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Creating an ensemble of future strategies for national infrastructure provision

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ABSTRACT

Well managed, maintained and effective national infrastructure (NI) systems (i.e. energy, transport, water, waste, ICT) provide the backbone for economic growth and societal wellbeing. Traditionally, NI planning and implementation has been conducted in isolation, based upon fixed assumptions about the future. This fails to recognise both the long-term socio-economic, climate-related and technological challenges and uncertainties of the coming century and the growing interconnectivity between these individual infrastructure systems. Here we develop a methodology for generating a range of strategies for the provision of NI suitable for an integrated 'system-of-systems' assessment of NI's future management. To provide coherent links with policy choices, integrated strategies are developed at an aggregate level with a diversity of investment requirements, demand management techniques, and levels of environmental targets. To facilitate implementation within NI simulation models, the example strategies are constructed from sectoral sub-strategies focusing on changes in demand, capacity utilisation and capacity expansion. Further new strategies can be explored and the approach lends itself to an iterative analytical approach, potentially capturing a wide range of policy questions. It is illustrated using the future provision of Great Britain's transport infrastructure as a case study, and demonstrates how cross-sector strategies for infrastructure provision can be developed.

1. Introduction

A nation's economic prosperity and societal wellbeing relies on high-quality infrastructure, particularly those essential services and systems which transport key resources and enable global communications (i.e. energy, transport, water, waste and information and communication technologies (ICT)) (CST, 2009). Provision of resilient, effective national infrastructure (NI) systems has become a focus of many advanced economies (CST, 2009; HM Treasury, 2010; ICE, 2009, 2010; Urban Land Institute and Ernst and Young, 2011, 2011b; WEF, 2011), but such systems face a number of serious challenges: (i) an increased demand for infrastructure services from a growing and ageing population; (ii) significant investment requirements to counter the vulnerabilities, capacity limitations and supply insecurities associated with an ageing

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infrastructure system; (iii) the increasing complexity, diversification and interdependence of infrastructure networks; and (iv) a widespread desire to maintain and improve environmental standards, including decarbonisation across infrastructure sectors.

Overcoming these multiple challenges requires a long-term strategic view on infrastructure provision, especially given the long lifespan of many physical infrastructure assets (particularly in water, transport and energy), and the long lead-time necessary to effect change in these systems (Hall, Henriques, Hickford, & Nicholls, 2013; Hall, Henriques, et al., 2014; ICE, 2009, 2010). However, the feasibility of such long-term planning is, in turn, challenged by future uncertainties associated with demographic, economic, environmental and political changes, as well as uncertainties about the nature of technological change (Faber, Idenburg, & Wilting, 2007), all of which are likely to have a significant effect on the demands and requirements of NI systems. Lastly, there is a wide range of potential future strategies (i.e. choices) concerning the future provision of national infrastructure.

Historically, policies and decisions regarding individual infrastructure sectors have been made through complex systems of governance and often in isolation, with little regard for other interconnected infrastructures. Levels of investment in infrastructure have been influenced by the perceived political and economic importance of individual sectors, and such investments have fluctuated over time (Helm, Wardlaw, & Caldecott, 2009; Marshall, 2010). More recently, the importance of taking a long-term and cross-sectoral view of infrastructure provision has been more widely acknowledged in many countries. For example, within the British Government, Infrastructure UK was formed in December 2009 with the specific aim of ensuring a more harmonised long-term vision of infrastructure planning. It promotes a more integrated approach to NI through the development of a National Infrastructure Plan (HM Treasury, 2010, 2011, 2012), which identifies a broad strategy for meeting the country's infrastructure needs.

In the longer term, such a broad strategy could evolve in a number of different directions, particularly depending on certain policy choices, such as (i) how much investment is available, (ii) the government's level of commitment to mitigating climate change, and (iii) the impact of differing approaches to managing demand for those services that NI helps to deliver. Fig. 1 outlines an analytic process to test the long-term impact and effectiveness of a range of infrastructure provision strategies across a wide range of socio-economic changes, and hence promote more effective decision-making and planning.

Modelling tools are used to simulate current and possible future configurations of the NI system for each sector and the possible interactions between interdependent sectors which have co-evolved spatially. Thus, a multi-sectoral integrative approach for a particular region is appropriate for this framework (Otto et al., 2014).

Exogenous input variables to these system models represent a range of scenarios of socio-economic and environmental change, while endogenous input variables are used to represent a diverse set of sector-specific strategies for infrastructure provision; these strategies also need to be combined to create plausible cross-sector strategies for the NI system as a whole.

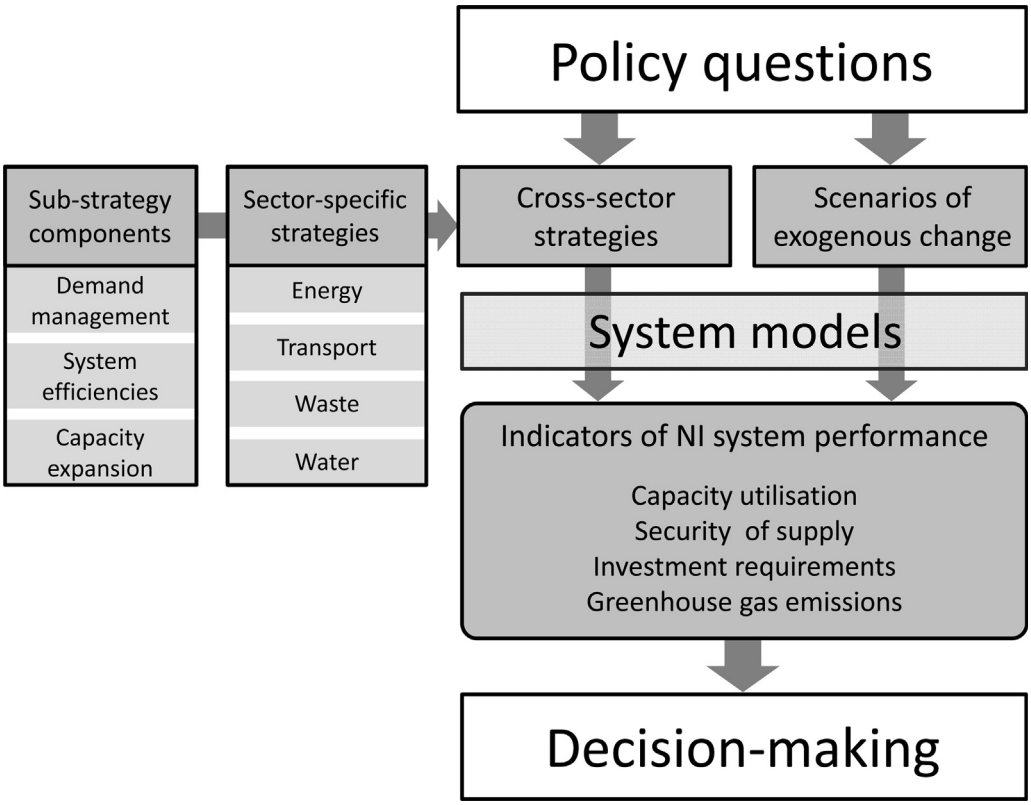

Fig. 1. An analytic process using models to inform decision makers about future NI provision.