



# When the circular economy diverges: The co-evolution of biogas business models and material circuits in Finland

Helena Valve<sup>a,\*</sup>, David Lazarevic<sup>a</sup>, Niko Humalisto<sup>b</sup>

<sup>a</sup> Environmental Policy Centre, Finnish Environment Institute, Latokartanonkaari 11, 00790 Helsinki, Finland

<sup>b</sup> Department of Geographical and Historical Studies, University of Eastern Finland, P.O. Box 111, 80101 Joensuu, Finland

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## ABSTRACT

The circular economy operates as an umbrella concept for attempts to find sustainable alternatives to linear 'take-make-dispose' production and consumption systems. Making a circular economy transformation has sparked interest in business models as means to decouple value creation and the use of virgin raw materials. However, so far, little attention has been given to the differentiating capacities of business models to enhance circularity. Using Finnish biogas production as a case study, this paper shows how business models operating within a single economic domain and within uniform institutional conditions differ in terms of how they organise material circuits. Four business models are differentiated based on what wastes and side-flows they enable to be recovered, and how. Because the business models co-evolve, their potentials are analysed in relation to the business model ecosystem. An emerging business model competes with the dominating model. The newcomer would help to generate more closed material loops, but the existing institutional landscape fails to provide support for its emerging modes of value creation and value capture. Two other business models qualify as niche solutions coexisting with the other models. Knowing the business model ecosystem opens up prospects for policy revisions that can foster a more circular economy.

## 1. Introduction

Business models—as templates through which firms 'do business' by creating and capturing value in their network (Zott et al., 2011)—are gaining increasing attention due to their potential to link institutional change to the reorganisation of economic activities (Diaz et al., 2019; Levänen et al., 2018; Provance et al., 2011). Institutional change, promoted by public policies, is supposed to transform the operation of markets so that sustainable business models (Boons et al., 2013) evolve and gain a competitive advantage (Schaltegger et al., 2016). Recently, interest has been directed to circular business models (CBMs) (Geissdoerfer et al., 2020; Lüdeke-Freund et al., 2019) as they indicate 'how a company creates, captures, and delivers value with the value creation logic designed to improve resource efficiency through contributing to extending useful life of products and parts (e.g., through long-life design, repair and remanufacturing) and closing material loops' (Nußholz, 2017, p. 1810).<sup>1</sup>

The circular economy operates as an umbrella concept (Blomsma, 2018) for attempts to find sustainable alternatives to linear 'take-make-

dispose' production and consumption systems. It is often described in terms of different strategies for retaining the value of products and materials, including extending product lifetime, product reuse, repairing or refurbishing, material recycling and energy recovery. Generally, CBMs tend also to be classified in these broad terms (e.g., Bocken et al., 2016; Geissdoerfer et al., 2018; Lüdeke-Freund et al., 2019). Due to this trend of broad CBM categorisation, two important aspects of CBMs are often overlooked. First, when all business models that aim to retain value through secondary resource recovery are grouped together, little can be learned about their different capacities to close material loops. Second, a focus on broad categories has left the relationships and interactions between business models mostly unaddressed. To fill the gap, recent literature has started to analyse business models as part of a *business model ecosystem*. This concept refers to the composition of, and relationships between, business models operating within shared institutional conditions (Bocken et al., 2020; Bocken et al., 2019; Boons and Bocken, 2018).

In the field of secondary resource recovery, it is important to ask 'which wastes are being recovered as resources' (Gregson et al., 2015, p.

\* Corresponding author.

E-mail addresses: [helena.valve@syke.fi](mailto:helena.valve@syke.fi) (H. Valve), [david.lazarevic@syke.fi](mailto:david.lazarevic@syke.fi) (D. Lazarevic), [niko.humalisto@uef.fi](mailto:niko.humalisto@uef.fi) (N. Humalisto).

<sup>1</sup> See Geissdoerfer et al. (2020) for a review of CBM definitions

22) and how. Answers are needed to reveal whether resource recovery is evolving in ways that can support a systemic transformation. There is always a risk that technologies and business-models become adapted to utilise the ‘low hanging fruits’ while more widely accumulated material stocks fail to attract interest and investments (Lazarevic and Valve, 2020). Likewise, focusing on the ‘how’ question is essential since the utilisation of specific material stocks may turn out to be wasteful. CBMs can all be seen as more sustainable than their linear ‘take-make-dispose’ counterparts. Incumbent actors may thus well argue that current institutional arrangements are justified and that there is little need for institutional change. This hampers the potential of more circular business models to compete the dominating ones. As a result, progress towards a circular economy slows down.

