Ecological Economics 131 (2017) 425–433

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Celestial bodies and satellites – Energy issues, models, and imaginaries in Denmark since 1973

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ARTICLE INFO

Article history:
Received 15 January 2016
Received in revised form 23 September 2016
Accepted 29 September 2016
Available online 5 October 2016

Keywords:
Macroeconomic modelling
Energy issues
Publics
Imaginaries
Economic growth

ABSTRACT

This article uses the history of macroeconomic energy modelling in Denmark as a case for presenting a theoretical framework which describes *issues*, *publics* and *imaginaries* as an important nexus for energy policy. The story evolves around the actions, tensions, and entanglement of two publics – the traditionalist and the environmentalist – and presents macroeconomic modelling as an instrument for *issue articulation* and the construction of *energy policy imaginaries*. The article concludes that macroeconomic modelling is an effective instrument for articulating the economic realities of energy policy, and that economic growth plays a key role in these articulations by determining the basic preconditions for collective imaginaries of energy system futures.

1. Introduction

The world is on the verge of climate disaster. Human-induced temperature increase is threatening societies across the planet, and global energy system transformations are urgently needed[1] (IPCC, 2014). At the same time, governments all over the world are staring fixedly at the economic growth indicator in the hope of upward-sloping tendencies, which are synonymous with better times ahead in their view. This situation is well captured by Jackson's term *the dilemma of growth* (Jackson, 2009), which means that modern societies have become heavily dependent on economic growth in order to secure social stability, employment and welfare institutions, despite mounting research which suggests that economic growth has undesirable effects on the planet (Wackernagel et al., 2002, Weinzettel et al., 2013, Wiedmann et al., 2015). Thus, the dilemma of growth encompasses two conflicting concerns: continued economic growth and global environmental havoc. The first can justly be termed as being top priority for states and governments, whereas the latter takes up a less prominent spot further down the list of government priorities and is often represented by publics less connected to the core operations of the state and its government.

Since the early seventies, it has become increasingly apparent that energy is a vital component of economic growth, societal order and stability. However, the use of energy, especially fossil fuels, for this purpose comes with severe environmental disadvantages such as carbon emissions and climate change (IPCC, 2014). Hence, the issue of energy encompasses the same concerns as the dilemma of growth, in relation to which the state and its government historically has been mostly interested in energy as a means for securing economic growth and stability, while those concerned with environmental issues have focused on the adverse effects of energy consumption.

In this respect, energy has, since the emergence of the first oil crisis in 1973, become an increasingly important political issue and the subject of perpetual policy-making and dispute (van Daalen et al., 2002). This increased political interest has also led to inquiry into the energy issue, which began to make use of *computational*[2] macroeconomic modelling already in the early seventies. The treatment of energy by this type of modelling is a key theme of the present article. By tracing the joint enterprises behind such modelling activities, this article provides insight to the apparatus behind the creation of *energy policy imaginaries*. This is achieved by addressing the following research question: *how has macroeconomic energy modelling been developed as an instrument for energy policy in Denmark since 1973, and what can be learned from this story about the role of macroeconomic modelling in Danish energy policy?*

The treatment of this question reveals a tension between the aforementioned concerns regarding economic growth, but also between different epistemic traditions, where mainstream macroeconomics is a tradition in favour of continued economic growth, while thermodynamics and system dynamics have been favoured by academics who are growth-

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[1] In fact, much more is needed; however, due to the limited scope of this article, I mainly focus on energy system issues.

[2] Computational, as opposed to theoretical, means that the model consists of a set of equations, which is solved by a computer, thus providing a numerical result. Since all the models treated in this article are computational, this will not be stated explicitly.

http://dx.doi.org/10.1016/j.ecolecon.2016.09.027
0921-8009/

antagonists (Georgescu-Roegen, 1971, Meadows et al., 1972). Mainstream macroeconomics conceptualises energy as a market good and a substitutable factor of production (Andersen et al., 2010), while the antagonistic perspective emphasises the systemic and entropic aspects of energy. The former perspective explains economic growth by enhanced factor productivity as a result of technological progress (Solow, 1956), whereas the latter holds that energy - or more precisely *exergy*[3] - is the key term in understanding economic growth (Ayres and Warr, 2005). Furthermore, the latter perspective points to the entropic consequences of economic growth, which means that maintaining low entropic societal order and stability (especially by means of fossil fuels) comes at the price of high entropic environmental degradation (Georgescu-Roegen, 1971).

The epistemic divide between mainstream economics and growth antagonistic perspectives is also key to understanding the title of the present article, which is inspired by macroeconomic modelling language. In this language, it is common to speak of an appendix model to a macroeconomic[4] model as a *satellite*. Hence, the macroeconomic model can be seen as a *celestial body* around which various satellites, such as energy models, orbit and whose gravity they have to obey. Taking an exergy view on this metaphor, however, requires a radically different explanation in which the role of celestial body is played by exergy, while the economy is a satellite under its command.

