ADVENT

ADdressing Valuation of Energy and Nature Together

WORKSHOP 1: Integrating Conceptual Frameworks of Energy Systems and Ecosystem Services

Summary report on the first in a series of four project workshops.
Held at the The Enterprise Centre, University of East Anglia, Norwich
14th & 15th December 2015.

Report compiled by Matthew Agarwala, Trudie Dockerty and Andrew Lovett,
University of East Anglia

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NERC SCIENCE OF THE ENVIRONMENT

Energy For a Low Carbon Future

The ADVENT Project

ADVENT (Addressing Valuation of Energy and Nature Together) is a 5 year research project funded by NERC as part of the RCUK Energy Programme. It involves a consortium of seven partner institutions and aims to develop conceptual frameworks and modelling tools to integrate the analysis of prospective UK energy pathways with considerations relating to the value of natural capital. This will include quantifying the implications of differing future UK low-carbon energy pathways for stocks of natural capital (e.g. groundwater and natural habitats) and for the provision of ecosystem services (e.g. irrigation, visual amenity, recreation). In addition, the project will compare the outcomes of different methodologies to value changes in ecosystem services and provide guidelines regarding the application of such approaches. Ultimately, the project seeks to provide both public and private sector decision makers with tools that allow them to take a whole-systems perspective on energy futures in a way that better integrates energy and environmental considerations.

Workshop Programme – Background and Aims

This workshop is the first in a series of four that will take place as part of Work Package 1 (WP1) of the ADVENT research programme. These workshops will establish the baseline of existing knowledge on which the programme needs to build, extending and combining existing conceptual frameworks and making key decisions regarding the energy pathways and appraisal mechanisms to be investigated further.

These reviews and discussions will build upon the experience of the partners in previous and ongoing projects (e.g. UKERC, VNN/VNP, NEA/NEAFO and SPLiCE). The objective is to build upon recent reports that cover future energy pathways being developed elsewhere, for example, options discussed in the Committee on Climate Change (CCC, 2015) 5th Carbon Budget Review, annual National Grid reports (e.g. National Grid, 2015) and those currently being developed in the pathways theme of UKERC Phase 3. The selection of pathways will also be important in terms of identifying the generation technologies and other changes that need to be evaluated in subsequent phases of the research. These will be considered in conjunction with ES pathways such as the 25 Year Plan forthcoming from the UK Natural Capital Committee.

The workshops in WP1 will examine the following topics:

- i) conceptualising the role of energy in ES and natural capital frameworks and developing these as necessary,
- ii) approaches to modelling and option appraisal in the energy and valuing nature communities,
- iii) the 'state of the art' regarding UK energy pathways through to 2030/2050, and
- iv) metrics for a holistic assessment of natural capital in energy pathways.

In addition to this summary report on the workshop a working paper is being drafted that will combine material from a briefing document prepared for the workshop by Matthew Agarwala with insights from the workshop and subsequent discussions amongst the project team. The working paper will also inform a presentation to be made at the European Geosciences Union (EGU) General Assembly Conference in Vienna, Austria in April 2016.

Workshop 1: Integrating Conceptual Frameworks of Energy Systems and Ecosystem Services

Workshop Participants

Name	Affiliation
Matthew Agarwala	University of East Anglia
Paolo Agnolucci	University College London
Ian Bateman	Exeter University
Brett Day	Exeter University
Trudie Dockerty	University of East Anglia
Astley Hastings	University of Aberdeen
Tara Hooper	Plymouth Marine Laboratory
Andrew Lovett	University of East Anglia (Project Leader)
Rick Lupton	Foreseer / WholeSEM Project, University of Cambridge
Gail Taylor	University of Southampton
Kerry Turner	University of East Anglia
Guy Ziv	Leeds University

Presentations

Where available, pdfs of the slides can be accessed by clicking on the titles below.