In this paper, we argue for an empirically-driven and *materially attuned* analysis of circular business models. We use biogas production in Finland as a case study to analyse the differentiation of business models in secondary resource recovery. Biogas production is a fast growing mode of secondary resource recovery, particularly in Europe (Dermince and Königsberger, 2017; Lambert, 2017). Furthermore, anaerobic digestion provides the basis for a multi-functional process that transforms multiple organic inputs into various energy and material outputs that can be used in different ways. Biogas refined from residual materials is an almost greenhouse-gas-neutral energy carrier (Lambert, 2017; Olsson and Fallde, 2015). The other main output, biogas digestate, retains valuable nutrients and organic matter. Processed or unprocessed digestate can be used to substitute fertilisers made from virgin raw materials (i.e. mineral fertilisers). Finland makes an interesting case as it is a European Union (EU) country which has placed the enhancement of the circular economy, and particularly the *circular nutrient economy* (Valve et al., 2020), high on its policy agenda during the last decade (Humalisto et al., 2020; Kuokkanen et al., 2016). However, while indications of a successful circular economy transition could be expected, the country still has problems with inefficient nutrient use, similar to many other countries in the global North (Valve et al., 2020). The findings from the case study can therefore point to dynamics relevant for the fostering of circularity in circumstances that are relatively common.

Concepts such as ‘circular business models’ and ‘co-evolution’ from ecological economics (e.g. Diaz et al., 2019; Levänen et al., 2018; North, 1990), together with theorisations about economic framing, market-creation and materiality developed in economic sociology (e.g. Callon, 1998; Gregson et al., 2013), enable us to analyse business models as instruments of material organisation. In this paper, material organisation refers to the reconnections and disconnections in material use that resource recovery enables. Meanwhile the ecosystem approach ‘directs attention towards the multiple ways in which a variegated set of entities (in our case, business models) interact’ (Boons and Bocken, 2018: 43), guiding us to ask to what extent biogas business models in Finland are competing, instead of merely coexisting.

The research questions are the following:

1. How do biogas business models differ in respect to their contribution to circularity and material reorganisation in Finland?
2. How do the business models relate to each other: to what extent do they co-exist or compete?

The paper is organised as follows. The following section outlines reasons for the need of new analytical perspectives in the CBM literature. Section three introduces the empirical strategy; based on interviews and observations from conferences, workshops and field visits; as well as the analytical framework.

Section four presents our results, we first outline the business model dominating the biogas sector, turning then to the emergent business models. In the final two sections we discuss and draw conclusions from the analysis, pointing to differences in the ways the business models contribute to the development of a more circular economy.

## 2. Circular business models: expanding the view

Business models consist of a number of interdependent components, which has led to the development of numerous conceptualisations to describe and understand a firm and its focal parts (e.g. Osterwalder and Pigneur, 2010; Zott et al., 2011). As there is no agreed definition of a business model and its elements, empirical practice shows that definitions and elements are adopted in an idiosyncratic fashion depending on the purpose of the study (Zott et al., 2011). However, core elements have been identified as specifically relevant to CBMs (see Levänen et al., 2018; Lüdeke-Freund et al., 2019). These include a combination of: the value proposition (benefits offered to customers based on products, services or product-service systems); value creation and delivery (partners/stakeholders in the supply chain, target customers and the customer interface) and value capture (financial models that generate costs and revenues). These elements provide the basic analytical components used in the growing volume of literature attempting to categorise CBMs. The outcomes operate in terms of generalised patterns (Lüdeke-Freund et al., 2019), archetypes (Bocken et al., 2018) and principles (De Angelis, 2018). However, for CBMs to foster change towards a more circular economy, analytical efforts must pay more attention (i) to the ways in which CBMs (re)organise material relations and (ii) to the business model ecosystems of coexisting or potentially competing CBMs.

First, the CBM literature does not adequately address the issue of how business models gain their material (re)organising capacities. Gregson et al. (2013, p. 20) note that ‘materials constitute both stubborn facts and economic possibilities ... Uncovering too much asbestos, recovering and extracting not enough non-ferrous metal and encountering too thick steel, all have an effect on profitability’. Materiality, thus, needs to be considered as an integral component of CBMs (Corvellec et al., 2020). Doing so helps to acknowledge that resource recovery is a specific kind of a business domain. As noted by Crang et al. (2013, p. 13), the ‘focus on resource recovery challenges accepted arguments about value’. Value is not just added onto materials but emerges along their redistribution. Moreover, ‘resource recovery networks challenge assumptions about supply since the impetus is generally from someone getting rid of existing, unwanted stuff’ (Crang et al., 2013, p. 15), implying that the ways materials accumulate and link to existing livelihoods and practices affect what business prospects seem attractive. Furthermore, CBMs do not automatically lead to more circular material flows (Corvellec et al., 2020). Hence, greater attention needs to be paid to the ways CBMs contribute to the organisation of material circuits.

Second, the development of CBMs is seldom analysed from a co-evolutionary perspective (Schaltegger et al., 2016). The ‘business model ecosystem’ approach allows business models to be understood in terms of (i) how they interact with each other, in terms of competition and complementarity, (ii) how their interaction influences resource efficiency, and (iii) how the institutional setting conditions the relationships between business models (Bocken et al., 2019; Boons and Bocken, 2018). Indeed, business model innovation ‘cannot be understood without considering the co-evolution of the ... ecology [of] firms’ business models’ (Björkdahl and Holmén, 2013, p. 218). Furthermore, the setting in which competition and coexistence occurs may be contested. Firms actively mobilise regulations and policy instruments in their business model development (Lazarevic and Valve, 2020). They may also seek actively to promote institutional change to ensure that their business model innovation can survive and flourish within the business model ecosystem (Boons and Bocken, 2018). If, at the same time, critical analyses on the pros and cons of different CBMs competing in the same domain is non-existent, policy-makers cannot make informed decisions regarding the business models they wish to promote at the expense of others.

