. Although a broad-based view clearly cannot provide the level of detail required for change initiatives at a micro level, it can help in the construction of orienting visions needed, for example to address what Weber and Rohrer (2012) have termed "directionality failure", where innovation lacks sufficient vision, co-ordination, regulation or targeted resources to address specific societal challenges.⁷ It is envisaged that a series of benchmarking activities at, or incorporating, different scale levels could contribute to such an overall assessment. To help inform such a process, the main report reviews a number of international experiences that seek to monitor change

in national energy systems and identifies potential rubrics that could be used to help benchmark transition in Ireland.

8.1 Examples of International Benchmarking

The main report considers the rationale for why a number of key international organisations have introduced forms of benchmarking of national energy systems. These vary from setting markers for best practice (e.g. the EU Covenant of Mayors Benchmarks of Excellence) to more regulatory reporting processes to monitor progress towards energy sustainability or efficiency (e.g. EU annual reports on national GHG emissions) and identifying priority areas for public intervention (e.g. the International Renewable Energy Agency – IRENA). A selection of these benchmarking organisations and instruments is reviewed in the main report and includes:

- The EU. The EU and its Member States are required to provide annual reports to the United Nations (UN) regarding their GHG emissions, and they must also report on climate change policies, measures and progress towards targets on a regular basis. Metrics relating to energy transition available on Eurostat include the proportion of renewable energy as a percentage of gross final energy consumption, energy intensity of the economy, the proportion of electricity generated from renewable sources, CHP generation and GHG emissions intensity of energy consumption. Also of relevance to a transitions approach is the benchmarking of innovation, with the EU having developed an Innovation Scoreboard.⁸
- The International Energy Agency (IEA). One of the IEA's roles has been to track progress towards

⁷ Weber and Rohrer (2012) define "directionality failure" of a technological innovation system as comprising a number of components: (i) the "lack of a shared vision regarding the goal and direction of the transformation process"; (ii) "inability of collective coordination of distributed agents involved in shaping systemic change"; (iii) "insufficient regulation or standards to guide and consolidate the direction of change"; and (iv) "lack of targeted funding for research, development and demonstration projects and infrastructures to establish corridors of acceptable development paths" (p. 1045).

⁸ See http://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards/index_en.htm (accessed 4 June 2019).

sustainable energy systems through a series of metrics, in order to focus attention on the steps needed to achieve long-term and short-term climate goals, which in turn inform the international climate policy process and the development of national action plans. The IEA deploys a suite of indicators of transition and tracks changes in underlying energy infrastructure, GHG emissions, renewable energy deployment, energy efficiency improvements, low-carbon investment and policy analyses of its member countries.

- The World Energy Council (WEC). The WEC undertakes an annual benchmarking process, ranking countries on their performance in the “energy trilemma” of energy security, energy equity and environmental sustainability.
- The main report provides a review of international benchmarking studies in energy and illustrates the diversity of approaches such as environmental and energy indicators, policy instruments and indicators of innovation capacity. These are undoubtedly useful, but can lack the level of detail needed to inform decision-making at national or regional scales and may be based on unstated assumptions. Translating complex phenomena into numerical values may also give false impressions, for instance taking potentially contentious normative agendas and converting them into formats that gain credibility through rhetorical claims to “neutrality” or “technocratic” assessment (Broome and Quirk 2015:814). In addition, Sovacool (2016) argues that looking at higher level benchmarks, such as overall energy consumption, misses the small-scale changes that are the foundation of transitions.

How a societal energy transition is conceptualised will shape how progress is evaluated, and this in turn will depend on the implicit or explicit values of those governing the framing process. There is a need to look at more diverse and contingent aspects of transition processes and how changes have been achieved, for example there could be more localised data gathering, aimed at building regional or community resilience to environmental challenges (Hulme, 2010). Given the need to account for future uncertainties and the potential of unforeseen side effects occurring with technical and social innovations, there is also a clear need for reflexive monitoring. It has been argued that transitions are best served by a “reflexive political

learning process” (Kuzemko, 2016), that does not assume that answers are already known and can be technically measured. Such a process would include monitoring of and reflection on emerging processes by relevant stakeholders and from different perspectives, so that unintended consequences of different types can be identified and remedied.

This review therefore leads to the identification of a number of principles that should be reflected in any benchmarking of the Irish energy system:

1. Benchmarking should be viewed as a reflexive practice and thus becomes a *cyclical* process.
2. Benchmarking processes should exist for use at different scale levels (community, regional, national).
3. Benchmarking indicators can be used to construct an orienting vision, based on a set of core values, and could therefore be used as a first stage in the transition process (see Chapter 9).
4. Processes used for setting benchmarks can, and should, involve deliberative engagement with multiple stakeholders.
5. Both qualitative and quantitative benchmarks are important.
6. Benchmarks should reflect both local and international experiences of transition, as well as the current state of the Irish energy system.

