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From Benefits to Value(s): Biogas Systems Valuation Practices from a Swedish Regional Perspective

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Abstract

Local and regional contexts are essential spaces to promote sustainable energy transitions. Within this space, biogas production and use are one choice considered part of a regional sustainable transition. The valuation of different options has become a recurrent and vital activity in connection with strategic energy decisions in the public sector. However, capturing the diverse benefits of biogas is challenging. This study scrutinises the socially and politically bounded practice that (re)produces value(s) by examining the valuation practices related to biogas performed by regional and national actors in Sweden. It finds that although the valuation practice has a degree of formality, it still reflects local needs and specific contexts. A wide range of benefits undergoes a translation process to produce value(s) using qualitative and quantitative rationalities. Still, there is tension between the desire to prioritise quantitative methods while at the same time acknowledging that some benefits are too difficult to quantify. This paper contributes to the literature on the valuation of non-market objects by highlighting the connections between established scientific and economic procedures and performative processes and the importance of rejecting a binary view of quantification and qualification.

Keywords: valuation, biogas, socioeconomic value, cost-benefit analysis

1. Introduction

While traditional cost-benefit analysis has been used for public investment decisions for some time, there is a growing trend to include socioeconomic analysis to put a numerical value and, ultimately, a monetary value on investment decisions (Damart and Roy 2009). The necessity to help prioritise decisions has become central as government agencies form high-level goals and policies to address climate change and fossil dependency. Local and regional authorities must decide and rationalise concrete actions and strategies to operationalise national policies, such as Sweden's goal to become the first fossil-free welfare state (Regeringskansliet 2016). To provide better decision-making, researchers and practitioners have been mobilised to help assist in knowledge building for assessing available options.

Policy supporting an energy mix that is in line with societal goals has been in focus for the last two decades, and one part of this has been the promotion of biogas by public actors. In Sweden, biogas is promoted as an alternative to fossil fuels for transport (Swedish Energy Agency 2020), and with the production of biogas additional benefits such as the digestate or bio-fertiliser, which can replace manure or mineral fertilisers, bringing additional benefits to society (Börjesson and Berglund 2007). While support has been strong, for municipal and regional political actors, the role of electrification in future systems is gaining traction, and biogas as a fuel choice for public transport is often weighed against electrification (Mutter 2019). One way to promote biogas is to value the socialised benefits linked to biogas systems. For example, Energigas, a Swedish energy gas branch organisation, claimed in 2016 that the benefits from biogas added SEK 760 million per year to the GDP of Sweden (Energigas Sverige 2022).

When considering a biogas system from a broad sustainability perspective, it has been acknowledged that biogas and other biofuels are challenging to assess due to the system's complexity (Lindfors 2022). As it is a system that produces both an energy and fertiliser product, it is considered a multifunctional system. Such systems have been argued to be particularly complex to enumerate via methods such as life-cycle analysis (LCA) (Bacenetti et al. 2016; Manninen et al. 2013), a common step in a cost-benefit or socioeconomic analysis. While biogas has been

reported to have a low return on investment (ROI), it is argued that it brings societal benefits, including material circularity, which should be addressed in valuation procedures (Winquist et al. 2019). Biogas, created from food waste sources, has been found to reduce climate impact by 62-80% compared to fossil fuels and recover 52-86% of phosphorus (Feiz et al. 2022). Biogas has been argued to contribute to fulfilling between 12 (McCabe and Schmidt 2018; Obaideen et al. 2022) and 17 of the UN's 17 sustainable development goals (Hagman and Eklund 2016). As such, it should instead be considered a sustainability object with benefits beyond the fossil-free classification (Hagman et al. 2018; Winquist et al. 2019). However, there has also been contestation to the realised benefits of circularity within biogas systems. It has been argued that circular systems have limited potential for sustainability with too much focus on the assumed advantages of circularity, which is not always realised, and, as such, the value estimated from such systems should be approached with caution (Corvellec, Stowell, and Johansson 2021, 8). Concerning biogas and digestate production, others have argued that circular systems based on waste tend to become a defence of excess waste when waste becomes a resource (Abrahamsson 2022; Corvellec 2013). Other concerns are the measurement of the environmental impact of biogas. The sustainability value of biogas is an integral part of public support, but the system analysis which supports these claims is often based upon best practices of production and usage, which are seldom found in operating sites (Paolini et al. 2018; Bakkaloglu, Cooper, and Hawkes 2022).

Various methodologies have been used to evaluate biogas, with multi-criteria analysis (Ammenberg, Bohn, and Feiz 2017; Lindfors 2022; Šišková 2015), LCA (Börjesson, Tufvesson, and Lantz 2010; Esteves et al. 2019; Hijazi et al. 2016), cost-benefit analysis (CBA), and socioeconomic analysis (Dobraja, Barisa, and Rosa 2016; Liu et al. 2022) being the most common. The challenges of using cost-benefit analysis and socioeconomic valuations can be both of a philosophical and pragmatic nature. Hansson (2007) has described the problem as the limitations that occur when the CBA depends on the perspective and specific problem framing, which are used as input, combined with the formation of alternatives that must be used for comparison. This results in calculations representing only one dominant viewpoint, excluding possible solutions, and has the potential to result in a degree of determinism. This is in addition to the more general problem of valuing the invaluable. Acknowledging this problem Hajkowicz (2008) has argued that multi-criteria analysis (MCA) is more suitable when non-market or intangible goods are under evaluation as traditional methods can never capture the complexities of questions such as nature.