### 3. Case study, data, methods and analytical framework

#### 3.1. Case study: biogas production in Finland

Value in resource recovery can be created in unexpected and unconventional ways. Hence, studying the co-evolution of business models and material organisation calls for an approach that does not make rigid assumptions about the relevant business drivers and material entanglements, but treats their identification as an empirical task. These goals can be met by the adoption of a case study approach.

The business models of Finnish biogas production make a clear-cut case study. In 2017, about 40 biogas reactor installations (excluding waste water treatment plants and landfills) in the country produced approximately 496 GWh energy (Huttunen et al., 2018).<sup>2</sup> The official aim is to almost double production by 2030 (Ministry of Economic Affairs and Employment, 2017). This is in line with the growing trend in biogas production in Finland (Huttunen et al., 2018). This trend, along with the expectation that biogas production can help to close nutrient cycles, implies that there is an obvious need for the analysis of biogas business models. Achievement of the Finnish policy goals depends on the properties of the emerging business models.

In Finland, biogas is mostly used for heat and electricity generation. However, refining biogas into a transport fuel can generate considerable added value. The annual consumption of biomethane in transport grew by 41% in 2017 compared to the previous year (Huttunen et al., 2018). Almost all Finnish biogas installations have been granted direct investment support from the state. In addition, the Finnish government has supported biogas production through tax exemptions and a feed-in tariff targeted at large production units (Deremince and Königsberger, 2017). Despite the recent attention given to nutrient recycling, the support schemes treat biogas production foremost as a means to produce renewable energy. Digestate processing or the use of recycled nutrient products are not incentivised. Biogas production could, however, also pave the way for efficient nutrient recycling. When water is removed from the biogas digestate, nutrients can be separated into phosphorus and nitrogen fractions, which can then be feasibly transported and used to tailor fertilisation to crop requirements and soil nutrient profiles. These qualities are often needed to help to close nutrient loops, increase nutrient use efficiency and to substitute inorganic fertilisers with organic ones (Valve et al., 2020).<sup>3</sup>

The bulk of feedstocks for reactor-based biogas production in Finland, as in Sweden (Ostwald et al., 2013), consists of wastewater sludge and organic waste. The marginal use of energy crops make these countries quite different from countries such as Germany that undertake large-scale cultivation of agricultural crops for biogas production (see Lupp et al., 2014). In Germany, the Renewable-Energy-Act generated a boost in biogas production, but also in the cultivation of green maize that became a dominant biogas feedstock (Britz and Delzeit, 2013; Deremince and Königsberger, 2017). Rather than feeding 'excess back into metabolic circuits' (Law and Mol, 2008, p. 141), biomass production competes with food production for arable land.

In Finland, the key problem is that only about 1% of animal manure is used as biogas feedstock (Marttinen et al., 2018). This contributes to

<sup>2</sup> We excluded biogas production from landfill and waste water treatment plants from our analysis. In both cases production potentials have been almost fully reached. Moreover, the landfill of organic waste has been banned since 2016. Research/training plants were also excluded.

<sup>3</sup> In Finland, as in many other countries in the global North, the differentiation of livestock and arable agriculture has created a situation in which regions with intensive animal husbandry create nutrient surplus causing environmental degradation while the regions dominated with crop cultivation suffer from a deficiency of organic fertilisers (Jarvie et al., 2015; Withers et al., 2015). Anaerobic digestion also turns manure into digestate which, in most cases, is a better fertiliser than raw manure (Tambone and Adani, 2017).

low nutrient use efficiency and a waste of manure energy contents. The theoretical energy potential of the Finnish manure stocks is high, calculated to be equivalent to an average nuclear reactor (3.5 TWh/a) in Finland (Tähti and Rintala, 2010). Out of different biomasses, manure covers 75% of all recyclable phosphorus in the country. Sewage sludge, surplus grass, biowaste, food industry side-streams and pulp and paper industry sludges count for the remaining potential. (Marttinen et al., 2018) Due to this distribution, Finland constitutes a typical case, particularly in Europe (Buckwell and Nadeau, 2016).

#### 3.2. Data and analysis

Table 1 summarises the data on which our qualitative analysis of Finnish biogas production is based. As secondary data we made use of the histories of major companies, publicly available financial statements, current statistics (e.g. from the European Biogas Association and Finnish Biogas Association) and company websites. This material provided us with an overview of the biogas sector but gave little information about business model innovation or the role of business models as organisers of material relations. Primary data consisted of semi-structured, mostly face-to-face, interviews with biogas entrepreneurs and experts.<sup>4</sup> We also visited biogas production sites and carried out participant observation in biogas workshops and promotional events. All the interviews were recorded and transcribed, and notes were taken during field trips and workshops. All data were coded using NVivo software and coded following the criteria and questions presented in Table 2. Most of the data was analysed twice so that the initial coding was confirmed by another analyst.