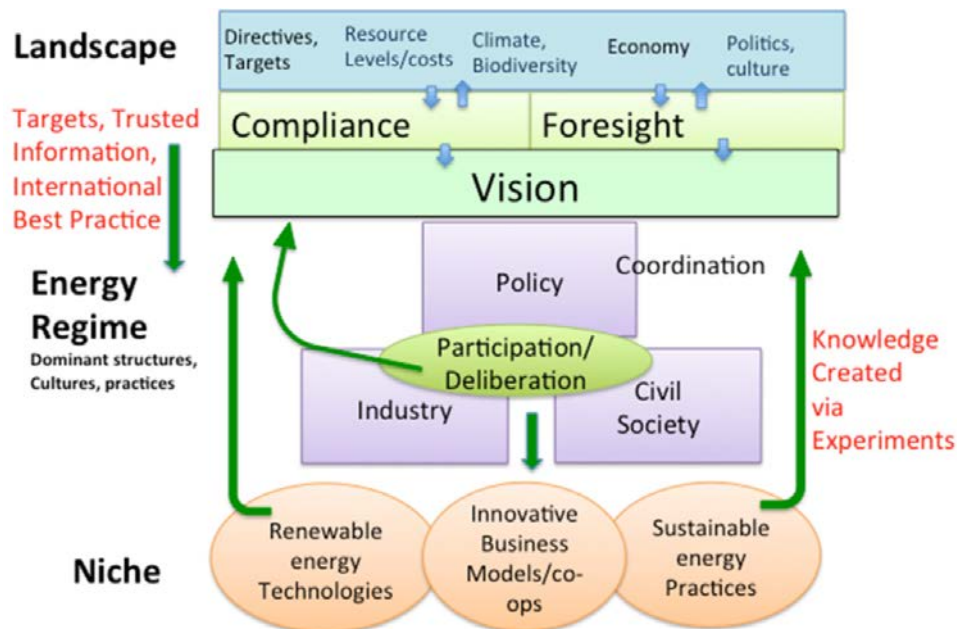
8.2 Benchmarking the Irish Transition

These principles can be combined with other concepts described in this report, particularly the MLP and TM, in order to suggest ways in which the Irish transition could be benchmarked. This could involve a reflective and inclusive process that would evaluate progress and itself while facilitating learning and change. This framework is briefly summarised in Table 8.1 and Figure 8.1, and shows how the MLP could be used to structure benchmarking processes in building capacity for energy transition.

Our primary assumption here is that benchmarking processes can best be viewed as tools for learning and path creation (Garud and Karnøe, 2001) in spaces enabling reflection, knowledge dissemination, debate, discussion and deliberation, and therefore

Table 8.1. Applying MLP to frame an Irish benchmarking process

MLP concept	Key benchmarking objective	Examples of benchmarking issues
Landscape	A focus on the capacities to respond to landscape forces highlights the abilities to comply with externally imposed requirements and to anticipate and ameliorate vulnerabilities to external shocks. Benchmarking at this level can also help understand the effectiveness of top-down transition pathways	- Ensuring compliance with EU directives and achieving energy and climate targets - Capacities to anticipate and deal with future vulnerabilities by risks linked to, for example, energy crises
Regime	A focus here is to understand the capacities for changing the dominant structures, cultures and practices of the energy regime	- Capacities to address identified problems, such as lack of overall transition vision or public awareness of the transition challenges - Capacities for policymaking, that can ensure policy coherence and enable policy learning - Capacities to enable <i>reflexive governance</i> including adequate stakeholder (including civil society) consultation and participation, through policy forums and citizens assemblies
Niche	A focus on social and technical innovation, including technologies, organisations, business models and social practices, facilitates an understanding of the extent to which Ireland is “open” to the sustainable, “full-spectrum” innovation of different types needed to drive an energy systems transition	A range of capacities could be usefully benchmarked here, and incorporate existing processes. For example: - Benchmarking <i>niche formation</i> could incorporate existing indicators of innovation that are relevant to energy transition (education, culture of entrepreneurship, patents), targets that encourage technological innovation, levels of R&D investment, etc. - Benchmarking <i>niche nurturing</i>: for example, capacities needed for the development of niches, such as the level and effectiveness of the different types of support provided or needed to encourage the development of energy communities

**Figure 8.1. Benchmarking capacities for transition: dynamic processes of path creation.**

act as an integral part of the transition process. It is assumed that benchmarking processes might involve a range of activities such as establishing core principles and values, identifying where further knowledge or evidence might be needed and reflecting on the effectiveness of indicators or the extent to which targets were achieved. A central principle adopted here is reflexivity, i.e. benchmarks

and targets and the means by which they are achieved should be subject to periodic reflection and review by relevant stakeholders. We also assume that the structuring of the benchmarking processes should also be subject to reflection and review. These assumptions imply that benchmarking essentially can constitute a cyclical learning process embedded within transition.

9 Catalysing an Irish Low-carbon Transition

This chapter brings together the insights from the previous parts of this report to identify the ways in which the perspective of sustainability transitions could be adopted in the case of the Irish energy system. The review of the different conceptual elements of transition (MLP, SNM, etc.) provides powerful frames in which to understand the dynamics of transformational change. The specific area of TM (Kemp *et al.*, 2007a; Loorbach, 2010; see section 3.3) attempts to operationalise these ideas through forms of governance that will catalyse the opportunities for progressive shifts towards desirable, sustainable outcomes for society, which are discussed in more detail in the main report. Roorda *et al.* (2014) usefully summarise the core criteria for TM as being to:

- generate insights into the overall system and understand complexities, interdependencies and functioning;
- aid system innovation in incremental steps and sustain progress through small radical initiatives;
- maintain diversity and flexibility to keep future options open;
- co-create innovation and solutions by engaging with a wide range of stakeholders;
- create opportunities for change agents by facilitating action by those who are already adopting new ways of thinking and doing; and
- encourage social and institutional learning and create the conditions for reflection, openness and pluralism.

These criteria are taken forward here to identify some first, tentative steps for an Irish process of TM focused on four dimensions – (i) research/knowledge exchange, (ii) implementing TM, (iii) experimentation and (iv) benchmarking/monitoring – as discussed below and in more detail in the main report.