To understand better the role and processes of valuation within a complex system such as biogas production and use, this paper examines the socioeconomic valuations from two Swedish counties. In Sweden, the counties are a key spatial demarcation that contains actors such as municipalities, regional administration, energy centres, and county administration boards, all involved in operationalising energy policies (Dzebo and Nykvist 2017). Their support is considered a critical success factor for developing regional bioenergy markets (Ammenberg et al. 2018). The analysis uses the conceptual lens of valuography, which seeks to understand value-making as a social practice. This allows the practice and the values to be open for discussion in the hope that this will bring the institutions and actors responsible for valuations into a position of dialogue and accountability (Doganova et al. 2014). Opening the black box of socioeconomic valuation can allow policymakers to evaluate better the usage of such information in future policymaking arenas.

Interviews with actors involved in the biogas market development in these regions are triangulated with socioeconomic valuation reports, which function as artefacts, specifically, calculative devices to the valuation process (Hasberg 2020). This article addresses the following questions: What normative assumptions are found as benefits of the biogas system are quantified and qualified in formal socioeconomic valuations? How does the valuation process deal with the complexities of the biogas system, and how do public actors manage the information produced in the valuation process?

1.1 Theories of Value Production

Since the 1920s, economics has attempted to incorporate the concept of externalities to account for the adverse effects of production (Pigou 1920), which has since been engrained within environmental economics through the concept of a negative externality, the unwanted effects of production (Venkatachalam 2007). Whose effects, positive or negative, are "imposed on someone without compensation" (Fairbrother 2016, 376). The management of externalities is often viewed as part of a political process (Conrad 1993; Wiesmeth 2011), and one method by which externalities can be expressed is through socioeconomic value (SEV).

While from a pragmatic stance, 'to value', as a verb, is to acknowledge that something can be measured and compared (Bigger and Robertson 2017; Beckert and Aspers 2011), defining value, specifically a monetary value, for objects such as nature or life quality involves the valuation of ‘peculiar objects’ (Fourcade 2011a). This requires scrutiny in the valuation process to avoid the taken-for-granted assumptions about the use of markets and prices

for setting value. When viewed as the commensurability of money to an object, price is portrayed as a representation of intrinsic value (Fourcade 2011b). As a response to these problems, economic sociologists, rejecting the idea that only price can reflect the value of an object, have focused beyond the materiality of commodities and considered the multiple ways value is actively constructed (Asdal 2015; Dalsgaard 2013).

One step in untangling these philosophical and pragmatic issues of valuation and understanding this active construction is through valuography, which considers valuation as a "social practice where the value or values of something are established, assessed, negotiated, provoked, maintained, constructed and/or contested social practice" (Doganova et al. 2014, 84) leading to the question of how something becomes a value. Addressing the questions of why, how, and by whom value is created helps us understand how value construction occurs and addresses the often hidden details of the valuation process (Dussauge, Helgesson, and Lee 2015, 3).

With inspiration from STS, socioeconomic reports are considered to be artefacts of the valuation process and have been used as such in this study. Hasberg (2020) has described a CBA as a calculative device whose facts and knowledge produced have performative effects in politics and decision-making. This view of the CBA or socioeconomic reports builds upon the work of performative economics thinking. That is, economic theories and tools do not simply describe the economic world; they have a performative function in creating it (MacKenzie 2009; Asdal 2014; Callon 2007). Calculative devices have been described as the components that make up markets, or the socio-technical agencements, that allow markets to function (Callon and Muniesa 2005; Muniesa, Millo, and Callon 2007). They have been studied in the context of diverse market objects such as biodiversity scores (Carver and Sullivan 2018; Cuckston 2018), credit scores (Poon 2007) and business models(Mason and Palo 2019). These calculative devices can be brought into the thinking from following valuation studies, where it is argued that to understand valuation, we must seek out sites of valuation (Doganova et al. 2014).

These sites of valuation become important locations for the setting of value. This is possible after objects have been subject to various forms of accounting, sorting, and classification. These sites of 'numbering practices' are not neutral, objective mirrors of reality but should be considered spaces occupied by particular interests (Callon and Muniesa 2005). These interests, whether ontological or political, are included to the exclusion of others (Sullivan 2017). Callon and Muniesa argue that calculation is often a series of numerical operations brought forward as part of an "ex-post operationalisation" (Callon and Muniesa 2005, 1230) and can be grounded in a range of epistemologies with the aim of "establishing distinctions between things or states of the world"(Callon and Muniesa 2005, 1221). Using these sensitivities from STS and valuography will allow me to unpack the valuation process used by regional biogas actors when valuing biogas systems.