To obtain information on the business model ecosystem we used quantitative data on the prevalence of the different business models using information from the Finnish Biogas Association, supplemented with data from Huttunen et al. (2018) and biogas supplier websites.

Our qualitative analysis was twofold, addressing research questions 1 and 2. In the data collection phase, both research questions were taken into consideration, but during the analysis phase, the data was examined from the two analytical perspectives. Table 2 summarises the progress of

**Table 1**  
Qualitative data.

Type of data	Characterisation	Timing
Interviews	22 interviews with 27 interviewees, out of which:  - 14 Biogas entrepreneurs or corporate representatives - 5 civil servants - 4 experts from agricultural extension services - 2 fertiliser manufacturers/service providers - 2 researchers	March 2016–May 2018
Field trips and site visits	Seven field trips and site visits which comprised:  - 2 guided excursions to 4 biogas installations - 4 private site visits including an interview - 1 agricultural extension event focusing on nutrient recycling	April 2016–May 2018
Participant observation/ Conferences and workshops	Participation in 7 events, of which one was an international biogas workshop and the others were national events	February 2016–May 2019

<sup>4</sup> Two of the interviews were conducted via Skype.

**Table 2**  
Progress of the analysis.

Perspective	Rationale	Questions guiding data collection and analysis
1. Material organisation and co-constitutive business models	Explication of how production has become focused on the processing of specific material stocks and generation of specific outputs.	Which material stocks have provided the basis for investments? How have waste and surplus biomasses turned into sources of value creation and capture? How do the different modes of material organisation link to strategies of value creation and capture – what business models can be differentiated?
2. Outline of the business model ecosystem	Explication of the prevalence of the business models and their mutual relations.	What is the prevalence of the different business models? In the case of marginal business models, are there any signs of expansion or challenge to the dominant model(s)? How do the institutional arrangements favour the dominant business model(s) and how should the framework change in order to support transformation of the business model ecosystem?

the analysis while Fig. 1 shows how the different dimensions of the analytical framework link together. The following sub-sections present the analytical concepts used in more detail.

### 3.3. Analytical framework

#### 3.3.1. Co-constitution of material organisation and business models

Despite the flexibility of anaerobic digestion technologies used in biogas production, not all biomasses qualify equally well as a feedstock. Biogas production may centre on the use of some materials stocks while some others remain underutilised. Recognising this problem, our analysis started by focusing on the materials that ground investment decisions and shape business strategies. The differences led to questions about the materials that qualified as feedstocks in biogas production. Moreover, what factors and what kinds of economic calculations had a bearing on the choice of the feedstocks? Here we expected that value can be generated at the market or it can evolve through closing material loops in production processes. When different modes of material organisation became apparent, the focus was placed on common value creation (i.e. what ‘value’ and how it is generated) and capture (i.e. how revenue is made) strategies.

From the point of view of emerging modes of material organisation, it is also important to ask how business models differ in the ways they transform material properties (e.g. energy, nutrient contents, organic matter) into producer value and which fractions simultaneously remain as an externality that only needs to be ‘gotten rid of’ in one way or another. In addition to recovered resources, biomass processing generates excesses that, for the producer, appears valueless or as a source of potential costs. We used the concept of an ‘economic frame’ (Callon, 1998) developed in economic sociology to examine the ‘narrowing down’ of resource recovery. The concept draws attention to the terms in which an activity is rendered economic. Focusing on economic frames guided the analysis to trace how, and at the cost of what kinds of underutilised fractions, waste and surplus materials became transformed into resources. Business models are likely to differ in the ways they internalise inputs and outputs of resource recovery into

profitability calculations. Depending on the economic frame some business models may support more ‘full’ recovery of resources and development of more closed material loops than others.<sup>5</sup>

The outputs that are recovered (see Fig. 1), and that generate value for the producer, vary depending on the input materials and on the expertise and technological solutions supporting recovery (Callon, 1998; Gregson et al., 2013). Markets with their embedded informational and normative codes indicate which material properties can be transformed to sources of value (Callon and Muniesa, 2005). However, markets do not just pre-exist, but are continuously being (re)made. As Gregson et al. (2013: 7) point out, this is the general impetus behind closing material loops: ‘To promote recycling... is a reflexive intervention in the organization of markets’. The similarities and differences in material underpinnings and economic frames, identified on the basis of the qualitative data (Table 1), allowed us to differentiate four business models. When sorting the business models, we tried to ensure, by careful examination of the borderline cases, that we did not force companies or installations into the typology. At the same time, it is evident that the typology conceals differences and freezes a target that is constantly moving. In the analysis, we draw attention to key variations and developments.

#### 3.3.2. Business model ecosystems

Following the ecological metaphors adopted in ecological economics, innovations (including business model innovations) can be understood as analogous to new mutant organisms or invasive species that at the same time seek to adapt to, as well as shape, their new environment (Constant, 2002). The interplay can materialise as the development of disconnected ‘niche’ spaces in which the newcomers, i. e. new business models, can survive. However, business models may also actively compete for market survival and related institutional support. The advocates of the business model innovations may seek to change market conditions so that they can gain a competitive advantage (Doganova and Karnøe, 2015).