Monday 14th December 2015

Introduction

- Overview of ADVENT (Andrew Lovett)
- Ecosystem Services Paradigm (Ian Bateman/Matthew Agarwala)
- Energy Systems Frameworks (Paolo Agnolucci)

Approaches to assessing energy-environment interactions

- The UKERC Phase 2 energy and ecosystem services project (Andrew Lovett)
- Global impacts of energy demand on the freshwater resources of nations (Gail Taylor)
- Implications of the UK Carbon Plans for land and water in Foreseer (Rick Lupton)
- SPLiCE: exploring the use of ecosystem service frameworks to compare the impacts of energy pathways (Tara Hooper)

Tuesday 15th December 2016

Introduction and Discussion

- The integrated modelling exercises in ADVENT (Brett Day/Paolo Agnolucci)

Summary of issues

- Discussion of questions outlined in the briefing document
- Discussion of next steps in terms of developing a conceptual framework for ADVENT

Summary of Key Discussions

In addition to specific questions about the papers presented, much of the discussion revolved around the diagrams of conceptual frameworks, such as Figure 1 below, which are explored further in the working paper that will follow this summary report.

Conceptual Frameworks

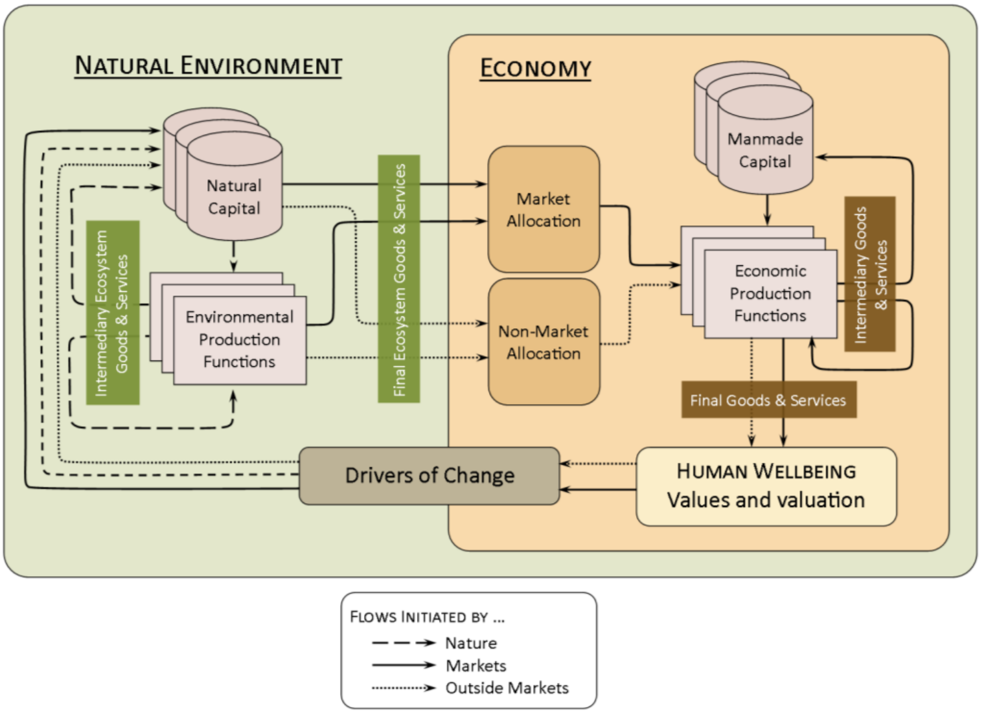

Figure 1: A conceptual framework linking the natural environment to the human economy (henceforth, LEEP Framework)

Key points from group discussion of Figure 1:

- Figure 1 has a simple purpose: to illustrate how economists characterise the natural environment as a production system that interacts with the human economy.
- Lots of extra lines and feedback loops could be added to highlight specific relationships, but such comprehensiveness might impair clarity which may not be desirable for a conceptual framework.
- Although it is not specifically tailored to consider energy systems, it could be argued that Figure 1 fully incorporates them already, since they combine elements of natural and man-made capital (e.g. fossil fuels and energy infrastructure) to generate final goods and services (energy for households).
- Although the outputs of natural capital are most commonly referred to as *'ecosystem services'*, it was agreed that within ADVENT we will use the term *'final environmental goods and services' (FEGS*) as this better incorporates the services provided by abiotic and biotic natural capital, as well as physical and geophysical processes.