2. Method

Sweden has three administrative levels: the national, regional, and municipal (Regeringskansliet 2015), with the national level having increasingly handed over areas for control to the local and regional levels of government (Stegmann McCallion 2017). This study focuses on the counties of Kalmar and Jönköping, two counties in terms of population and area, which are close to the median among the 21 counties in Sweden. They were selected as they have been actively promoting biogas as a part of their sustainability strategies and have performed socioeconomic valuations.

This study uses a multi-method strategy, starting with ten semi-structured interviews with biogas sector representatives connected to various government levels involved in biogas market development, as shown in Table 1.

Table 1. Interview respondents

Actor	*-Region*	*Code in text*
Public Transport Authority	Kalmar	Kalmar 1
Energy Office	Kalmar	Kalmar 2
Kalmar Region	Kalmar	Kalmar 3
Municipal Authority	Kalmar	Kalmar 4
County Authority	Kalmar	Kalmar 5
Consultant Biogas	Kalmar	Kalmar 6
County Authority	Jönköping	Jönköping 1
Energy Office	Jönköping	Jönköping 2
Jönköping Municipality Politician	Jönköping	Jönköping 3
Energy Office	Jönköping	Jönköping 4

From the interviews, formal socioeconomic valuation documents for biogas were identified for both counties. In Jönköping, the valuation exercise was initiated in 2016 and followed up in 2017 as a two-part project within the regional energy office organisation tasked with assisting public and private actors in meeting common environmental goals. In Kalmar, the valuation exercise was initiated in 2018 by the "regional association" (swe: Regionförbundet), an organisation that included the regional and municipal levels of government, who tasked a consulting company to conduct a system study of a specific biogas production scenario focusing on stable manure for biogas production. The analysis also included three national-level reports as they were used as reference material for the regional reports or have significantly influenced the regional processes. In 1997, the first attempt to highlight the benefits of biogas to society was made through a national enquiry report. Although the specific term 'socioeconomic value' was not found in the report, the document outlines the benefits and value to society of increased biogas production. In 2010, the Swedish Energy Agency, in conjunction with the Agricultural Department and the Swedish Environmental Protection Agency, was tasked by the government to provide a strategy for biogas development. The final report included an extensive socioeconomic valuation of biogas, focusing specifically on those values connected to environmental effects. The next significant national exercise was the white paper "more biogas!" which was commissioned by the government in 2018 to provide a systemic study of the value of biogas as a resource. The report included socioeconomic valuations, along with policy recommendations, which have to some degree been since implemented (Regeringskansliet 2023). The artefacts analysed are shown in Table 2.

Table 2. Socioeconomic valuation artefacts

Original Title	English Title [1]	Prepared on behalf of	Code in text
Biogas som fordonsbränsle 1998:157[2]	Biogas as Vehicle Fuel 1998:157	Statensoffentliga utredningar (Swedish Government Inquiries)	SOU 1998
Samhällsekonomiska värden av olika miljöeffekter vid ett ökat utnyttjande av biogas: Underlagsrapport till utredningen Förslag till sektorsövergripande biogasstrategi Rapport ER 2010:14[3]	Socioeconomic values of environmental effects with increased utilisation of biogas: Supporting report for the investigation Proposal for a sector-wide biogas strategy Report ER 2010:14	Swedish Energy Agency	SEA 2010
Mer biogas! För ett hållbart Sverige Betänkande (SOU 2019:63) [4]	More Biogas! For a sustainable Sweden (SOU 2019:63)	Statensoffentliga utredningar (Swedish Government Inquiries)	SOU 2019
Samhällsnyttan med Biogas: En studie i Jönköpings län.[5]	The social benefits of biogas: A study in Jönköping County.	Energikontor Norra Småland (Energy Office Småland North)	Jönköping 2016
Värdet av biogas: En samhällsekonomisk analys av biogasens nyttor [6]	The value of biogas: A socio-economic analysis of the benefits of biogas	Energikontor Norra Småland (Energy Office Småland North)	Jönköping 2017
Biogas från stallgödsel systemstudie och samhällsekonomiska effekter for Kalmar län [7]	Biogas from manure system study and socioeconomic effects for Kalmar County	Region Kalmar	Kalmar 2018

The documents and interviews were analysed to understand why and how public actors perform and use valuations. This was followed by a close reading of the valuation artefacts in Table 2. The document analysis was broken into two steps. First, the reports were analysed to give an understanding of the rationality behind what properties of a biogas system are translated into a value and, by extension, which values are excluded. Secondly, an analysis of the reports was conducted to understand the reports as part of a value-making process through thematic coding of the documents. The documents were categorised for text that indicated the intention and method to answer the "how" and "why" benefits are translated to a value.