9.1 Research and Knowledge Exchange in Support of an Irish Energy Transition

University research, and academic collaboration with policymakers, have been a central feature of how we have come to understand societal

transformations as transitions. Although there has been a wealth of international and Irish-specific research undertaken in fields, such as climate change and energy and technological innovation, this has not, as yet, been brought together within a transitions framework. As noted previously, the intricacy of energy transition demands new ways of thinking in order to grapple with the intractable nature of persistent problems and mobilise long-term shifts in complex regimes and systems. This must combine the normative dimensions (steering, visioning) of transitions with an action-oriented approach to help overcome the policy–practice interface and the politicised context of powerful, incumbent actors (Kl  y *et al.*, 2015; Fazey *et al.*, 2018a). A transition approach recognises that long-term shifts evolve from a collection of short-term actions and that research can be highly influential in shaping these. Research, and its interface with those “doing” transition, is therefore an important component in developing national capacity for, and the catalysation of, energy transformation.

Universities, research funders and other knowledge creators have opportunities to stimulate new forms of thinking and innovative practice that can help generate and sustain a sustainability transition. There are a number of emerging agendas for the knowledge needed for sustainable transformation (e.g. K  hler *et al.*, 2017; Fazey, 2018a), which can help guide an Irish framework for transitions research. With this in mind, Fazey *et al.* (2018b) usefully set out 10 critical principles for research that most effectively support transition:

1. Focus on transformations to low-carbon, resilient living, i.e. research should explicitly focus on the need for radical change, including drivers, barriers and possibilities. There are, of course, different views on what “transformational” change actually is, so there is a need to be explicit about normative assumptions, envisaged end states and motivations.
2. Focus on solution processes. This may include more conventional approaches to problem-oriented research but should go further to

seek normative solutions and intervention methodologies for change.

3. Focus on “how to” practical knowledge, i.e. the development not only of academic knowledge (episteme) but also practical forms of knowledge (techne, phronesis), including research *into, for/as* or *through* practice, which faces challenges in the context of traditional university research.
4. Research “from within” the system, leading to intervention, i.e. a shift away from researchers seeing themselves as outside the phenomena they are studying and encouraging reflection on their own role. Research can then become as much about social change, innovation and engagement as about knowledge generation and dissemination.
5. Work with normative aspects, i.e. with researchers being explicit about the values and ethics that influence their investigations, as one can see in ‘post-normal science’ approaches.
6. Seek to transcend current thinking, i.e. seek to overcome the inherent conservatism and incremental nature of change in science by seeking new ways of framing problems and generating new research fields and novel research questions.
7. Take an explicitly interdisciplinary, multi-faceted approach to understand and shape change, i.e. seek to adopt pluralistic ontologies and epistemologies to understand problems in order to avoid narrowly prescribed solutions and reflect the complexity of the phenomena that influence transitions.
8. Acknowledge the value of alternative roles of researchers. Although posing several challenges, researchers should acknowledge the diverse roles that they can play in transition research, including being knowledge brokers, mediating between parties and framing or guiding action.
9. Encourage second-order experimentation, i.e. an important element of transitions is an ability to experiment. This can provide a key role for researchers to integrate their work with actions,

projects and initiatives, which can give unique insights that cannot be achieved through more traditional approaches to project evaluation.

10. Be reflexive. It is crucial for researchers to embrace reflexivity as much as other actors, as this helps maintain a focus on transformational change and practice, and helps identify new frames to understand and tackle persistent problems.

This presents a challenging set of criteria for a transition-supporting research programme, which underlines the fact that transition requires a deep questioning of how we unlock new knowledge and modes of thinking to further catalyse the future trajectory of sustainable development, in addition to understanding the dynamics governing the regimes of energy, food, transport, etc. Although Ireland does have a number of scholars engaged with innovative work on a wide range of topics of value to the country’s energy transition, there is not a critical mass of researchers working explicitly on the topic of a transitions frame, undertaking research that aligns with the key criteria listed above and who are heavily integrated with wider international networks of transition scholars. Given the potential contribution that could be made by an effective transition academy, this should be regarded as a critical component of Ireland’s capacity for transition. Therefore, in addition to the wider TM approach described below, consideration should be given to both developing strategic knowledge actions for stimulating broader research capacity for transitions and assembling a specific agenda of research topics, including strategic knowledge actions and topics for an Irish transition research agenda, as detailed in sections 9.1.1 and 9.1.2.

9.1.1 Strategic knowledge actions

This should broaden the understanding of research to encompass, and explicitly encourage, those knowledge-generating activities that most support transition, guided by the principles of Fazey *et al.* (2018b; discussed previously). A key way of understanding this is to conceptualise science as

being both first-order⁹ and second-order¹⁰ science. The current research landscape is dominated by first-order research, with second-order science viewed as risky (Umpleby, 2014), not least because of established conceptions of credibility and legitimacy. Nonetheless, varied types of research conducted into, for/as and through practice particularly relate to transition-aligned experimentation (see below). In order to develop such capacity in this type of research, the following could be considered as strategic actions:

- Create strategic funding streams – through the EPA, Irish Research Council, Science Foundation Ireland (SFI), etc. – for action research, the science–policy interface, systems analysis and future studies.
- Reinforce the value of second-order research by ensuring that key “change agents” (rather than vested interests, incumbents) have a voice on funding decisions to challenge what we already know and stimulate new conceptual frames.
- Fund innovative partnerships, fellowships or even establish research centres to act as centres of expertise through open competitive calls, develop appropriate methodologies for more open science, generate impact in transitions research and create links with similar established centres in other jurisdictions.¹¹
- Encourage research funders (EPA, SFI, etc.) to engage in experimentation on how best to stimulate and sustain innovative knowledge-generating activities aligned with the objectives of low carbon energy transitions.
- Develop new models of knowledge network, including new forms of intermediary, to engage with a wider range of social and economic actors and innovate ways of sharing the knowledge that could help drive transition.