The LEEP framework depicted in Figure 1 is consistent with The Integrated Model (TIM), developed by Bateman, Day *et al.* (2014). This is an economic optimisation model underpinned by strong natural science models (e.g. climate, soil carbon, etc.) that can be used to value changes in the supply of FEGS and guide economic decision making. There is potential for TIM (or some variant thereof) to be used within ADVENT to value and compare the environmental impacts of various energy scenarios such as those arising from

1. Energy models (i.e. potentially linking TIM with UCL energy systems models)
2. A set of energy pathways described by UKERC, CCC, or others.

Useful discussions led to the conclusion that there is very likely some way to 'soft-link' energy models with TIM (e.g. feed outputs from energy models into TIM), but that technical meetings between the modelling teams would be necessary to determine what exactly is feasible. It also became apparent that any such discussions would benefit from a clearer understanding of the various energy pathways that ADVENT might wish to address (e.g. those from the CCC or current UKERC work).

In addition to the LEEP framework, it was also noted that while economics and cost-benefit analysis (CBA) are extremely useful tools for informing decision making, there are many other factors and influences that affect policy decisions.

Kerry Turner pointed to another ES conceptual framework developed for the NEA-FO (Figure 2) that deliberately places governance and institutions at the centre, noting that real world decisions often differ (sometimes substantially) from those that would arise on the basis of CBA alone. There are strong parallels between the NEA-FO framework (Figure 2) and the conceptual framework devised to underpin the functions carried out by the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) (Diaz *et al.* 2015). The most substantial difference arises in terminology used, with the IPBES conceptual framework incorporating both western science and other knowledge systems reflecting its global scope. The importance of the IPBES conceptual framework may be that it is intended to provide a means to align work being conducted across different scales (local, regional and national) and so allow comparison between studies.