[1] English title as translated by author for clarity

[2] (Statensoffentliga utredningar 1998)

[3] (Brännlund, Nilsson, and Söderholm 2010)

[4] (SOU 2019)

[5] (Anderson 2016)

[6] (Anderson et al. 2017)

[7] (WSP 2018)

3. Findings

From the analysis of the reports, a categorisation of the identified steps included in the socioeconomic valuation process is shown in Figure 1. The first step is the motivation for performing a socioeconomic analysis of biogas. These motivations, section 3.1, became part of a broader justification and narrative for the value of biogas. This step was followed by scenario building, detailed in section 3.2, which is required to enable quantification and assign a monetary value thereafter. After scenarios are established, the value produced was either described quantitatively or qualitatively or, at times, a hybrid, as discussed further in sections 3.3-3.6. Finally, depending on the method of value production, it resulted in a narrative or monetary number to represent the value.

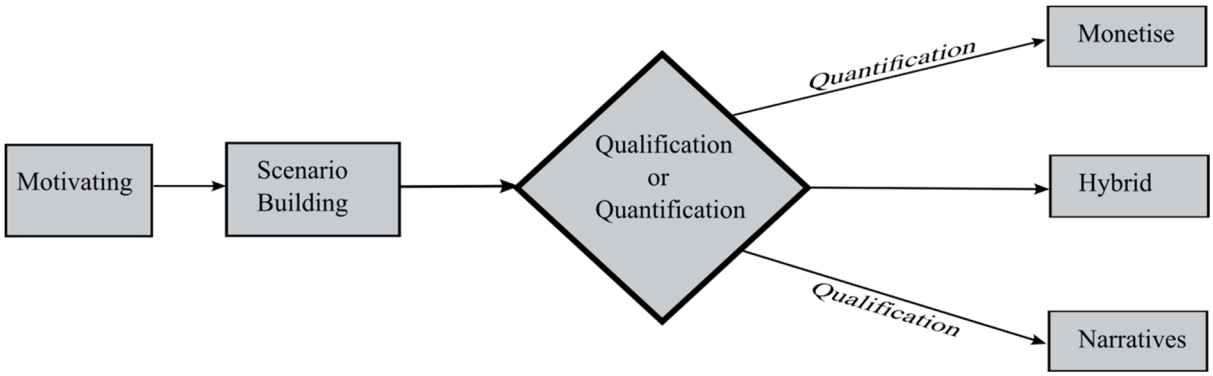

Figure 1. Main elements of the valuation process

3.1 Motivating the Valuations

Considering the valuation reports through a valuography lens, the answer to the 'why' question was evident through the rationality for conducting the socioeconomic valuation. Although CBA and socioeconomic valuations are considered necessary in public investment, they are often considered part of *ex-ante* decision-making (Beukers, Bertolini, and Te Brömmelstroet 2012). Both regional reports were made after significant investment and policy support had been implemented for biogas. Two main themes were found within the motivation: market failure and knowledge building for decision support.

Market failure, defined as the situation where market trading produces sub-optimal outcomes, is associated with new niche markets such as biogas and in connection with the environmental pollution of market activities (Jaffe, Newell, and Stavins 2005). In Kalmar County, it was noted that it was deemed necessary to find alternative ways to represent the value of a biogas system, as market prices do not exist for many of the positive effects of biogas:

> "The ambition is to capture all relevant effects and assign them a monetary value, regardless of whether they are priced in a market or not." (Kalmar 2018, 28: bold added by author).

In Jönköping County, a socioeconomic valuation was considered a way to expand decision-making tools beyond traditional cost-benefit and account for market failure.

> "It is important to build an understanding of the socioeconomic consequences of different types of energy investments. This applies not least to biogas, whose social and environmental benefits are multifaceted, complex, and often not valued on the market." (Jönköping 2016, 8)

This need to adjust public perception in the face of market failure was echoed by the respondents.

> "[because of high price] That is why it is extra important to have on paper the value and benefits to biogas" (Interview: Jönköping 1)

On the national level, the first national-level report (SOU 1997) stressed that formalising the benefits to society was necessary as market forces alone were unlikely to create growth in the biogas sector. Similarly, the SEA report in 2010 argued that as no market exists for societal effects, a socioeconomic valuation would be an acceptable "measuring stick" to allow comparisons when market value alone could not be used.

Knowledge building, decision support and legitimisation were also strong motivators for the valuation exercise. The Jönköping County report was part of a large EU and state-funded project aiming to increase the production and market for biogas, which was beginning to see stagnation and can be considered to have a role in legitimising existing policies. In Kalmar County, the report's role was partly regarded as a way to clarify the benefits of biogas production and add to the debate regarding goal conflicts between environmental goals and primary food

production. Here, the respondents agreed that a socioeconomic analysis could be a positive input into decision-making and help make visible the complex array of values a biogas system brings.

"We wanted to make the different uses of biogas visible as a base for regional discussions among different politicians, civil servants, and biogas actors."(Kalmar 2: Email correspondence). Respondents from both regions noted that performing an analysis requires time and knowledge, which is not always available (interview: Kalmar 2,3, Jönköping 2) and that when political support is high, such explicit calculations were not always necessary (Interview: Kalmar 2, Jönköping 1). There is an acknowledgment that investment and strategic decisions require varying degrees of assessment, mainly as a comparison between renewable options. However, respondents also indicated that formal valuation practices were not historically part of decision-making.[8] As previously mentioned, both regional valuations were produced after ambitious strategic goals for the production and consumption of biogas were set in each region.

