Energy Policy 119 (2018) 585–599

Contents lists available at ScienceDirect

Energy Policy

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

The burden of sustainability: Limits to sustainable bioenergy development in Norway

Bianca Cavicchi[a,b,*]

[a] Norwegian Institute of Bioeconomy Research (NIBIO), Storgata 2-4-6, 0030 Oslo , Norway
[b] Centre for Technology, Innovation and Culture (TIK, University of Oslo), Eilert Sundt building, 5th floor Moltke Moes vei 31, 0851 Oslo, Norway

ARTICLE INFO

Keywords:
Bioenergy
System dynamics
Governance
Sustainability
Transitions

ABSTRACT

This paper analyses the case of bioenergy development in Norway – drawing on Hedmark county located on the borders with Sweden – from a social, economic and environmental perspective (triple bottom line). Since 2008, the number of forest-based bioenergy plants increased rapidly, following the introduction of the wood-chips scheme and the high local expectations of its benefits for rural development. Obstacles to its continuous sustainable development have subsequently been increasing. Therefore, the goal of the study is to investigate the causal processes of bioenergy development to understand what threatens its triple bottom line sustainability. The study does so by employing qualitative system dynamics (i.e. causal loop diagram) and using interviews with local actors to elaborate on studies that look at the influence of power, institutions and expectations on the transition processes. Results show that the local actors' positive perceptions of the benefits of bioenergy mainly drove its initial development, but that conflicting local interests, power relations, and market dynamics now threaten these initially positive perceptions.

1. Introduction

This study is an attempt to use system dynamics to investigate the complex interrelations between economic, social and environmental factors at different levels of governance within the bioenergy system of Hedmark, a Norwegian county. It frames the problem as a system of feedback relations; hence, it represents a theoretical and methodological effort to overcome the tendency to focus on a single or few issues.

In the last two decades, climate change has been a concern of Norwegian politicians. Policies have targeted the reduction of greenhouse gas emissions, the increase in the renewable energy share and the connection to the European electricity grid. Despite the dominance of hydropower and its low price compared to other European countries, the core political strategy supports green technology adoption either via public grants to investments or green certificates to electricity production (see for instance NREAP, 2012).

As in many other European countries, bioenergy became part of this policy strategy both to tackle climate change and provide an alternative market for forest industries in the context of a declining pulp and paper industry. Rural areas in the inland counties (i.e. Buskerud, Oppland, and Hedmark) seized the bioenergy opportunity and significantly adopted bioheat plants between 2009 and 2012. However, eventually the interest in bioenergy lost momentum, and the bioheat system showed its limits. This study focuses on the case of forest-based bioheat development in the context of Hedmark County. *Bioheat* refers to the production of biomass and bioheat mostly from burning wood chips (most of the plants do not coproduce heat and electricity because it would not be economically profitable). The paper adopts a triple bottom line (TBL) sustainability approach (i.e. interrelations and mutual influence of economic, social and environmental processes) to study what led to the sustainability failure of bioheat in the case study. To this purpose, the paper applies qualitative systems dynamics, QSD (i.e. use of causal loop diagram, CLD) and the transitions governance literature (e.g. Avelino and Rotmans, 2009; Leach et al., 2010a; Meadowcroft, 2002, 2009; Scoones et al., 2007; Smith et al., 2005). Primary results show that local actors' expectations and perceptions play a very crucial role in supporting the production of bioheat. Since the beginning, they have firmly believed that bioheat could help rural economy and the achievement of climate change goals. However, the empirical findings show that the feedback relations between perceptions, established norms, politics and market processes may be the primary cause preventing sustainable bioheat development.

2. Problem articulation

This paper is based on a previous study of bioenergy policy in

* Corresponding author at: Norwegian Institute of Bioeconomy Research (NIBIO), Storgata 2-4-6, 0030 Oslo, Norway.
E-mail address: bianca.cavicchi@nibio.no.

https://doi.org/10.1016/j.enpol.2018.05.015
Received 22 June 2016; Received in revised form 27 April 2018; Accepted 6 May 2018

Norway – and Emilia Romagna – (Cavicchi et al., 2014; Cavicchi et al., 2014) that investigated the impact of policies and institutions on bioenergy and rural development in the two case studies. The study showed Norway's great potential to develop a structured bioenergy system and other bioeconomy specializations (e.g. biochemical) especially because of the abundance of forestry resources, knowledge, experience, and skills. Local and national stakeholders who are most sensitive to rural interests saw in bioenergy a means to foster rural employment and growth of the forestry sector, but also a way to tackle climate change mitigation (OED, 2008; SKOG_22, 2015; interviews with 24). At present, bioenergy is predominantly forest-based bioheat because of the favorable climate conditions and large stock of forest resources in the inland counties (Hedmark, Oppland, Buskerud, Trøndelag). In this regard, the case of Hedmark is particularly compelling because the forestry sector is still quite economically relevant and local actors (e.g. municipal councils and county governor, forest owners, local engineers and farmers) have shown an exceptional interest in bioenergy. In the last decade, these elements have fostered the adoption of bioheat. However, in the most recent years scholars have shown that the sector is affected by the hydropower system dominance on the energy production side, and the competition of more profitable forest markets (e.g. export of timbers o Sweden) on the biomass supply side (see for instance Trømborg et al., 2011; Bolkesjø and Solberg, 2016; Albrecht, 2014a; Brough et al., 2013; Forbord et al., 2012; Sjølie et al., 2010). On the ground, 'feelings' are ambiguous. On the one hand, big forest owners agree with the scholars' analysis and are not very optimistic regarding the future development of bioheat. Conversely, particularly small forest owners are very keen to embark on new projects. Municipalities also display different attitudes. Some are willing to facilitate the bioheat adoption; others prefer other energy solutions. Therefore, questions remain whether there are more subtle dynamics at play. This study asks *'why is bioheat development inhibited? How does the interrelation of social, environmental and economic factors foster or hamper the development of the bioheat system over time?'* The idea of interrelated economic, social and environmental processes refers to the notion of TBL sustainability (Elkington, 1998; but see also Bryden et al., 2011; OECD, 2012; Bluemling et al., 2013; del Río and Burguillo, 2009; Mårtensson and Westerberg, 2007). TBL is a crucial notion to this study as it posits that the interrelation of the three dimensions influences the processes and outcomes of economic/production activities. Thus, the paper conceives TBL as a broad normative policy objective that guides semi-structured interviews and data analysis.