9.1.2 Topics for an Irish transition research agenda

In addition to the strategic actions required to encourage the emergence of Irish research capacity, the EPA and other research funders are also in a position to stimulate and commission research (both first and second order) on a range of topics that will directly support the Irish transition, and in so doing they also contribute to wider international learning. Although there is a need for a more focused review to provide a more robust analysis of Irish research priorities in this area and to provide a more coherent overall framework, Köhler *et al.* (2017) have established a broad research agenda for sustainability transitions that provides useful guidance for the type of research that could be considered for future research calls. Although more detail is provided in the main report, the categories of Köhler *et al.* (2017) are described in the following sections.

Understanding transitions

Understanding transitions relates to the development of the analytical framework used to understand the characteristics of sustainability transitions and how they can be deployed to conceptualise the Irish energy transition. Topics may include developing a systems approach to understanding the Irish energy sector – in particular, how changes in one sector (food, transport) can have consequences for a broader multi-regime transition – and the specific path dependencies that now shape Ireland’s potential future energy pathways.

Power, agency and politics in transitions

Power, agency and politics in transitions relates to the criticisms of transition research that suggests that it inadequately addresses the political nature of

9 First-order science is that which identifies, describes and analyses processes of change, from a distance, and disseminates these through a process of knowledge exchange. Research is independent from the process of change. Examples include understanding technological innovation, the impacts and causes of climate change and the economics of energy production.

10 Second-order science is more linked to action and emphasises reflective practice, tending to see change as emerging from within, rather than as a result of addressing, an external problem. Because of this, the science is more likely to be transdisciplinary and involve action research, resulting in practical suggestions of solutions to real-life problems. Examples include developing resilience strategies directly with local communities and evaluating their impact, or working with companies to understand how they make critical decisions on energy use or investment on energy efficiency.

11 For example the Dutch Research Institute for Transitions (DRIFT, <https://drift.eur.nl/>), Climate CoLab (<https://www.climatecolab.org/>) and the Edinburgh Centre for Carbon Innovation (<https://edinburghcentre.org/>).

social change (e.g. Shove and Walker, 2007; Kern, 2015; Avelino *et al.*, 2016), which has both theoretical and operational values. Although this is now being addressed by researchers in a range of countries, there is little detailed understanding of the specific politics of transition in Ireland, in particular mapping of the conflicting goals and interests around transition in an Irish context, including identifying powerful incumbent regime actors in Ireland, specifically in relation to food and transport regimes. There is also little detailed understanding of the role of public participation and bottom-up pressure for transition and the influence of non-state actors in initiating regime shifts.

Governing transitions

While linking with other themes, governing transitions specifically relates to how to most effectively use the agency of the state and other institutions to steer sociotechnical transformation in desirable directions. Topics may include the role and impact of experiments on transition outcomes in Ireland, a detailed comparative mapping of Irish institutional structures for transition compared with other national “forerunners” and exploring how a range of policy areas (spatial planning, agriculture, etc.) may align or conflict with emerging transition visions.

Civil society, culture and social movements in transitions

This relates to the important roles of civic actors, grassroots innovation, cultural change and social movements as alternative sources of agency and power for transition. Topics may include understanding the nature and role of broad coalitions around key transition topics (such as community energy) in an Irish context and the potential role of “traditional” civic actors (farmers’ co-operatives, trade unions, religious groups) in initiating and sustaining change.

Organisations and industries in sustainability transitions

This includes understanding the role of firms and businesses in transition, particularly in relation

to driving innovation, creating markets for novel technologies and developing many other aspects of demand and collective expectations. Topics may include the dynamics of “alternative” economic organisation (prosumers, sharing economy, social enterprises) in niche formation in Ireland and the role of finance capital (hedge funds, pension funds, private equity, etc.) as a barrier to, or facilitator of, transition.

Transitions in consumption and everyday life

Transitions in consumption and everyday life relate to issues, such as the final consumption of goods and services, and, particularly, the users of new technologies and innovations. Topics may include consumer perspectives on the circular or sharing economy and deepening the understanding of key social mechanisms and cultural shifts involved with sustainability in everyday life in an Irish context.

Geography of transitions: spaces, scales, places

This relates to the under-researched aspects of the spatial and scalar dimensions of sustainability transitions. Topics may include understanding how urban and regional visions and policies in Ireland can act as sources of transition, exploring how the “smart city” discourse can be harnessed for transition and exploring the impact of local natural resource endowments and infrastructure obduracy on local transition narratives.

Ethical aspects of transitions: distribution, justice, poverty

These relate to the need to confront value-based trade-offs (future/present, human/environment) and the idea that transitions are not just a vehicle for reflecting environmental concerns but also constitute a broader normative idea of sustainable development and thus they encompass issues of gender inequality, poverty alleviation and other aspects of social justice. Topics may include exploring opportunities for an Irish transition to be linked to other outcomes, resulting in “just sustainabilities” (Agyeman, 2013) and poverty reduction (including energy poverty), and identifying how transition can

be linked to Ireland's commitment to overseas development and the New Urban Agenda.

Methodologies for transitions research

The methodologies for transitions research relate to the further development of epistemologies and methodologies for how we investigate transitions. Topics may include refinement of appropriate indicators for benchmarking and monitoring of the Irish transition, linking existing Irish energy modelling (TIMES, etc.) with transition perspectives and developing models of participatory and action research that are suitable for the Irish context.

In addition to the above, an important and initial step will be to conduct a more detailed systems mapping of complexity of the Irish energy system, noting key actors, sources of agency and path dependencies, as well as its interactions with other systems (food, transport, etc.). There appears to be an undeveloped picture of how this operates holistically as a complex sociotechnical system, and an elaborate systems map, developed through a foresight approach, would offer a valuable exercise to develop a common

understanding of the challenge ahead and act as an initial input to the TM process discussed below.