3.2 Scenario Building

Continuing to unpack the valuation process and asking "how" values are made, we can consider the reliance on scenarios. Although scenarios are a routine and uncontroversial step within life cycle analysis and economic valuations, behind such routines, there are normative structures and taken-for-granted assumptions embedded in the process.

The scenarios used were tightly linked to the socially constructed motivation for the valuation. As the Kalmar County report aimed to use socioeconomic value to, in part, clarify the goal conflict between increased animal agricultural and environmental goals, the constructed scenario focused on using stable manure as the input into an expanded biogas market. Stable manure was framed as an available input into a future biogas system, not a pollutant or waste product, demonstrating the reclassification of manure from externality to resource. For Jönköping County, the scenario was based on a production and consumption scenario proposed in an earlier regional strategy and can be linked to the motivation for legitimising biogas policies and strategies within the region. These scenarios assume a sustained or increased production of waste stream inputs from the forest and animal agriculture industries.

The scenarios also included assumptions regarding the use of biofertiliser from the expanded biogas markets. Both regional reports acknowledge that logistics or economic barriers exist, preventing the use of all the biofertiliser produced in the increased biogas production scenario. Despite these concerns, the final socioeconomic value includes the benefit of using all the produced fertiliser. Such subjective decision-making, such as to include or exclude a benefit, demonstrates that despite the formalised process, the value-making process has a degree of subjectivity.

3.3 Turning Benefits into Values

Once scenarios and system boundaries are in place, the next step in the valuation process is translating the identified benefits of biogas into a value via quantification, qualification, or a hybrid approach, as shown in figure 1. A translation process occurs when a described benefit becomes a value. The benefits assigned a value are shown in Table 3 and grouped according to the translation method used. Common to all the reports studied was the quantification and monetization of avoided greenhouse gas emissions, which is unsurprising considering the widespread use and maturity of methods for valuing emissions (Lövbrand and Stripple 2011).

[8] The exception to this is limited formal valuation exercises which were done by the local public transport system which inherits methodology from the national and EU level formalities for some procurement decisions.

Table 3. Categorisation of the benefits translated to value(s) as produced by reports

	Kalmar	Jönköping	SEA 2010	SOU 2019
	Reduction in Greenhouse Gases	Reduction in Greenhouse Gases	Reduction in Greenhouse Gases	Reduction in Greenhouse Gases
	Reduction in Particles (PM2,5)	Reduction in Particles	Reduction in emissions of particles	Reduction in emissions of particles
	Reduction in Ammonia and nitrogen oxides	Reduction in emissions of the climate gases methane and nitrous oxide from handling manure	Reduced nitrogen leakage from agriculture	Reduction in Acidification
Monetised Values	Reduction in Sulfur Dioxide (SO2)	Reduction in leakage of nitrogen from agriculture that causes eutrophication	Reduced emissions of methane when stable manure is used for biogas	Reduction in Eutrophication
			Reduced emissions of nitrous oxide when stable manure is used for biogas	
	Biogas creates security in energy supply	Biogas creates security in energy supply		
	Replace artificial fertiliser	Replace artificial fertiliser		
		increased employment		
		industrial export possibility		
	Increased animal production			
Quantified Values	Employment effects		Improving rural life goal	
	Biogas' effect on Gross National Product (GDP)			
	Odour			
				Recirculation of plant nutrients,
Descriptive Values	Landscape picture			Reduced eutrophication,
	(-) Noise from vehicles using biogas			disposal and utilisation of waste streams,
	(-) Noise from vehicles to and from the biogas plant			Increased security of supply,
				Rural development
				Employment and industrial development

Despite quantification's formality and established scientific routines, the representation of complex natural and societal systems is not always possible, which the reports addressed to various degrees. The subjectivity, as well as the flexibility in the valuation practice, was seen in the differing rationality behind quantification. For example, the Jönköping County and Kalmar County reports monetised slightly different benefits from each other. Employment was an example whereby in Jönköping, they rationalised that although increased employment can be theoretically difficult to assign, it was justified in estimating the impact as it was deemed sufficiently large. The report in Kalmar, however, rationalised that via common macroeconomic rationality, increased employment is a cost to the region and left the benefit as a descriptive value without setting a monetary amount.

3.4 Quantifying What Has Not Happened: Avoided Emissions

The concept of avoided emissions was a central quantified value of biogas in the reports under investigation and was echoed in the interviews, which was in line with other studies that placed avoided emissions as one of the most recognisable benefits of biogas (Hagman and Eklund 2016). According to one study of Swedish biogas, emission reductions are one of the more significant socioeconomic value(s), accounting for between 53 - 90% of the overall socioeconomic value (Tufvesson, Lantz, and Björnsson 2013, 45). However, despite the availability of a national standard for pricing emissions provided by the Swedish Traffic Agency (*swe Trafikverket*), the reports used various pricing methods shown in table 4, resulting in a range of different monetary values for the net reduction in emissions of greenhouse gases.