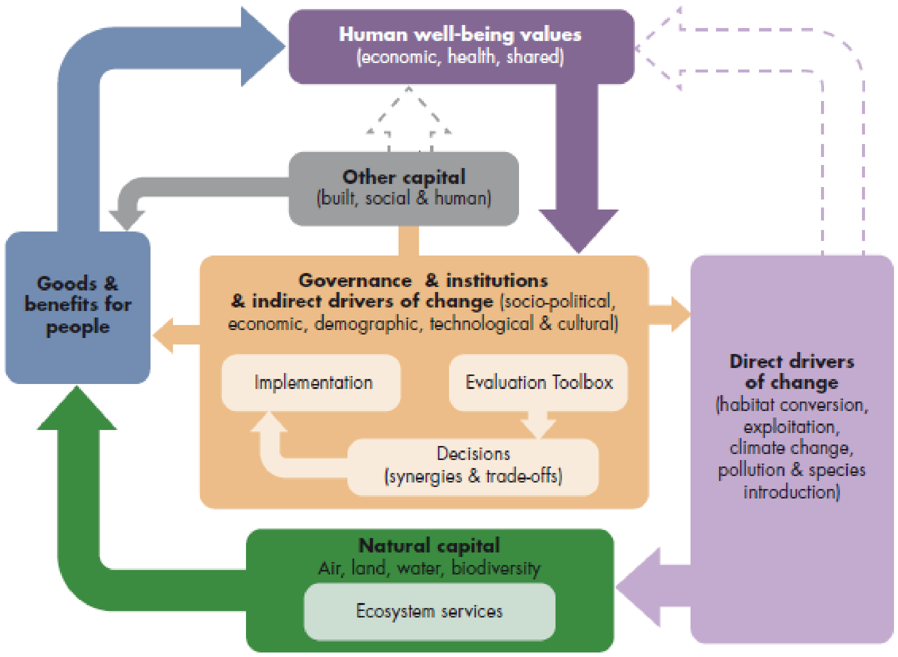

Figure 2. The UK NEAFO Ecosystem Services Conceptual Framework showing the roles of governance and institutions in the decision-making process, as well as the functions of built, human and social capital in transforming ecosystem services into goods and benefits for people.

Figure 2: Ecosystem Service Conceptual Framework used in NEA-FO (2014) (henceforth, NEA-FO Framework).

Although the LEEP and NEA-FO frameworks contain many of the same components, they emphasise slightly different relationships and serve different purposes. The LEEP framework depicts the way economists might conceptualise the natural environment as a production system existing alongside and interacting with the human economy. In contrast the NEA-FO framework emphasises interactions between decision-making processes (e.g. of governance and institutions), the environment, and the economy. In effect, the LEEP framework is a subset of the wider NEA-FO conceptualisation. While the former helps motivate environmental valuation exercises for use in CBA, the latter seeks to contextualise CBA (and related strategic analyses) within a broader 'balance sheet' of decision making tools and influences (see Figure 3).

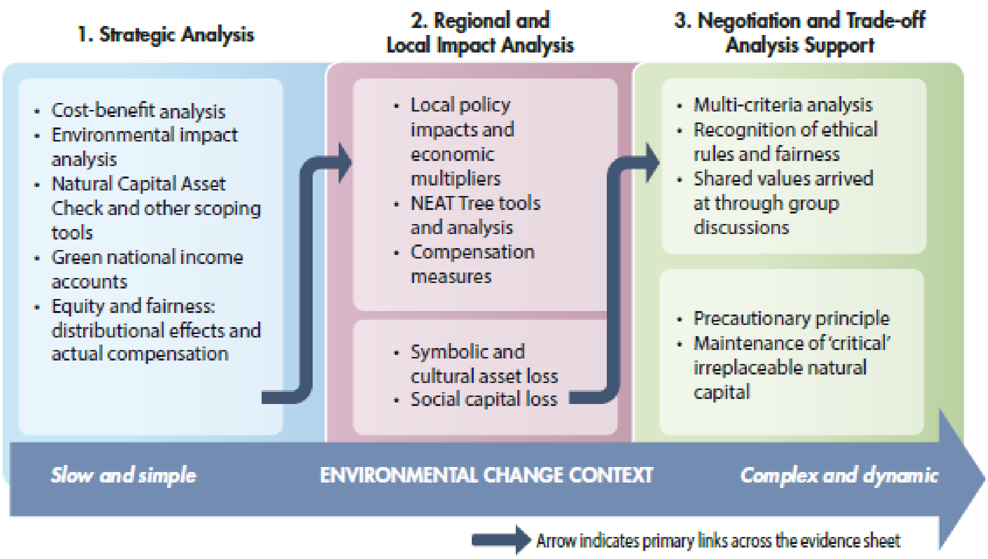

Figure 3: Decision making balance sheet (source: NEA-FO, 2014)

The decision support tools detailed in the balance sheet vary in terms of the scale at which they are likely to apply, as well as their relative transparency and objectivity (strategic analyses on the left are likely to be more objective and transparent than some of the negotiation and trade-off analysis tools on the right). The balance sheet does not indicate relative reliability or objectivity of the decision support tools it includes, but rather indicates which tools are commonly used under particular circumstances.

There was general agreement that the energy systems literature doesn't have an analogous conceptual framework, but that many energy systems models do seem to follow a linear chain, as depicted in Figure 4.

Figure 4: Steps commonly considered in energy systems models.

