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Bridging the gap between energy and the environment

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HIGHLIGHTS

- Obligations for climate, biodiversity and ecosystem services must be aligned.
- Ecosystem service based assessments of energy systems can inform energy policy.
- Assessment to incorporate life cycle stages across spatial and temporal scales.
- Implications for ecosystem services differentiate between energy options.
- Pathways to decarbonisation should be identified based on such a holistic assessment.

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ABSTRACT

Meeting the world's energy demand is a major challenge for society over the coming century. To identify the most sustainable energy pathways to meet this demand, analysis of energy systems on which policy is based must move beyond the current primary focus on carbon to include a broad range of ecosystem services on which human well-being depends. Incorporation of a broad set of ecosystem services into the design of energy policy will differentiates between energy technology options to identify policy options that reconcile national and international obligations to address climate change and the loss of biodiversity and ecosystem services. In this paper we consider our current understanding of the implications of energy systems for ecosystem services and identify key elements of an assessment. Analysis must consider the full life cycle of energy systems, the territorial and international footprint, use a consistent ecosystem service framework that incorporates the value of both market and non-market goods, and consider the spatial and temporal dynamics of both the energy and environmental system. While significant methodological challenges exist, the approach we detail can provide the holistic view of energy and ecosystem services interactions required to inform the future of global energy policy.

1. Introduction

Meeting the world's energy demand over the coming century represents a major challenge for society (Foresight, 2011), increased further by the need to do so while simultaneously minimising the environmental burdens associated with energy production and use (Naik et al., 2010). Due to the contribution of energy systems to greenhouse gas emissions (Edenhofer et al., 2014), a primary driver of energy policy is identification of decarbonisation strategies, as reflected in international and regional policy (European Union, 2009; UK Parliament, 2008; UNFCCC,

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1998).

A range of technological and policy options for decarbonisation exist (Chu and Majumdar, 2012; Committee on Climate Change, 2013; Ekins et al., 2013) that broadly fall into five categories: (1) use of mature technologies as a bridge in the short to medium term; (2) increased energy efficiency across society; (3) increased reliance on renewable technologies; (4) refinement of existing energy systems; and (5) deployment of new technologies such as carbon dioxide capture and storage. To achieve energy decarbonisation targets such options need to be implemented in some combination rather than singly, resulting in substantial variation in the range of possible future energy pathways, as demonstrated through numerous scenario exercises (e.g. Ekins et al., 2013; International Energy Agency, 2012). While each option may contribute to decarbonising energy, each is also associated with a diverse and complex array of social, environmental and economic impacts occurring at a range of spatial and temporal scales (Gasparatos et al., 2011; Hastik et al., 2015; Papathanasopoulou et al., 2015a).

Outside the energy domain, consideration of sustainability at local, national and global scales is increasingly framed in terms of ecosystem services (Daily and Matson, 2008; Gomez-Baggethun and Ruiz-Perez, 2011). Ecosystem services is used throughout as a broad term to refer to the benefits that people derive from nature (Díaz et al., 2015a; Mace et al., 2012). Ecosystem services stem from the world's natural 'capital', which represents the stock of the earth's physical and biological resources (Sukhdev, 2010). When combined with other forms of capital (Goodwin, 2003), this give rise to final ecosystem services such as crops, timber and fresh water that provide goods of value (monetary and non-monetary) and contribute to human quality of life. The fact that ecosystem services are a function of the biophysical environment and the social and economic context in which provision occurs, means they represent an ideal metric to inform energy policy (Bateman et al., 2013; Gasparatos et al., 2011; Hastik et al., 2015; Howard et al., 2013; Ruckelshaus et al., 2013).

