# EVALUATING THE EU'S ENERGY INNOVATION SYSTEM

Yeong Jae Kim, Tyndall Centre for Climate Change Research, Phone +44 7776 02 0595, E-mail: Y.kim@uea.ac.uk
Charlie Wilson, Tyndall Centre for Climate Change Research, Phone +44 1603 59 1386, E-mail: Charlie.Wilson@uea.ac.uk

## Overview

The European Commission has stated "the ambition to achieve ... a fundamental transformation of Europe's energy system" (EC, 2015). This transformation requires solutions and policies informed by systemic analysis of energy innovation. Economics research on energy innovation has provided robust evidence to explain key relationships between R&D, patenting, knowledge stocks, market structure, environmental regulation, and policy uncertainty (Popp, 2002; Popp, 2003; Aghion, Bloom, Blundell, Griffith, & Howitt, 2005; Kalamova, Johnstone, & Hascic, 2012). This deep causal understanding of specific innovation processes is usefully complemented by innovation systems analysis. An innovation system emphasises the actors, networks, and infrastructures which are important structural elements of innovation activity (Lundvall, 1992), as well as the necessary functions that these structural elements provide (Hekkert & Negro, 2009). By linking these broader dimensions of innovation system functioning with specific innovation processes, a systems perspective helps explain the relative successes and failures of different historical experiences with energy innovation (Wilson, Grubler, Gallagher, & Nemet, 2012).

The EU's Strategic Energy Technology (SET) Plan is the principal EU-level approach for achieving system transformation to meet climate, security and efficiency goals. The SET Plan was launched in 2008 to provide strategic planning and coordination of energy research & innovation activities within the EU (Carvalho 2012) and the Commission proposed a revised SET Plan that was more targeted and used a whole systems approach to ensure better integration across sectors and technologies in 2015 (EC, 2015). This revised 'Integrated SET Plan' set out four priority areas (renewable energy and storage, smart systems and consumers, energy efficiency, sustainable transport) and two additional areas (carbon capture and storage, nuclear).

The aim of this paper is to evaluate the consistency of directed innovation activity in the EU with the priority areas set out in the SET Plan. We apply the Energy Technology Innovation System (ETIS) framework to evaluate the distribution of directed innovation efforts between the SET-Plan priority areas in 2015. First, we review relevant literature on innovation system frameworks and their application for evaluating strategic policies like the SET Plan. Second, we develop a set of indicators for measuring innovation system functioning. Third, we identify available EU-level data from a wide range of sources. Fourth, we collect data on relevant indicators to characterise the EU energy innovation system in the priority areas identified by the SET Plan. Finally, we draw conclusions about the functioning of the EU's SET Plan from an innovation systems perspective by analysing the distribution of innovation efforts. We find that EU-level innovation system activity is unbalanced across the SET Plan priority areas.

## Methods

To characterize ETIS processes, we reviewed the related literature to find indicators as proxies for ETIS processes (Borup et al., 2013; Borup, Andersen, Jacobsson, & Midttun, 2008; Miremadi, Saboohi, & Jacobsson, 2016). Unlike an ex-post analysis of policy intervention, indicators framework allowed us to monitor and evaluate the broader spectrum of energy technology innovation processes (International Energy Agency, 2011). Indicators framework is more suitable for analysing on-going projects such as the current SET-Plan.

We identified a comprehensive set of indicators as a general description of ETIS processes. To select the most appropriate indicators, we apply two selection criteria: usefulness and availability. First, indicators should be relevant for the ETIS. An indicator should be a strong predictor of ETIS processes. It should be understandable, measurable, and generable. Second, data for indicators should be available. Sometimes, data limitations hamper what we would like to analyse. In addition to availability, we have data scope and scale issues. We used tech-specific indicator at the EU level.

Building on Wilson et al. (2012)'s work, we collected data measuring each indicator. We distinguished data measuring activity within the six SET Plan priority areas from data measuring activity outside the SET plan. For activity within the SET Plan, we computed the relative proportion of activity associated with the six priority areas.

## Results

Our initial findings are twofold. First, we find that directed innovation efforts - including public R&D, asset finance, and analysis and modelling activity - are unequally distributed across the priority areas of the SET Plan. Actions benefitting from greater public attention tend to be those involving large-scale centralised infrastructure and/or large-scale firms and capital markets. Second, we find that innovation outcomes to-date - including patenting activity, observed cost reductions, and capacity installations - are also unequally distributed between the priority areas of the SET Plan. While strong progress and evidence of innovation system functioning are observed in renewables and other energy-supply actions, successful outcomes are less clear in networks and end-use efficiency.

## Conclusions

Our findings can be briefly summarized as follows. We found that EU-level innovation system activity was unbalanced across four dimensions. Relatively strong progress and evidence of innovation system functioning were observed in renewables, electric vehicle and energy efficiency. Conversely, we found that nuclear safety and CCS are less emphasised within the portfolio of six SET Plan priority areas. We also found relatively diverse actors and organisations in the EU energy innovation system, but we need to be cautious about generalizing indicators because of the limitation of the data.

Depends on the different maturities of the SET Plan priority areas, indicators show imbalanced portfolios of innovation activity. An indicator describing early stage innovation processes would be expected to favour electric vehicles. This can be observed for some indicators such as Demonstration Budgets, but not for other indicators such as the number of patent applications or Public RD&D expenditure. On the contrary, indicators describing the late stage of innovation processes would be expected to favour nuclear safety and energy efficiency. We can only found indicators such as density of regulatory policy instruments for energy efficiency and a rapid decline in public interest in energy efficiency.

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