9.2 Implementing Transition Management in Ireland

As noted previously, this report has drawn on a number of valuable conceptual approaches to help understand the dynamics involved in the transformation of the Irish energy system and this discussion focuses on the insights from TM and its implementation in practice, drawing on its outline in theory (e.g. Kemp *et al.*, 2007a; Loorbach and Rotmans, 2010; Frantzeskaki *et al.*, 2012) and practice (Voß *et al.*, 2009; Loorbach and Rotmans, 2010; Loorbach *et al.*, 2008) and following guidance on how to implement a transition process (Roorda *et al.*, 2014). This suggests that TM can be envisaged as a cycle having four key components (see Figure 3.4), which has been further elaborated by Roorda *et al.* (2014), as shown in Figure 9.1 and Table 9.1.

This provides useful guidance for how a transition process could be initiated in Ireland and much of what follows draws on Roorda *et al.* (2014) to outline

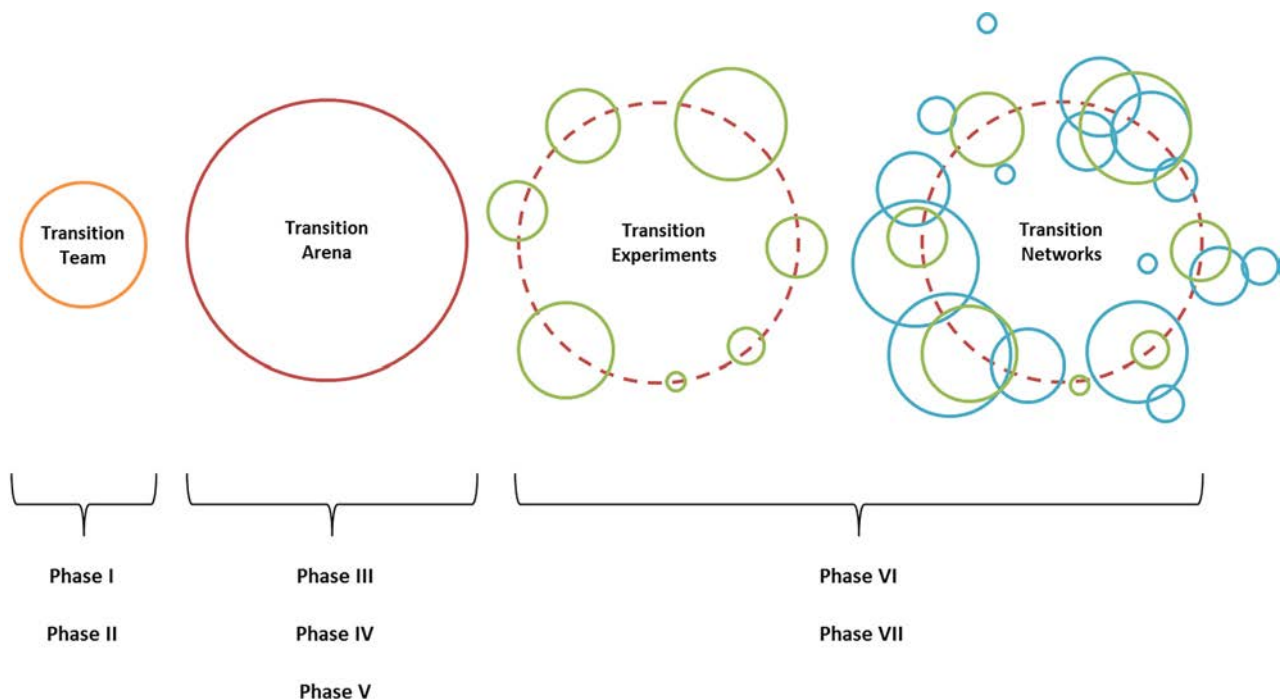


Figure 9.1. Process outline of TM. Reproduced from Roorda *et al.* (2004). This is an Open Access article distributed under the terms of the Creative Commons Attribution-NoDerivs 3.0 Unported License, which permits the copying and redistribution of the material in any medium or format for any purpose, even commercially, provided the original author and source are credited. See <https://creativecommons.org/licenses/by-nd/3.0/>.

Table 9.1. Outline of the TM process

Phase	Process steps
I Setting the scene for Transition Management	The Transition Team is formed to drive the TM process and start to explore the cities dynamics (takes 3–6 months)
II Exploring dynamics in your city	
III Framing the transition challenge	The Transition Arena group is formed and engages in a series of meetings to jointly structure the transition challenge, draft visionary images and develop transition paths and the transition agenda.(takes 6–12 months)
IV Envisaging a sustainable city	
V Reconnecting long term & short term	
VI Getting into action	Effort is put into disseminating the vision and transition agenda; initiating actions in line with the vision (transition experiments); and engaging more actors and networks.
VII Engaging & anchoring	

Reproduced from Roorda *et al.* (2004). This is an Open Access article distributed under the terms of the Creative Commons Attribution-NoDerivs 3.0 Unported License, which permits the copying and redistribution of the material in any medium or format for any purpose, even commercially, provided the original author and source are credited. See <https://creativecommons.org/licenses/by-nd/3.0/>

the key steps. However, while this represents an outline of a potential process, it will, of course, have to be adapted according to the specific Irish actors involved, sponsoring bodies and resources available. The main report discusses these steps in more detail, but some of the key factors requiring external catalysts are discussed in the following subsections.