The main objective of this paper is to propose how knowledge of the influence of energy systems on ecosystem service provision can be used to inform energy policy. Given the strong parallels that exist with the Intergovernmental Panel on Climate Change (IPCC), we frame our discussion within the context of work being undertaken by the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES). The IPBES Conceptual Framework provides a theoretical model of the interactions between people and nature, so can help our understanding of the interactions between energy systems and ecosystem services. The framework describes the relationships between the natural world and humanity based on six elements (Fig. 1; Díaz et al., 2015b). Development of energy policy would be based on understanding of (i) anthropogenic assets (e.g. energy infrastructure, energy technology), the (ii) direct (e.g. anthropogenic climate change, pollution) and (iii) indirect (e.g. energy policy, business interests) drivers of pressures on (iv) nature and (v) the benefits that people derives from nature that ultimately influence (vi) human quality of life (roman numerals indicate elements depicted in Fig. 1). The importance of the IPBES Conceptual Framework is that it specifically considers both direct drivers of change (e.g. habitat loss associated a specific energy technology; Fig. 1 element ii) and their underlying cause (e.g. energy policy; Fig. 1 elements i and iii).

Readers are referred to Díaz et al. (2015a, 2015b) for a detailed

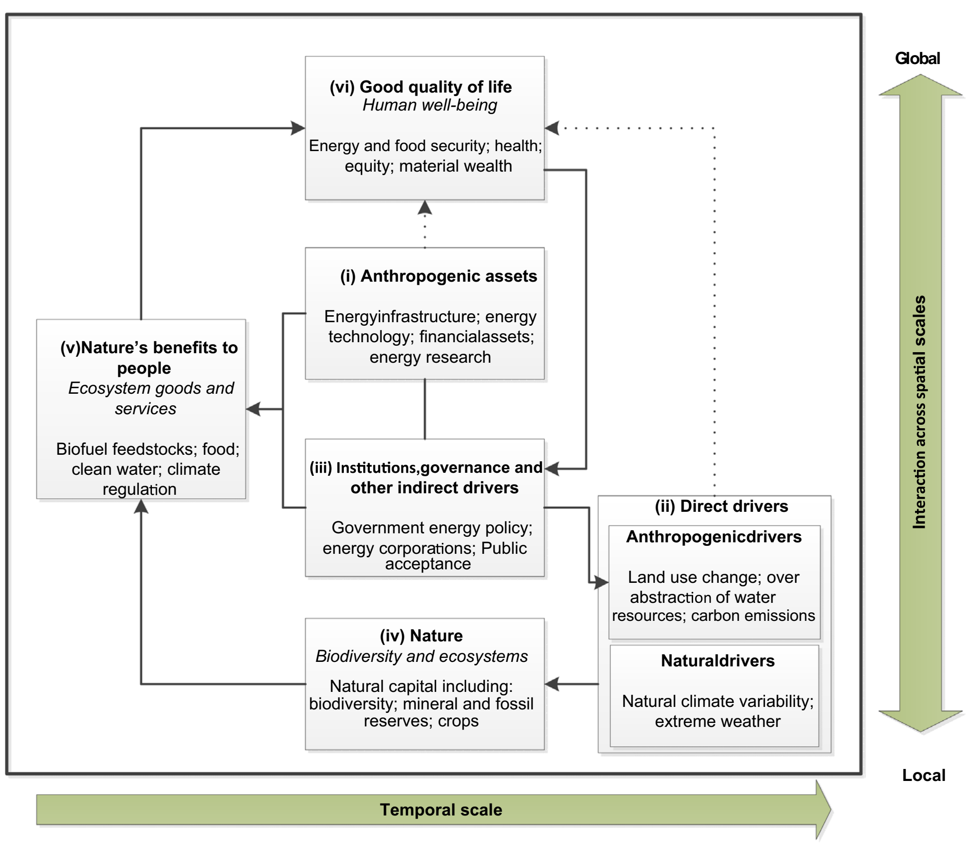

Fig. 1. Schematic of the IPBES Framework from Díaz et al. (2015a) adapted to illustrate its application for energy policy. Text in bold indicate IPBES categories, text in italics concepts from western science commonly used in policy, normal text examples of relevance to energy systems and the design of energy policy. Roman numerals refer to individual elements of the framework and cross reference with the main text.