Table 4. Socioeconomic value reported for greenhouse gas emissions

	Kalmar	Jönköping	SEA 2010	SOU 2019
Method /Source	Shadow pricing *	ASEKS 5.2 / SEA 2010	Median value of social cost of carbon / Swedish political reference	ASEKS 6.1
Price CO_2/kg	0,2 - 3,50 kr/kg CO_2-ekv	0,20 - 1,08 kr/kg CO_2eq	0,20 - 1.00 kr/kg CO_2eq	1,23 - 7 kr CO_2eq

*(Tufvession, Lantz and Björnsson 2013)

The reports placed significant attention on the choice of emission costs. However, many underlying assumptions implicit and nested within the costing are neglected. Concerning future damages, it is, for example, never made explicit what damages are being measured, damages to whom, what, or where. Other forms of valuation that exist for valuing nature, such as ethical, moral, or aesthetic (Estes 1972), were not covered. However, a moral dimension was brought up in one of the reports.

> "[the carbon price] is to some extent a scientific question, but also depends on ethical considerations" (Jönköping 2017)

A taken-for-granted assumption in the reports was the validity of a carbon price on avoided emissions when a biogas system was in place to manage waste. The respondents did not view the rationality behind the valuations as controversial. Instead, they cited that the lack of implementation of emission costing was often due to the knowledge and resources required. The lack of resources was seen as a barrier to using such methods, as they were not always available to public actors.

3.5 Value through Qualification – Hybrid and Discursive Practices

Continuing to ask *how* value is made, the material showed that discursive strategies were also used in addition to quantification to create value in a biogas system. When examining the qualitative descriptions of value produced, distinguishing the classification between a benefit and a value becomes an area of blurred boundaries. Firstly, a property of a biogas system is classified as a benefit that can become a value through quantification, such as through a life cycle analysis (LCA) step, and can further be monetised. In these cases, it was found that discursive strategies were used to produce value. Value produced in this hybrid manner, combining both quantification and narrative building, was found to focus on two main themes: the value of growth and the value of obtaining political goals.

The value of economic growth demonstrated the hybrid nature of value-making as it often combined a discursive and qualitative component. This was exemplified in the Kalmar County case, with the animal agriculture growth strategy for the region and biogas promotion being linked. Although the report concluded that it was impossible to classify this benefit in monetary terms for society, it had a significant impact and was included as a

socioeconomic benefit. However, this lack of monetary value did not mean other definitions of value could not be calculated, such as the economic value to local farmers. Other values connected to growth were found within the practices where the value of expanded biogas production was linked with increased employment, gross regional product (GRP), export possibility and increased animal agriculture; however, the degree to which these values were measured and monetised varied.

The value of political goals was also found to be performed using a hybrid of qualitative and quantitative methods. From the earliest official investigation of biogas, the SOU of 1998 positioned biogas as part of the solution for reducing emissions according to national and E.U. and global goals, such as becoming in line with the Kyoto Protocol. This value was a central part of the regional reports. When the fossil-free property of biogas was connected to CO_2 reduction, it was assigned a monetary value. In contrast, when associated with the value of political goals, it lacked any monetary value. When discussing the value of biogas with the participants, the political goals were often listed as the most recognisable value of biogas:

> "For our part, to replace fossil industry is the number one value [of biogas]" (Interview: Kalmar 1)

The reports and interviews often found different framings of political value. For example, biogas could replace fossil fuels or be valued as a local renewable source. In cases where the regions have brought in their own goals for becoming fossil-free, the ability for biogas to contribute to either of these goals was an important motivation for including biogas in their energy transformation strategy and thus cementing a value for biogas which was not measured with an economic value. Increased animal agriculture was another example of a benefit discursively connected to multiple values and the fulfilment of political goals. This was found to produce value in terms of economic growth as well as contribution to political goals for creating a 'liveable countryside'.

Energy security was a further example of value produced using a hybrid between qualitative and quantitative. In the case of energy security, it is often assigned a value in connection to political goals. In some circumstances, such as in the Jönköping County report, a monetary value was assigned to biogas in a scenario where biogas replaced imported oil. However, this valuation was noted to be inadequate to fully capture the value of biogas as a part of energy security, noting that complex geopolitical value is not captured in the measurements, such as the value of stored oil.

The national-level reports addressed the difficulty in quantification, with the SEA report of 2010 describing the problem of quantification as stemming from either the difficulty of physical quantification of affected variables or uncertainty in the pricing mechanisms (SEA, 2010). The SOU of 2019 handled the uncertainty by using explicit discursive methods to assign value. The result is that despite being a multi-year nationally funded project, the SOU report has the least number of benefits translated into quantified values.