Interactions between Energy Systems and Environmental Goods and Services

Much of the subsequent discussion revolved around the need to understand the intersections between (a) the energy systems steps shown in Figure 4 and (b) the core set of environment-related goods and services that ADVENT will address. This was informed by findings from previous UKERC research by a number of ADVENT consortium members (see Dockerty *et al.*, 2014; Papathanasopoulou *et al.,* 2015; and Lovett *et al.*, 2015). Their method created a matrix linking lifecycle steps for specific energy technologies to the CICES ecosystem service classification system and then involved a systematic literature review to establish the extent of research examining impacts on ES for five energy systems (gas, nuclear, biomass, onshore wind and offshore wind) and recording the dominant direction of impact as a set of scores - negative, positive, conflicting, none/ negligible.

Table 1 summarises the key findings and indicates that most research was focussed in the fuel-cycle element of the energy lifecycle for gas and biomass and in the operational element for nuclear and offshore wind. The direction of impact shown is based on the modal score from multiple studies. Brackets denote (no. of scores/percentage of studies contributing to the modal score). Table 1 only includes cells where there were at least three contributing studies.

The results in Table 1 also serve as a gap-analysis, indicating where there is a lack of data; progress in any of the areas where data is absent in the table would be beneficial. However, the research concluded that given the interactions between energy, food and water resources (Hoff, 2011), a focus on provisioning services (nutrition, water, materials, energy) appears particularly important. Further discussion is needed to establish exactly which FEGS indicators ADVENT will examine and how impacts will be evaluated, but six were provisionally highlighted at the workshop (visual amenity, biodiversity, GHGs, water, food and recreation).

Table 1: Where and in which direction is there evidence of FEGS impacts relating to UK energy systems in the research literature?

KEY: Impacts predominantly -
■ - - or - Negative ■ ++ or + Positive ■ -/+ Conflicting ■ **-0-** No/negligible impact

	Upstream (infrastructure provision)	**Fuel Cycle** (extraction /production and processing of feedstock)	**Operation** (power production)	**Downstream** (de-commissioning)
Supporting (processes and functions)		**-/+ BIOMASS (4/50%)** **- -/++ GAS/Offshore (16/88%)**	**- - NUCLEAR/Offshore (10/60%)** **+ OFFSHORE WIND (3/66%)**	
Provisioning Nutrition		**- - GAS/Offshore (9/88%)**	**-0- OFFSHORE WIND (3/66%)**	
Provisioning Water Supply				
Provisioning Non-food biotic materials			**-0- OFFSHORE WIND (3/66%)**	
Provisioning Energy				
Regulation and Maintenance Regulation of biophysical environment		**-/+ BIOMASS (11/18%) (bioremediation)**		
Regulation and Maintenance Flow regulation				
Regulation and Maintenance Atmospheric Regulation		**BIOMASS (5/60%)** **- - GAS (10/70%)**	**GAS - (15/60%)**	
Regulation and Maintenance Water quality		**- - GAS/ Offshore (8/75%)**		
Regulation and Maintenance Soil quality		**BIOMASS (5/80%)**		
Regulation and Maintenance Reg. Biotic Env		**BIOMASS (10/80%)** **- - GAS/Offshore (16/50%)**	**-0- NUCLEAR (5/60%)** **-0- OFFSHORE WIND (6/50%)**	
Cultural (use and intrinsic value)	**- -NUCLEAR/Offshore (5/60%)** **-/+ONSHORE WIND (4/50%)** **- - OFFSHORE WIND (8/50%)**	**- - GAS/Offshore (8/86%)**	**-0- OFFSHORE WIND (14/29%)**	**- - /+ + GAS/Offshore (5/80%)**

Taking a Broader Perspective

Other discussion and post-workshop e-mails suggested that at this stage we need a conceptual diagram that avoids getting too far into the detail of how the process of integrating FEGS evaluations with energy system model outputs might proceed. Tara Hooper provided a further conceptual diagram (Figure 5), moving us in the right direction. The underlying rationale is to think at a higher level about what an FEGS evaluation brings to the development of energy strategies. For example, i) what additional issues could be addressed by using an FEGS evaluation (e.g. conservation directives), ii) other specific advantages of the methods (e.g. spatially resolved outputs) and iii) at what point in the broad process an FEGS evaluation could fit in? This, in turn, led to further two questions that were considered at the workshop:

1. Are we trying to use FEGS evaluation to develop improved energy pathways (termed an integrated approach in Figure 5), or
2. To evaluate pathways that have already been produced (a reactive approach)?