9.2.1 *A national Irish transition team*

The creation of a transition team is the first step in initiating the TM process. This is expected to drive the process over 18–24 months and should consist of three to five people from a mix of the initiation organisations and other external experts (energy experts, facilitators, etc.). The team would be responsible for designing and facilitating the national process of TM appropriate to Ireland, liaise with other key organisations, co-ordinate logistics, facilitate processes and have substantive input into transition arena meetings. Although a matter for government and related institutions, this could be sponsored and initiated by the EPA, NESC, the Taoiseach's office or a government department. Roorda *et al.* (2014) suggest that the transition team should undertake a systems analysis to provide an overview and understanding of the key challenges, and map key actors through a mix of research, interviews and expert discussions. A key and challenging element of this is to identify individuals and organisations that may represent “change agents” to join the transition arena. It was previously noted that this first step could be taken forward as an elaboration of this report, drawing on the need for a more complex systems mapping and elaboration of benchmark indicators, potentially through future EPA-funded projects. It may also be useful to

engage with transitions teams that have operated at the national level in other European countries to learn from and reflect on their experience.

9.2.2 *A national transition arena for Ireland*

A “transition arena” is a core idea of TM, envisaged as “a small network of front-runners with different backgrounds, within which various perceptions of a specific persistent problem and possible direction for solutions can be deliberatively confronted with each other and subsequently integrated” (Loorbach, 2010, p. 173). The transition arena is intended to be temporary and should consist of a series of meetings of a small and diverse group of 10–15 people, aimed at engaging in critical reflection and visioning innovative aspects of a sustainability transition. There are many factors to consider when inviting people to participate in the transition arena, particularly if a state body is the initiating/sponsoring body. Members are not intended to be representative and are invited on an individual capacity basis, with a willingness to go beyond the business-as-usual approach being a key criterion. Members should also be open to change and have a diversity of opinions, backgrounds (business, research, politics, government, etc.), domains (energy, food, transport, industry, etc.) and competencies (leadership, communication, analysis, etc.). The initial focus of the transition arena should be to consider and elaborate the systems analysis prepared by the transition team to develop a shared understanding of the transition challenge and to begin to envisage the transition process. The outcome of this process is a long-term vision that acts as a motivating storyline and a steer for strategies and short-term action.

9.2.3 Developing an Irish transition agenda

The vision of transition developed in the transition arena is then taken forward via the development of transition pathways, which can provide potential routes to the envisaged future and which involve a variety of techniques, including backcasting. This will include the identification of potential interventions and goals for the short, medium and long term, which should come together in a transition agenda to prioritise transition pathways and motivate short-term actions. Subgroups of the arena will then be expected to take on different aspects of implementation. The end of this phase is a transition narrative, encompassing vision, agenda and pathways.

At this point (the end of phase iv, see Table 9.1), the transition process needs to be opened up to a broader audience and the transition arena is formally ended; participants will take forward the initiative in different guises and experimentation then becomes important. At the national level, it will be important that a sponsoring body continues to support a transition team to sustain the process, engage a wider set of stakeholders in the transition vision and establish broader support networks for experimentation (see section 9.3).

9.3 Supporting Transition Experiments

The role of experimentation has an important role in transitions (Kemp *et al.*, 2005), offering opportunities to develop niches that may induce wider regime shifts, stimulate more reflexive forms of governance and provide opportunities for the second-order forms of science noted previously (i.e. learning into, for/as and through practice). Such experiments have been defined as “an innovation project with a societal challenge as a starting point from learning aimed at contributing to a transition” (van den Bosch and Rothmans, 2008, p. 17). These are not just related to emerging technologies, but could relate to, for example, institutional, social-cultural, legal or financial innovations (Weiland *et al.*, 2017), and are often regarded as high risk. Experiments could involve co-ordinating individual actions (such as a campaign for individuals to adopt a lifestyle without plastic) at a local community scale (such as a group implementing car sharing or a community energy scheme) or at a much larger scale (such as the diffusion of

innovative green technologies or the implementation of new regulatory systems). Given the central role of experimentation, it is important that Ireland reflects on how the energy of pioneers and first movers (from individual entrepreneurs to innovative civil servants), seen as the core lifeblood of transitions, can be enhanced and used as a broader vehicle for social learning. Given the limited desk-based nature of this study, it is suggested that the idea of “sustainability experimentation” needs more explicit attention across a wide range of state and state-related activity, with state and semi-state institutions being encouraged to experiment themselves. This includes reviewing existing programmes of R&D support offered by bodies, such as Enterprise Ireland and SEAI, as well as instigating second-order science programmes in the traditional research funding offered by SFI, the Irish Research Council and the EPA. This could also involve a review of the current state of social and sociotechnical innovation in Ireland in this area (drawing on the TIS approach, as previously outlined in this report) and government strategies for innovation. This may result in bringing together programmes that already support innovation (e.g. Enterprise Ireland) into a broad transition portfolio. This should not be about simply “rebadging” existing activities, but about attempting to re-orientate and prioritise experimentation that will be most effective in progressing the vision developed by the national transition arena, while maximising opportunities for cross-learning. This may also involve the transition team developing common guidance for experimental design, evaluating opportunities, identifying common trends and barriers and even instigating new streams of research on the nature of Irish transition experiments.

9.4 Benchmarking, Monitoring and Evaluating the Irish Transition

Throughout this report, it has been stressed that enhancing reflexivity is a key dimension of the transitions approach, as this helps stimulate the social learning that is generated from the type of interactions promoted under the types of governance and experimentation for transition discussed previously. It is also an important process to ensure that the overall objectives identified for “steering” society towards long-term goals are maintained and adjusted as new circumstances and challenges emerge. Chapter 8

reviewed the ways in which the Irish transition could be benchmarked in a way that harnesses existing reporting instruments to measure how Ireland is meeting its sustainability challenges compared with other nations, and how effectively it is developing its capacities for transition in terms of policymaking and innovation at the niche level. This framework provides an outline for a set of interlinked processes for monitoring the Irish low carbon energy transition at different levels, with a core focus on learning. Here it is suggested that processes of identifying, monitoring and evaluating the utility of indicators might themselves act as collaborative vehicles for inspiring and stimulating transition.