The analyses of this article are a combination of sociology of science and policy analysis with an inclination towards the former. This means that the article does not attempt to trace the influence of modelling on concrete policy-making, but rather investigates the historical development of a specific type of modelling as a certain mode of inquiry with the ability to produce energy policy imaginaries. Even though the article relates to several strands of literature, one of its main purposes is to contribute to on-going discussions of politics as a matter of *issues*, *publics* and *imaginaries* (Dewey, 2012 (1927); Marres, 2005, 2007; Brown, 2009, 2015; Jasanoff and Kim, 2009, 2013). Epitomising these strands of analysis, Marres has emphasised the significance of issues and publics to politics and democracy (Marres, 2005, 2007; Brown, 2015), while Jasanoff and Kim (2009, 2013) have highlighted the important role of sociotechnical imaginaries in policy-making. However, these two perspectives have, to my knowledge, not yet been merged together, which is what I do in the following.

Also of interest to this article are two different literary strands covering two different kinds of modelling: *macroeconomic* and *energy/environmental* modelling. The former investigates the role of macroeconomic modelling in various contexts of political decision-making (Andersen and Madsen, 1995; Evans, 1997; den Butter and Morgan, 2000; Henriksen, 2013; Reichmann, 2013), while the latter does the same for energy/environmental modelling (Midttun and Baumgartner, 1986; Baumgartner and Midttun, 1987; Hogan, 2002; van Daalen et al., 2002; Nilsson et al., 2011; Upham et al., 2015). Even though they discuss two different types of modelling, these two strands are closely connected since discussing one makes it hard to ignore the issues and concerns which motivate the other. Thus, energy has become part of macroeconomic modelling and macroeconomics has become part of energy modelling. For the purpose of elaborating on this relationship, this article puts the connection between macroeconomic and energy modelling at the centre of attention and investigates activities of developing a discipline which I have labelled *macroeconomic energy modelling* (MEM). Denmark – one of the leading renewable energy nations of the world – was chosen as the case for this historical investigation. Due to its compelling history of energy system transformations, Denmark provides an interesting case of entangled grassroots mobilisation and governmental policy intervention (Jørgensen and Karnøe, 1995, Karnøe, in progress). This article focuses primarily on the governmental policy side of the matter and investigates how macroeconomic modelling has been mobilised as a tool for articulating energy policy imaginaries in Denmark.

The story focuses on three characteristic MEM collections from three different decades: the 1970s, the 1990s and the 2010s. Each of these decades saw events and were characterised by themes of special interest to MEM and, therefore, provide a good background for telling the story. The models of the seventies are called the IFIAS[5] models, EMMA[6] is the model of the nineties, while a model collection named IntERACT[7] represents the current decade.

The rest of the article is organised as follows: in Section 2, a brief account of the empirical material is given, while, in Section 3, some of the limitations of the research are considered. The theoretical framework is presented in Section 4, and Section 5 discusses macroeconomic modelling and national accounting. Section 6 unfolds the story; Section 7 discusses some aspects of the story, while a conclusion is provided in Section 8.

2. Empirical Material

The empirical material of this article consists of fifteen semi-structured, audio recorded and transcribed interviews, and one audio recording from a public seminar on multi-sector models[8] (see Appendix 1 for a list of interviewees and their institutional affiliation). This material conveys the worldviews and stories of key actors including economists, civil servants and energy system researchers involved in the story of MEM in Denmark. Since all the interviews were performed in Danish, I have translated direct quotes from the interviews to English. The interviews and the seminar are referred to in square brackets. To supplement the audio recorded material, I rely on academic articles and book chapters and a body of reports and documents from central agencies such as the Danish Energy Agency, Statistics Denmark[9] and the Danish Ministry of Finance.

3. Limitations

The following story naturally has several limitations, two of which are the missing treatment of the impact of computer technology on macroeconomic modelling, and the fragmentary ethnographic detail concerning the linkages between policy change and modelling. It is widely recognised that the evolution of digital computers had a tremendous impact on computational modelling, and I am convinced that this influence also provides an opportunity for interesting investigations in relation to macroeconomic models. Yet, due to the focus on issues, publics and imaginaries, this part of the story has been omitted, leaving a gap for further research. Regarding the linkages between policy change and modelling, it is not easy to acquire the desired ethnographic detail since these linkages require access to rather closed and secretive environments such as the Danish Ministry of Finance. Several times during the research, I realised that access to such sites was quite limited and often beyond my reach.

4. Theoretical Framework

In order to analyse the case at hand, a selection of different, yet kindred theoretical perspectives have been weaved together, the purpose being to highlight the relation between issues, publics, and imaginaries as an important nexus for energy policy, in which macroeconomic

[3] Ayres & Warr define exergy as 'available' or 'useful' energy, which means the potential for physical work contained in a given quantity of energy (Ayres and Warr, 2005). The high exergy content of fossil fuels is, thus, key to understanding the rapid economic growth, which has taken place since the Second World War.

[4] To be more precise, satellites are developed for so called macro-econometric models, which are a special type of macroeconomic model.

[5] The International Federation of Institutes for Advanced Study.

[6] Energy and eMissions Models for ADAM (Annual Danish Aggregate Model).

[7] INTegrated Economic eneRgy Applied Computational Tool.

[8] All together comprising approximately 24 h of audio recordings.

[9] The Danish National Bureau of Statistics.