When analysing this co-evolutionary dynamic (cf. Boons and Bocken, 2018), we separated ‘dominant’ business models from the more marginal ones. The latter may either seek to survive in their localised niches or have the ambition to change the selection environment with its ‘rules of the game’ (North, 1990).<sup>6</sup> This raises questions about the institutional features (Levänen et al., 2018) conditioning the development of markets and the business model ecosystem (Boons and Bocken, 2018). Institutional arrangements affect how particular waste and surplus biomasses qualify as raw materials and how the recovered outputs can generate producer value.

Analysis of quantitative data enabled us to identify which business model(s) dominate the field. Subsequently we classified the more marginal business models based on their intentions to try to reform markets and co-constitutive institutions. We also analysed how the models are enabled or challenged by institutional features. Here we made use of reviews of the policy framework (Kampman et al., 2017; Mutikainen et al., 2016) and the collected qualitative descriptions of the issue.

## 4. Results: Four biogas business models

In this section, the analytical framework is used to categorise the business models of Finnish biogas production based on the material circuits they generate and maintain. Table 3 summarises the findings. It distinguishes four types of business models and the institutional enablers

<sup>5</sup> Since value-creation cannot be based on static interactions, inclusion cannot be complete. There are always some externalities that ‘overflow’ (Callon, 1998).

<sup>6</sup> As we argued elsewhere (Lazarevic and Valve, 2020), from a sustainability transitions perspective, the dominant business models can also be analysed as niches.

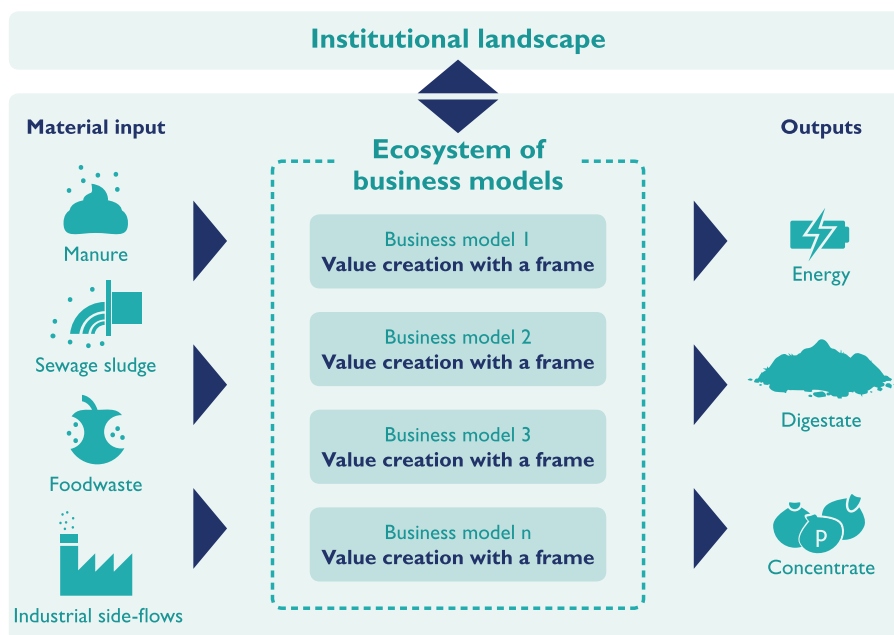


Fig. 1. Key components of the analytical framework.

Table 3  
Business models constitutive for Finnish biogas production.

Business model	Approximate scale of production (MWh/a) <sup>a</sup>	Value creation and capture	Position in the ecosystem	Critical institutional enablers (+) and barriers (-)
<b>Biogas production as waste-management and energy generation</b>	422,500	'Gate fees' as the main strategy for value capture: 'moneyed' biomasses in and manure out Energy outputs the source of revenue Digestate is often outside the economic frame	The dominant business model	The Waste Act, Land-fill restrictions (+) Institutionalised position of biogas production as a waste management option (+) Restrictions regarding the use of digestate that originates from sewage sludge can complicate digestate management (-)
<b>Manure processing to support farming</b>	16,500	Better utilisation of manure nutrients and organic matter Output focuses on nutrients over energy Energy savings create added value	Niche solution	Farm-level investment subsidies (+) Regulatory restrictions prohibiting the sale of energy (-)
<b>Biogas production to support rural energy generation</b>	23,000	Making the most of underutilised energy-rich side-flows and their spatial proximity Energy outputs as the main source of revenue	Niche solution	Farm level investments subsidies; Agri-environmental support for grass cultivation (+) No sustainability criteria for grass to ensure that grass counts as renewable energy source (Renewable Energy Directive 2018/2001/EU) (-)
<b>New rules for the game: biogas as centralised manure processing to enhance nutrient recycling</b>	20,500	Redistribution of manure nutrients and organic matter Investment in advanced digestate processing Energy refined into transport fuel the main source of revenue	Challenging the dominant business model	Institutionalised position of biogas production as a waste management (-) No markets for recycled fertiliser products (-) Weak incentives for the recovery of manure nutrients and energy (-)

<sup>a</sup> Data for biogas production is based on approximations from the Finnish Biogas Association, Huttunen and Kuittinen (2017) and firm websites. Data is incomplete and should not be read as exact production volumes; but the figures provide an approximation of the scale of production for each business model

or barriers critical for their survival or competitiveness. The business model ecosystem includes a dominant business model, two niche business models that do not challenge the dominant model and, finally, one that seeks to gain ground along with new rules of the game.