Although this is not the place for being overly prescriptive on the detailed monitoring instruments, processes and responsibilities, it is appropriate that this is acknowledged as a key action to be taken forward in the context of the Irish transition arena, highlighted previously. The approach and indicators identified in this report highlight a potential way forward, but it is important to note that this will need further work and broad stakeholder engagement around appropriate ways to monitor transition, depending on key issues, such as barriers, opportunities and preferred pathways for the Irish energy transition.

10 Conclusion

This report has summarised the findings of the EPA-funded desk study focusing on how we should conceptualise and catalyse energy transition in Ireland. The complexity, time frames and depth of the social, economic and technological challenges involved in such a transformation mean that governments, businesses, social movements, researchers and other stakeholders require new conceptual frames for understanding the dynamics of change and will have to develop new processes for initiating and sustaining transition. This project has only been able to scratch the surface of such a challenge, but it has outlined a number of available theoretical approaches, a range of international experiences, and potential next steps that could act to consolidate the action already being taken in Ireland, and can act as a catalyst for a longer term vision for an Irish energy transition.

The main report covers a large number of issues that can potentially be taken forward through future EPA-funded research and more ambitiously through a high-level, cross-sectoral TM process that will provide invaluable insights into the specific challenges of mobilising energy transition in Ireland. Although there is a need for further research into different aspects of transition, the most neglected aspect in Ireland is an attempt to produce a high-level vision of the Irish energy future and the different pathways that may deliver this. TM may offer one avenue to mobilising this, while recognising that this may be seen by the government as a relatively unorthodox process with inherent risks. However, given the severity of the climate and energy challenges ahead, it may also deliver high rewards.

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Abbreviations

Btu	British thermal unit
CHP	Combined heat and power
EPA	Environmental Protection Agency
ETP	Environment-oriented technology policy
EU	European Union
EV	Electric vehicle
GHG	Greenhouse gas
IEA	International Energy Agency
MLP	Multi-level perspective
NESC	National Economic and Social Council
R&D	Research and development
SEAI	Sustainable Energy Authority of Ireland
SFI	Science Foundation Ireland
SNM	Strategic niche management
TIS	Technological innovation systems
TM	Transition management
UN	United Nations
WEC	World Energy Council

AN GHNÍOMHAIREACHT UM CHAOMHNÚ COMHSHAOIL
Tá an Gníomhaireacht um Chaomhnú Comhshaoil (GCC) freagrach as an gcomhshaoil a chaomhnú agus a fheabhsú mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaoil a chosaint ó éifeachtaí díobhálacha na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialú: Déanaimid córais éifeachtacha rialaithe agus comhlionta comhshaoil a chur i bhfeidhm chun torthaí maithe comhshaoil a sholáthar agus chun díriú orthu siúd nach gcloíonn leis na córais sin.

Eolas: Soláthraimid sonraí, faisnéis agus measúnú comhshaoil atá ar ardchaighdeán, spriocdhírthe agus tráthúil chun bonn eolais a chur faoin gcinnteoireacht ar gach leibhéal.

Tacaíocht: Bimid ag saothrú i gcomhar le grúpaí eile chun tacú le comhshaoil atá glan, táirgiúil agus cosanta go maith, agus le hiompar a chuirfidh le comhshaoil inbhuanaithe.

Ár bhFreagrachtaí

Ceadúnú

Déanaimid na gníomhaíochtaí seo a leanas a rialú ionas nach ndéanann siad dochar do shláinte an phobail ná don chomhshaoil:

- saoráidí dramhaíola (*m.sh. láithreáin líonta talún, loisceoirí, stáisiúin aistrithe dramhaíola*);
- gníomhaíochtaí tionsclaíocha ar scála mór (*m.sh. déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta*);
- an diantalmhaíocht (*m.sh. muca, éanlaith*);
- úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe (*OGM*);
- foinsí radaíochta ianúcháin (*m.sh. trealamh x-gha agus radaiteiripe, foinsí tionsclaíocha*);
- áiseanna móra stórála peitril;
- scardadh dramhuisce;
- gníomhaíochtaí dumpála ar farraige.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil

- Clár náisiúnta iniúchtaí agus cigireachtaí a dhéanamh gach bliain ar shaoráidí a bhfuil ceadúnas ón nGníomhaireacht acu.
- Maoirseacht a dhéanamh ar fhreagrachtaí cosanta comhshaoil na n-údarás áitiúil.
- Caighdeán an uisce óil, arna sholáthar ag soláthraithe uisce phoiblí, a mhaoirsiú.
- Obair le húdaráis áitiúla agus le gníomhaireachtaí eile chun dul i ngleic le coireanna comhshaoil trí chomhordú a dhéanamh ar líonra forfheidhmiúcháin náisiúnta, trí dhíriú ar chiontóirí, agus trí mhaoirsiú a dhéanamh ar leasúchán.
- Cur i bhfeidhm rialachán ar nós na Rialachán um Dhramhthrealamh Leictreach agus Leictreonach (DTLL), um Shrian ar Shubstaintí Guaiseacha agus na Rialachán um rialú ar shubstaintí a ídionn an ciseal ózóin.
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaoil.

Bainistíocht Uisce

- Monatóireacht agus tuairisciú a dhéanamh ar cháilíocht aibhneacha, lochanna, uisce idirchriosacha agus cósta na hÉireann, agus screamhuisc; leibhéil uisce agus sruthanna aibhneacha a thomhas.
- Comhordú náisiúnta agus maoirsiú a dhéanamh ar an gCreat-Treoir Uisce.
- Monatóireacht agus tuairisciú a dhéanamh ar Cháilíocht an Uisce Snámha.