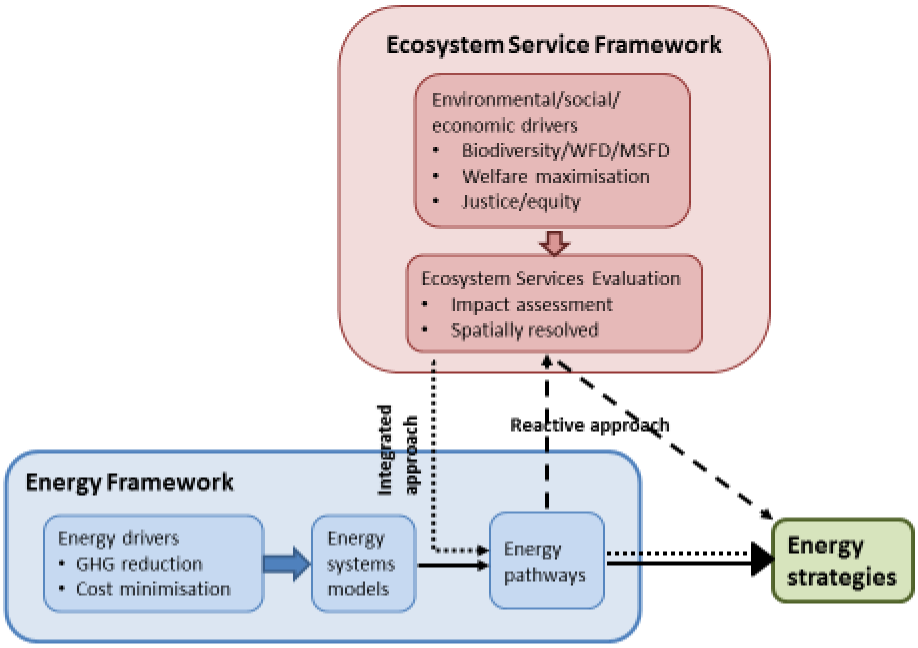

Figure 5: Further proposed Energy / ES framework (source: Tara Hooper)

Key points from group discussion of Figure 5:

- The reactive approach is essentially the minimum that ADVENT set out to deliver in the Case for Support (i.e. using energy pathways already developed by CCC, UKERC, etc.), but the more integrated approach would be a greater scientific advance and have more benefits for policy. Achieving a more integrated approach would also require some form of optimisation against defined criteria (e.g. the equity, security and sustainability dimensions of the energy trilemma), possibly by treating the use of natural capital as a portfolio allocation problem.

- Much of the research in ADVENT will focus on metrics, data, and modelling approaches. Combined, these will make up the arrows linking the integrated and reactive approaches to integrating energy system and ecosystem service frameworks.
- What metrics do we have, and what metrics do we need or would be helpful in measuring and modelling these links? What data do we need?
- It might be a good idea to make the integrated and reactive arrows much wider, so that we can write text inside them. This could call out specific links we're going to address (e.g. energy mixes and land use) or in other versions it could show how the various WPs fit in. In particular, we could show which FEGS will be examined within ADVENT (e.g. visual amenities, biodiversity, GHGs, water, food and recreation).
- The kinds of information, modelling techniques, data and metrics that are most relevant will depend on the particular FEGS in question and the decision-making and modelling scales of interest.

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