4.1. The dominant model: biogas production as waste management and energy generation

Finnish biogas production relies significantly on the collection of so-called 'gate fees'. Biogas companies charge gate fees as compensation for their waste-management services. Gate fees are mostly paid for

materials such as sewage sludge and household organic waste that are classified as waste according to the Waste Act. Manure does not belong to this category. Moreover, farmers cannot afford to pay any noteworthy fees for someone to receive the manure. When biogas production is based on the collection of gate fees, materials that enable collection of such fees qualify easiest as biogas feedstocks. This dominant business model makes use of a value capture strategy that is dependent on the revenues that travel with the materials. Here, we refer to these as 'moneyed' materials, because they have a market value even before any resource recovery has taken place.

‘So, in this sense these installations are mostly built on solving the waste problem, if one can say so. The processing chain creates costs although it also generates energy and fertilisers, but in practice the costs cannot be covered by the earnings gained from the sale of energy, for example. So... the operation needs to be partly based also on the waste treatment fees [gate fees]’ (Representative of a biogas company).

Within this category, biogas production acts as an alternative that outcompetes, on the one hand, waste incineration, which squanders nutrients and organic matter and, on the other hand, composting, which does not recover the energy contents of biomass. Many companies who employ this business model are major energy producers. The largest producer, Gasum, is owned by the Finnish state.<sup>7</sup> This company, in particular, has invested significantly in biogas refining.

This business model frames biogas production as an economic activity in a way that raises criticism among the interviewees. *The biogas digestate tends to fall outside the economic frame so that it becomes an externality that the companies just want to get rid of in the easiest, least costly, way.* Although the unprocessed digestate is spread on fields or used in landscaping, critics argue that the biogas companies treat the digestate as an externality rather than a raw material that could, and should, be processed further into recycled fertilisers. However, the companies whose business models are based on gate fees are not fully identical, and several accept manure in small quantities. The emphasis placed on digestate processing and the development of fertiliser products also varies even between companies’ different production sites.

This business model is primarily enabled by the Waste Act that transposes the EU Waste Framework Directive (2008/98/EC) and sets additional requirements such as a ban on the landfill of organic waste. In the scope of this business model, biomass processing can generate profit as long as anaerobic digestion maintains its institutionalised status as a technology that, even without digestate processing, fulfils the criteria set for resource recovery and sound waste management. Any restrictions that limit the spread of sewage sludge based digestate hamper this business model. Sludge is a ‘moneyed’ biomass but may contain traces of contaminants. Some foodstuff companies have announced that they do not purchase cereals grown with sludge-based digestate (Luke, n.d.).

#### 4.2. Niche A: manure processing to support farming

On farms, and on animal farms in particular, biogas production supports farming activities. Not many farms have invested in biogas production, but those that have often use manure as a biogas feedstock. Manure qualifies as biogas feedstock, and drives investment in biogas production, as a material that is improved by the anaerobic digestion process. During the anaerobic digestion process, nitrogen mineralises and becomes more accessible for plants and odours are neutralised; thus, gaining better properties as a fertiliser. In the short growing season in Finland, fast accessibility is important for the cultivation of organic crops in particular. As a result, the business model is:

‘[...] not based extensively on the amount of energy produced but on the smart separation of nutrients into organic fertilisers that can be spread on fields using the existing machinery.’ (Biogas technology entrepreneur).

This business model has been adopted on individual farms, but it also characterises the operation of biogas companies established by farmers’ cooperatives. The business model frames biogas production as a supportive activity that serves farming businesses in conditions of manure excess, but also when there is a scarcity of transportable organic fertilisers. The

<sup>7</sup> Gasum’s biogas production potential is about 218 GWh. The potential is calculated from the data presented on the company website (<https://www.gasum.com/en/About-gas/biogas/Biogas-plants/>, accessed 6 November 2020). The amount equals 57% of reactor-based biogas produced in Finland.

biogas that is produced can be used within farms or, for example, in greenhouses associated with the biogas company. The production of transport fuel is also being piloted. As value-creation takes place mostly outside markets, the business model represents a niche solution that does not seek to challenge the dominant model.

Investment subsidies paid to farms play an important enabling role in the initial phase of establishing on-farm installations. However, regulation on the use of the subsidies complicates value-creation by restricting the sale of biogas outside the farm.

#### 4.3. Niche B: Biogas production to support rural energy generation

Some Finnish developers of biogas production technologies show evident frustration towards the development of the biogas sector. In seminars and workshops focusing on biogas, these actors are eager to point out that rural regions in Finland have the materials to enable a significant increase in biogas production: *‘There should be an immediate effort to allow rural areas of Finland to participate in Finnish energy production’* (Biogas technology entrepreneur). According to critics, this potential for energy production is not properly acknowledged.