Monatóireacht, Anailís agus Tuairisciú ar an gComhshaoil

- Monatóireacht a dhéanamh ar cháilíocht an aeir agus Treoir an AE maidir le hAer Glan don Eoraip (CAFÉ) a chur chun feidhme.
- Tuairisciú neamhspleách le cabhrú le cinnteoireacht an rialtais náisiúnta agus na n-údarás áitiúil (*m.sh. tuairisciú tréimhsiúil ar staid Chomhshaoil na hÉireann agus Tuarascálacha ar Tháscairí*).

Rialú Astaíochtaí na nGás Ceaptha Teasa in Éirinn

- Fardail agus réamh-mheastacháin na hÉireann maidir le gáis cheaptha teasa a ullmhú.
- An Treoir maidir le Trádáil Astaíochtaí a chur chun feidhme i gcomhair breis agus 100 de na táirgeoirí dé-ocsaíde carbóin is mó in Éirinn.

Taighde agus Forbairt Comhshaoil

- Taighde comhshaoil a chistiú chun brúnna a shainathint, bonn eolais a chur faoi bheartais, agus réitigh a sholáthar i réimsí na haeraíde, an uisce agus na hinbhuanaitheachta.

Measúnacht Straitéiseach Timpeallachta

- Measúnacht a dhéanamh ar thionchar pleananna agus clár beartaithe ar an gcomhshaoil in Éirinn (*m.sh. mórfhleananna forbartha*).

Cosaint Raideolaíoch

- Monatóireacht a dhéanamh ar leibhéil radaíochta, measúnacht a dhéanamh ar nochtadh mhuintir na hÉireann don radaíocht ianúcháin.
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha.
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta.
- Sainseirbhísí cosanta ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Faisnéis Inrochtana agus Oideachas

- Comhairle agus treoir a chur ar fáil d’earnáil na tionsclaíochta agus don phobal maidir le hábhair a bhaineann le caomhnú an chomhshaoil agus leis an gcosaint raideolaíoch.
- Faisnéis thráthúil ar an gcomhshaoil ar a bhfuil fáil éasca a chur ar fáil chun rannpháirtíocht an phobail a spreagadh sa chinnnteoireacht i ndáil leis an gcomhshaoil (*m.sh. Timpeall an Tí, léarscáileanna radóin*).
- Comhairle a chur ar fáil don Rialtas maidir le hábhair a bhaineann leis an tsábháilteacht raideolaíoch agus le cúrsaí práinnfhreagartha.
- Plean Náisiúnta Bainistíochta Dramhaíola Guaisí a fhorbairt chun dramhaíl ghuaiseach a chos agus a bhainistiú.

Múscailt Feasachta agus Athrú Iompraíochta

- Feasacht chomhshaoil níos fearr a ghiniúint agus dul i bhfeidhm ar athrú iompraíochta dearfach trí thacú le gnóthais, le pobail agus le teaghlaigh a bheith níos éifeachtúla ar acmhainní.
- Tástáil le haghaidh radóin a chur chun cinn i dtithe agus in ionaid oibre, agus gníomhartha leasúcháin a spreagadh nuair is gá.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil

Tá an ghníomhaíocht á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóirí. Déantar an obair ar fud cúig cinn d’Oifigí:

- An Oifig um Inmharthanacht Comhshaoil
- An Oifig Forfheidhmithe i leith cúrsaí Comhshaoil
- An Oifig um Fianaise is Measúnú
- Oifig um Chosaint Radaíochta agus Monatóireachta Comhshaoil
- An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag comhaltaí air agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair inní agus le comhairle a chur ar an mBord.

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Catalysing and Characterising Transition



Authors: Geraint Ellis, Therese Hume,
John Barry and Robin Curry

Identifying pressures

This report reviews the social, economic and political transformations that will be required to achieve a low-carbon transition. Ireland is required to decarbonise its energy systems and make very substantial reductions in its greenhouse gas emissions as a result of international treaties such as the Paris Agreement and European Union commitments on energy and climate, as well as its own legislative initiatives such as the Climate Action and Low Carbon Development Act 2015. These commitments imply very far-reaching changes in the Irish energy regime, which in turn create pressures in many other systems, such as those related to food and mobility. This suggests that transition will require a process of redirecting a wide range of factors (markets, energy technologies, infrastructure, governance, individual behaviour) towards more sustainable configurations. This report reviews the ways in which these pressures can be conceptualised and integrated into a broad approach through which such complex changes can be steered, drawing primarily on transition theory.

Informing policy

The report also reviews the experiences of the Netherlands, Sweden, the UK, Germany, Denmark, Norway and New Zealand to identify key dimensions of their energy transitions, including the landscape forces, dominant actors and scope of niche innovations, which highlight the diverse range of pathways towards transition. This provides insights from international experience, noting the complexity of forces that can act as a driver or barrier to a country's transition, the benefits of a strong sustainability vision and the way in which incumbent, vested interests can frustrate progress. The report also describes case studies of two technologies in Ireland seen to be central to Ireland's low-carbon transition, bioenergy and electric vehicles, highlighting that they have considerable opportunities to contribute to the Irish transition, but that they also face significant challenges in order to fully reach their potential. Finally, the report examines how Ireland's transition can be benchmarked against the progress of other countries.

Developing solutions

The report synthesises the theoretical reviews of transition theory, benchmarking and case studies in order to make recommendations on how a transitions approach can be operationalised in an Irish context. This has two key aspects. First, there is a need to develop and consolidate further research capacity for transitions in Ireland and, second, there is a need to initiate a national transition management process. The report highlights a range of strategic actions that could be undertaken by research funders and outlines key topics that could form a transition research programme. It also draws on the transition management approach to outline key steps for a national Irish transition process, consisting of creating a transition team and a national transition arena and encouraging greater experimentation in policy, technology and social innovations that could help stimulate the transformation of the Irish energy system.