3. Theory and methodology

3.1. Theory

This study rests on the systems thinking (Checkland, 1981; Senge, 1990; Richardson, 1991; Forrester, 1968; Sterman, 2000) and 'transitions governance' literature (e.g. Avelino and Rotmans, 2009; Meadowcroft, 2002; Tyfield et al., 2015; Kern, 2011; Leach et. al, 2010; Ely et al., 2014). The use of systems thinking to explore obstacles to sustainable bioenergy development is covered elsewhere (i.e. Cavicchi, 2016). Therefore, this section will focus more on its integration with the transitions governance approach. The latter will be used to understand the influence of contextual conditions on social, environmental and economic processes. This theoretical framework supports the analysis of the problem situation as a system of feedback relations (i.e. economic, environmental and social processes mutually influence each other) influenced by contextual conditions. Other theories[1] could explain dynamics such as the path-dependency (hydropower lock-in), but these would narrow the attention on a specific issue or factor, thus missing the aim of this study.

[1] i.e. path dependency or sociology of expectations.

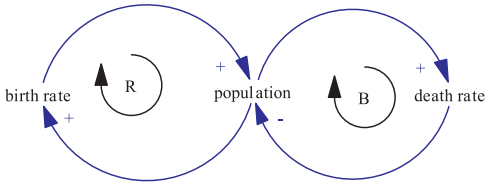

Fig. 1. Example of a feedback process.

Peter Senge (1990, p. 23) argues that *"system thinking is a discipline for seeing wholes. It is a framework for seeing interrelationships rather than things, for seeing patterns of change rather than static "snapshots"*. There are different perspectives and methods within the 'systems thinking' literature. These are commonly distinguished in 'soft' and 'hard' approaches (see Cavicchi, 2016; Lane, 2000; Lane, 2001a; Lane, 2001b; Checkland, 1981; Haraldsson et al., 2006; Haraldsson and Sverdrup, 2004; Haraldsson and Ólafsdóttir, 2003). As Cavicchi (2016) explained, the hard approach relies on principles of servo-mechanics and cybernetics; hence, it uses mathematical models and simulations to explore possible fixes to system misbehaviors. The soft approach, conversely, relies on principles of constructivism to understand why a system behaves in a certain way and reach shared solutions to the problem situation. Both approaches share the concept of feedback and time-space[2] 'Feedback' (Fig. 1) explains how actions can reinforce or balance each other, i.e. nothing is ever influenced in only one direction (Senge, 1990).

These feedback relations often produce unpredicted effects that are delayed in time and space while misdirecting our focus towards the problem symptoms rather than its underlying causes (e.g. Sterman, 2012; Senge and Sterman, 1990; Sterman, 2000; Sterman, 1994, 2015). This paper applies the soft approach to explore feedback relations between social, economic and environmental processes via causal loop diagrams (CLDs). The CLDs will include the time-space element as an informative dimension because its effect cannot be simulated in a qualitative inquiry.

In line with the soft approach, the study assumes that 'systems' (i.e. 'wholes' of interconnected social and material processes) are a social construct; therefore, they ensue from people's mental models and their interrelations (e.g. Doyle and Ford, 1998; Checkland, 1981). A 'system'*"[…] consist[s] of social, institutional, ecological and technological elements interacting in dynamics ways"* (Leach et al., 2010, p.43). Hence, systems are subjected to contingencies and contextual conditions such as power (who decides and controls critical resources[3]), rules of the game (e.g. norms, policies and laws), actors' visions and expectations and the natural environment (see for reference Senge, 1990; Leach, 2010; Meadowcroft, 2002; Scoones et al., 2007; Tyfield et al., 2015). Considering these governance dimensions is crucial to understand the contextually embedded nature of bioheat development and its consequences from a TBL perspective (see in particular Leach et al., 2010; Meadowcroft, 2002; Avelino and Rotmans, 2009; Avelino and Wittmayer, 2015; Meadowcroft, 2009). This contribution is particularly evident in the 'social' part of the causal loop diagram. For instance, the transitions governance approach explains the dynamics of *local conflicts* (in red, see Fig. 5), *pressure on politicians* and *policy change*.

Following this theoretical discussion, the expression *"bioheat*

[2] Soft and hard approaches apply the time-space dimension differently. The former translates it into a formula to include in the simulation; the latter treats it as an informative dimension to interpret the behavior of the system over time.

[3] The paper adopts the definition of Avelino and Rotmans (2009, p. 550): "We define resources more broadly as persons, assets, materials or capital, including human, mental, monetary, artefactual and natural resources. There is no inherent hierarchy of relevance between the different resources. Each type of resource can be the object of power to more or less extent. All resources are interrelated and in order to mobilize one type, one may need to make use of other types.".