Rural biomasses attract attention as a theoretical possibility but already serve as materials on which some small biogas companies base their current or planned operations. *Energy-rich biomasses accumulating in geographically restricted areas drive biogas investments and are used as production feedstocks.* Mostly, these biomasses include surplus grass, food industry side-flows and organic waste.

Characteristic to this type of a business model is the *economic framing* of biogas production as small-scale, distributed *energy generation*. The energy sold as a transport fuel or electricity generates economic value, while gate-fees have a minor or non-existent role in the financial model. The biogas digestate is used unprocessed as a fertiliser close to the biogas installations.

In many ways, this business model builds on existing strengths. It builds on the spatial proximity of both material supply and demand. Material circuits can be organised without high transportation costs and digestate processing investments. The reliance on spatial proximity means that the business model cannot be easily transferred from one region to another. Thus, it also follows that the business model, while innovative, is not oriented towards the major reorganisation of energy, transport fuel or fertiliser markets.

This business model is enabled by the special role that grass cultivation plays in Finnish agriculture. Grass cultivation is subsidised for use as a forage crop, but also for the environmental benefits cultivation generates. However, if production of grass-based biogas is to qualify for renewable energy subsidies according to EU regulations (Renewable Energy Directive 2018/2001/EU), official sustainability criteria need to be defined for grass.

#### 4.4. New rules for the game: biogas as centralized manure processing to enhance nutrient recycling

*‘Many of the [biogas] projects are based on the idea that they are located in the middle of the forest [figuratively speaking] and that they dump it [the digestate]. This has, in principle, destroyed the entire brand. But if we could now get some successful examples that could show that it is not the gate fees but the productification...’* (Entrepreneur planning a biogas investment).

As already described, animal manure does not easily qualify as a biogas feedstock, although the total energy and phosphorus potentials of manure stocks are very significant. The reasons for the situation are often seen to be so obvious that even to ask why manure disqualifies implies that the person posing the question knows little about the biogas business. The logic is simple; no gate fees paid for the biomass, no utilisation of the biomass. One is also reminded that the energy generation potential of manure is significantly lower than most other organic

side-flows and residues.

Nonetheless, the dominant business model based on gate-fees and processing ‘moneyed’ biomasses is being explicitly challenged. The *material driving* the emerging business model is manure; mostly pig and cow slurry. Animal husbandry is concentrated on bigger farms and in smaller areas. Thus, the need to process manure and solve the manure excess problem in areas of intensive livestock production is increasing. The decoupling of animal husbandry and crop cultivation has created demand for manure processing that can effectively separate nutrient fractions and increase the transportability of organic matter and manure-based phosphorus.

Technologies that enable the efficient processing of biogas digestate have been developed in recent years (Marttinen et al., 2018). At the same time, solutions for refining biogas into transport fuel have become a feasible option that generate higher revenues compared to other energy products. The firms planning investments in large-scale biogas production articulate explicit aims to transform both transport fuel and fertiliser markets. However, demand for biomethane must increase for new businesses to be profitable. At the same time, markets for recycled fertiliser products need to develop, almost from scratch. This *economic framing of biogas production as both energy and nutrient recovery* is presented as a normative, as well as practical, position. Production creates new output materials and seeks to enhance new forms of material organisation and feed excess manure back into agricultural production so that its nutrients can replace the use of industrial fertilisers. However, the value capture is based on the sale of transport fuel.

Currently, in one major company, processing manure-biogas into a transport fuel has created the basis for profit. In addition, two large food processing companies have published plans and started the environmental permitting processes for manure-based biogas production and nutrient fractioning. Demands for increased institutional support are also strengthening. Since profitability rests significantly on selling biomethane, the business model is more dependent on the development of the biomethane market than the dominant model. The development of markets for organic fertilisers, and incentives for farmers to hand over manure, are also critical (Marttinen et al., 2018).

## 5. Discussion

Based on the assumptions that (i) business models are tailored to serve the recovery of some residues and their properties and (ii) that business models vary regarding the ways production outputs are framed as economically relevant, we have been able to differentiate four types of business models constitutive for Finnish biogas production (see Table 3). Whilst the business models have become tailored to serve the recovery of different material feedstocks, value capture and value creation strategies have also become differentiated.

The business model *biogas production as waste management and energy generation* has a *dominant* position in the biogas business model ecosystem. Revenue is generated mainly through the provision of waste management services; by helping ‘someone getting rid of existing, unwanted stuff’ (Crang et al., 2013, p. 15). Meanwhile value for waste biomasses is created through energy recovery. This business model is problematic for two main reasons. First, the dominance of the business model blocks the growth of biogas production. Reliance on ‘moneyed’, waste-based biogas feedstocks will limit biogas production levels because their reserves are limited. At the same time, the energy and nutrient contents of the most significant biomass stock, manure, remain underutilised and problems caused by manure overaccumulation are left unsolved. Second, the emphasis on energy recovery implies that the dominant business model serves to organise material loops that promote energy production at the expense of the recovery of nutrients and organic matter.

These problems draw attention to the other business models identified, begging the question of whether they provide grounds for more complete circularity. Indeed, at the first glance, this seems to be the case.

However, studying how the business models are positioned in the overall business model ecosystem shows that two of three ‘alternative’ business models qualify as *niche* solutions; implying that they are not aimed at reorganising markets or altering the business model ecosystem.