> "One problem with valuing these benefits is that some cannot be quantified with sufficient accuracy. Secondly, there is a lack of sufficient documentation. It is also challenging to compare the benefits as a result of difficulties in standardising them, which is a prerequisite for weighing them against each other"(SOU 2019,168)

The reports acknowledged the difficulty in monetising all benefits, such as odour, scenic changes, and noise from traffic. Benefits or costs such as odour demonstrated how value could be positive or negative depending on the situation, similar to the description of an externality, which is neither positive nor negative but depends on the receiver's experience (Callon 1998a). In the case of odour, the positive experience of escaping an often-described negative smell of manure on the fields is weighed against the potential for unpleasant odours around the location of the biogas plant. Due to the conditional value of 'odour', it is easy to see how the valuation becomes difficult. Who would pay to avoid the odour? Or who should be compensated for them to endure?

4. Discussion

The socioeconomic value produced in the reports, expressed in monetary and non-monetary units, lies outside the neoclassical market, whereby the transaction of money is central to the definition of value and whereby everything can translate into a monetary amount (Kenter 2017). In contrast, within economic sociology, it is presupposed that in all markets, value is a complex construct which starts with the social (Beckert and Aspers 2011) and that value determination is always a part of social practices. The socioeconomic reports in this study reflect the first view, whereby the motivation and underlying assumptions within the value-making begin with the aim to use money as a comparative device. This notion of value found in the artefacts, which is tightly bound to this economic rationality, is argued to be problematic as it may justify decisions that lack moral consideration (Swanson 1992, 534). Despite the normative stance that money can be used to formalise the benefits of biogas into value, it was

found not to be possible for all benefits, and the reports relied upon qualitative reasoning when quantification and monetisation were not possible.

4.1 Effect of Quantification

To address how the reports have a performative function in the process of value-making, it can be helpful to see a socioeconomic valuation as a calculative device which relies heavily, although not entirely, on quantification (Morgan 2015). Quantification is often called upon when decisions are in question and used to justify decisions where there is a level of distrust or distance, but the presence of quantification can often mask the subjectivity of the process (Porter 1995).

Following Callon and Muniesa (Callon and Muniesa 2005), a calculation contains three steps; firstly, the objects are sorted and detached from the original setting and put together in a single space, such as the socioeconomic report. From here, the authors argue that the objects are manipulated to break old relationships and create new ones, creating space for this new placement. Lastly, the result is displayed as an aggregate in their new placements. The arrangement of the objects, such as increased employment figures, net greenhouse gas amount, or judgements on energy security, fit into this socioeconomic report, this new "spatiotemporal frame" (Callon and Law 2005, 719) artificially. Within this new frame, new objects are produced. Emissions are no longer considered to be the CO_2 emissions released upon the combustion of biogas. They are detached from this reality, and new relationships to the emitted CO_2 are made. In this case, they are connected to the 'would be' methane emissions from the organic material used in biogas production. This process involves a series of classifications as brought forward, a mandatory step in valuations, and is built upon shared understandings and existing social structures (Kruger and Reinhart 2017). However, the shared understanding can change, such as in the example of manure, which can be re-classified from waste and pollutant to resource.

Although quantification was central to many of the values produced in the reports, we can also pay attention to the quantification, which went beyond enumeration. Callon and Muniesa's (2005) stages of calculation can help us understand the blurred lines between quantification and qualification, taking a step back from viewing the two steps of value-making as binary options. According to the authors, the output does not necessarily mean a sum or a numerical indicator. It can also take the form of lists or, in this case, a discursive argument regarding the value of an object.

A tension could be found within the framing of qualitative and quantitative valuation where, on the one hand, the reports stressed the preference for quantitative methodology. On the other hand, considerable effort was spent to produce qualitative values. In a similar vein, although the end goal was to provide a monetary valuation, both regional reports acknowledged the subjective nature of the process and the limitations when aiming at full monetisation.

4.2 The Production of Value

The framing from 'benefit' to 'value' was connected heavily, although not exclusively, to monetisation. Building on Latour (1987), one of the steps described as part of the calculation as a practice is producing a new entity through the summary work done in the calculative space. This new entity, in this case, a value, must be able to be transferred from the calculative space to "circulate elsewhere in an acceptable way" (Callon and Muniesa 2005, 1231). This circulation of the output of a calculative space can be understood by considering how a socioeconomic value becomes a part of a 'fact' brought together and maintained via communities. As the respondents explained, knowledge production was an important motivation for the reports. The reports have, in this sense, a performative function where they transfer knowledge about biogas to new actors through the translation of biogas production properties to facts concerning its value. This fact-producing process found in socioeconomic valuations has been problematised in situations where social value is commodified within a market, which can black-box the agendas behind the calculations and rationale (Morgan 2015).

Extending the arguments of Porter (1995) Henneberry, Ma, and Privitera (2020) maintain that this production of knowledge requires social and political work and that the degree of assigned objectivity and legitimacy occurs through ensuring forms of standardisation, even above accuracy. An example is the legitimacy allocated of a socioeconomic valuation using the highly formal and standardised life cycle analysis method, which has been argued to be used to provide legitimacy (Lazarevic 2018). The legitimacy of the outputs of LCA and monetisation was echoed in the interview data; however, when this preferred method was unavailable, it did not distract from the respondent's valuation of biogas as an important renewable option for their region. This flexibility in the production of value may be a stabilising force when considering the notion of fragile legitimacy, as described by (Kupzok 2020). The utilisation of the scientific community to uphold policy can become problematic when the

scientific logic that was initially used to support policy becomes contested and then is used to disassemble policy, as was the case for the reliance on land use change calculations in the E.U.'s biofuel policies of the early 2000s.