It is only the *new rules for the game* business model that seeks to challenge the dominant model. The problem with this business model is that the existing institutional landscape fails to provide support for its alternative modes of value creation and value capture. In circumstances in which nutrient recovery from biomass digestate is not incentivised, and markets for organic fertilisers are underdeveloped, attempts to stimulate a circular nutrient economy seem to be facing a hostile environment. However, knowing why this is the case opens up prospects for policy revision.

The relationships identified between business models, on one hand, and modes material organisation, on the other hand, point to a need to rethink how business models serving resource recovery are analysed and differentiated. Prevailing CBM categorisations (e.g. Bocken et al., 2016; Geissdoerfer et al., 2018; Lüdeke-Freund et al., 2019) focus, for example, on the creation of value propositions, delivery and capture, but pay no attention to material drivers, qualifications and exclusions. Therefore, existing CBM categorisations are ill-equipped to unravel the kind of normative differences that are central for the creation of more closed material loops and the attainment of a more circular economy. It is also evident that operationalising business models in terms of broad categorisations of their value propositions or outputs, e.g. ‘products based on recycled waste’ (Lüdeke-Freund et al., 2019), is seldom enough.

Following Schaltegger et al. (2016), Boons and Bocken (2018) and Bocken et al. (2019) we have argued that business models form a business model ecosystem, co-existing and/or competing with one another within the same institutional conditions. The relationship between the business models, and hence also between modes of material organisation, is shaped by institutional arrangements. Due to the existing arrangements in Finland, some materials and material properties—such as energy contents—become internalised into the value capture and value creation strategies easier than others. Thus, treatment of the dominant mode of material organisation as a ‘natural’ alternative would be a mistake.

In our case study, institutional analysis carried out independently from the business model ecosystem would not have grasped the aspects relevant for the shift to a more circular economy. Moreover, the potentials of business model innovation might have remained unacknowledged. These innovations are unlikely to have any system wide changes unless supported by institutional change (Bolton and Hannon, 2016). While some niche solutions can co-exist quite well with the dominant model, the business model ecosystem does not change unless the rules of the game also change. As our findings indicate, it may be the same institutional features that incentivise the dominant model and disincentivise its challengers (see also Lazarevic and Valve, 2020). However, in part, different aspects of the institutional landscape matter for different CBMs (see also Levänen, 2015). Our findings, thus, substantiate calls for the adoption of a policy mix that is ‘not just a collection of individual instruments, but rather that instruments are designed to address specific aspects of a challenge in a complementary way’ (Wilts and O’Brien, 2019, p. 60; Flanagan et al., 2011); the challenge being, in the case of CBMs, the potentially deficient material (re)organisation they enable and help to maintain. To this end, our case study of Finnish biogas and analysis of the biogas business model ecosystem has generated recommendations to support the re-incentivisation of resource and nutrient recovery (see Luostarinen et al., 2019).

## 6. Conclusions

The transition towards a more circular economy draws attention to the different means by which material excess can be fed back to production. This paper has introduced a new framework to study business models for secondary resource recovery as co-existing and potentially

competing modes of material organisation. Analysis of Finnish biogas production through the framework allowed for the differentiation of four biogas business models and their mutual relations: (i) biogas production as waste-management and energy generation, (ii) biogas production as manure processing to support farming; (iii) biogas production as a means to enhance the utilisation of rural energy potentials, and (iv) biogas production as centralized manure processing to enhance nutrient recycling.

The findings show that the business models differ regarding the ways they limit the spectrum of the biomasses used as raw materials in resource recovery. The dominant model, biogas as waste-management and energy generation, is exclusive in the ways it hinders the growth potential of the more circular biogas business model emphasising nutrient recycling and weakens the capacities of Finland to become a more circular economy.

Business models also frame resource recovery differently. In the case study, the dominant business model enables material excess to be fed back into production first and foremost as energy. Its challenger specifically seeks to transform nutrients and organic matter into production inputs. However, as long as biogas digestate can be legitimately regarded as an externality, to be left out of the economic frame of value creation, the dominant business model has an advantage compared to ones that explicitly aim to go beyond this frame.

Our findings show that when the aim is to support the actualisation of a more circular economy, it is necessary to examine how business models interact and help to reorganise material circuits. Disregarding the diversity of business models may end up treating one mode of material organisation as a natural one, or as the only possible non-linear option. Research then gains an institutionalising, path-maintaining role of its own. Meanwhile a focus on the co-evolution of business models and material organisation can create knowledge that enables policy-makers to reach informed decisions about institutional change. However, the business model ecosystem is constantly evolving and both research and policy-making should be alert to new business model innovations—typically co-emerging with technological innovations—that seek to reform markets and establish new rules of the game.

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Fig. 1 shows how the key components of the analytical framework link together. The material inputs refer to the different material stocks that ground investment decisions and business models. The business model ecosystem co-evolves with (i) the business models that create value based on different economic frames and (ii) the institutional landscape. Depending on the business model, the recovered outputs vary from energy (transport fuel, electricity, heat) and biogas digestate to concentrated organic fertilisers.

### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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