The formality and standardisation of practice can be problematic when it masks alternatives to a solution for the original problem, the problem of market externalities. The difficulty with externalities, even within neoclassical economics, could be addressed in various ways, which become backgrounded when value is presented as a socioeconomic value. For example, externalities could be addressed by "prohibition or restriction of pollution, negotiations resulting in some form of payment between polluters and those suffering from the pollution; a system of penalties for external diseconomies" (Estes 1972). These other forms of redress do not exist today for many of the pollutants contained within the biogas systems, such as methane or ammonium, from the agricultural sector. However, it can also be argued that the very reliance on the theory of market failure for solving social and environmental problems rests on the assumption that sustainability can be achieved by correcting this failure (Olsson and Öjehag-Pettersson 2020)

4.3 Searching for Equivalence

The search for equivalence or commensurability is at the root of the neoclassical idea of valuation, a notion which is rejected by ecological economists (Isacs 2021). Although not all value produced was connected to the environment, in terms of monetary equivalence, the economic value assigned to natural systems, such as greenhouse gases, represented the largest share. As discussed, carbon and other GHG emissions have been focused upon within socioeconomic valuations, which can be connected to the commodification of carbon (Randalls 2011), and have been central to much public policy since the Kyoto Protocol. Regarding the treatment of carbon, Dalsgaard (2013) asks if it is reasonable to consider all forms of carbon equal, a critique not addressed in the reports or interview material. In the case of biogas, the studied reports produced *a fact* that there is an equivalence between the CO_2 released when producing and burning biogas and the emissions that would have been released had the organic material not been treated in a biogas system.

The equivalence-making occurring through a socioeconomic valuation is just one example of the commensurability of nature, which is seen in the discussion of greenhouse emissions. The reclassification which occurs for emissions is based upon the concept of net zero, which has been argued as a way to manage the climate crisis and has become central to national and local policies (Bellamy et al. 2021). This preference for -net zero thinking has occurred despite the critique that the focus on balancing emissions and removals creates mitigation deterrence (Bellamy et al. 2021; McLaren et al. 2019). Much of the discussion regarding the problems of net zero has centred around technologies such as carbon capture or off-setting. In contrast, the net effects of biogas have received less attention, which could be seen in the value-producing reports studied.

5. Concluding Remarks

Valuography has been described as "Unveiling the invisible or hidden realities lying in the routine and non-creative application of existing norms and procedures to the various situations that pose new concerns on value and values." (Kjellberg et al. 2013). Using this perspective as a starting point and unpacking the process, it was found that for the valuation of biogas systems, general series of steps are used but applied in a way to take into consideration the local needs and normative structures. The steps allow a benefit to be translated into a monetised value. For biogas systems, which are intertwined with multiple social, political, and environmental systems, the degree of complexity has resulted in an inability to reach a fully quantitative and monetary value. This process follows formalised steps and procedures yet allows for the legitimacy of the benefits of biogas as a sustainability system to be discursively established when the benefits are not fully translatable to an economic value, demonstrating the tendency to prioritise quantitative reasoning while accepting that this is not always possible.

The close reading of the data revealed how subjective reasoning, entwined with normative understandings, becomes a part of the valuation process with different degrees of acknowledgement of the subjectivity in the processes. Active work is required to produce value through, when possible, relaying on the legitimacy of quantification. A socioeconomic valuation not only sets a value on non-market objects but also involves classifying and representing nature and living systems through the processes of classification and calculations. These steps become performative when the valuation process changes our understanding of the object. This can remind us of the political and social work required to detach objects from one context and allow them to be managed in another.

While practitioners and academia widely acknowledge limitations to the process, the cost-benefit and social-economic techniques persist. The preference for quantitative rationality was seen throughout, and actors would rather have an incomplete quantification than no quantification at all. One way public actors use this imperfect quantification is to combine the CBA with other methods, such as multi-criteria analysis, strong narrative building, and consensus between decision-makers. As seen in these cases, the use of the data as a linear input into decision-

making was not found. Instead, the results of such practices are to fill in the details of an existing story. In this way, for biogas as a renewable energy choice, the socio-economic valuation becomes what was referred to by Simmel (1900) as "*wertbevis*" the proof of value which can only be provided by connecting and contextualising existing objects (Krüger and Reinhart 2017). The information becomes a part of a wider biogas narrative where the properties of biogas as an energy source which extend to more than another renewable fuel, are brought forward and made concrete. Although this hybrid method of calculating, which is neither solely quantitative or qualitative, may be challenging for the purist of either tradition to accept, it does, in fact, resemble the definition of calculation as argued by Callon: that calculation always involves judgement and subjectivity (Callon and Muniesa 2005; Callon 1998b).

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