INTRODUCTION

Circular economy (CE) is a concept that has gained increased traction in policy, academia and business (Hobson and Lynch 2016). Essential to this is the idea of closing energy and material loops in order to increase competitiveness of industries, as well as reduce the environmental impact (Baldassarre et al. 2019). Thus, a transition from a linear to a CE involves redefining waste as a resource (Ellen MacArthur Foundation 2013). On a practical and local level, this often requires inter-firm innovation processes, in order to assign this resource a value, as well as enable its circulation by establishing organizational and technical structures. However, valuing what was previously regarded a waste is in many contexts a new endeavour, and rarely a straightforward task, as this chapter will illustrate with the case of utilizing surplus heat.

Surplus, excess, or waste heat, is an interesting by-product in the context of CE. It is a by-product of almost any production process such as refrigerators in shops and restaurants or server parks in data centres. In most cases, this heat goes through cooling systems, which themselves consume more energy, and out into the ambient environment. Several studies have shown the significant possibilities of directing surplus heat into other useful applications, such as space heating in offices or homes, or industry processes requiring heating such as greenhouses, onshore fish farms, and asphalt production (Enova 2009; Miró et al. 2015). Utilizing surplus heat in this way means consuming energy more efficiently, since it reduces outtake of primary energy. Furthermore, it represents an economic opportunity for both parties. The heat provider saves money on cooling systems and compensation for the delivered energy, while the heat user receives energy that is often cheaper than primary energy sources. These multiple benefits are increasingly being recognized, such as in the Renewable Energy Directive (European Commission 2016). Yet, despite the significant potential of this waste resource, the utilization rate is still low in European countries (Lygnerud and Werner 2018).

As a commodity, surplus heat has some ‘extreme case’ properties and limits to use, which makes it particularly interesting to investigate as an example of CE. Surplus heat is recovered from industry processes by heat exchangers and transported to its destination as heated water (or gas) through pipelines. This requires costly infrastructure for energy recovery, transportation and end-use technologies, as well as a responsible party in charge of operations and maintenance. Compared to material waste products, heated water cannot travel far before its temperature, which essentially is its significant quality, starts degrading. Because of this, surplus heat is a local resource, bounded in time as well as space. Furthermore, firms that want to exchange surplus heat need to construct technical and organizational structures between them in order to facilitate the trade. Essentially, they need to innovate new ways of delivering, consuming, buying, selling, giving or receiving energy. These properties make it an interesting case of how by-products are valuated differently across localities, and can thus provide further
How waste becomes value: surplus heat exchange in Norwegian industry

insight and contextualization into barriers and drivers for CE innovation (e.g. Jakobsen and Steinmo, Chapter 13 this volume) and sustainable business models (Bocken et al. 2019).

This chapter explores different ways of framing, valuating and organizing surplus heat as a resource in local CE. We start by providing a short overview of previous research, theoretical perspectives on valuation processes and our methodological approach. Drawing on qualitative case studies from a Norwegian industry context, we show different modes of valuating surplus heat. In conclusion, we discuss the opportunities for integrating valuation perspectives in research on innovation and CE and conclude with practical recommendations.

DRIVERS AND BARRIERS FOR SURPLUS HEAT UTILIZATION

The main focus in social science research on surplus heat has traditionally been on identifying drivers and barriers towards utilization in district heating (DH) networks (Broberg Viklund 2015; Enova 2009; Werner 2017) and case studies of local heat markets (Päivärinne et al. 2015; Webb and Hawkey 2017). Päivärinne et al. (2015) combine insights from industrial symbiosis (Chertow 2000) with a business model perspective to identify financial, technical and organizational drivers and barriers towards excess heat collaborations. They find that aspects such as mutual economic benefits, available technological solutions, trust and embedded networks between the participants are important preconditions for establishing heat exchanges between heat provider and DH companies. The importance of social ties for enabling local resource exchanges is also highlighted in the wider literature on industrial symbiosis (Walls and Paquin 2015).

Previous studies have identified barriers such as lack of attention in policy and awareness in firms, regulations and the need for framing surplus heat as an energy source (Fontaine and Rocher 2021). At the site level, the most notable barriers are economic factors, agreeing on the price of surplus heat and the business model for exchanging it (Fontaine and Rocher 2021). For example, the heat provider and the DH company often hold different views of the quality of the heat and what its price should be (Lygnerud and Werner 2018, p. 431). However, while lack of agreement on price is a known barrier towards adoption, the processes of how waste resources become a commodity and achieve (different) value in (different) local contexts have largely gone unrecognized. Furthermore, there is a need to examine the particular local contexts that favour or hamper realization of surplus heat concepts (Fontaine and Rocher 2021). We address these gaps from a bottom-up perspective through exploring how actors make sense of the value of surplus heat.

THEORETICAL FRAMEWORK: CIRCULATION OF THINGS

In order to analyse the fundamental issues of transforming by-products into resources with a value, we draw on the concept of entification (Larsen 2010). This refers to processes where a phenomenon (e.g. heat escaping an industrial site) takes shape and is framed as an entity (e.g. surplus heat). With this understanding as a basis, we elaborate on studies exploring how entities are transformed into commodities or gifts, which circulate in communities based on different logics (Çalışkan and Callon 2009).
The separation between commodities (something you buy) and gifts (something you receive) forms the basis for different systems of circulation. Commodification involves the transformation of goods, people or services into objects of trade (see e.g. Lock 2001). An illustrative example in climate policy is MacKenzie’s (2009) study of how the permission to emit a certain amount of greenhouse gases has been made into a commodity (carbon credits) that circulates between firms in carbon markets. As such, commodification entails assigning goods, which previously had none, an economic value, and through this enable its circulation.

Other goods, such as gifts, circulate in communities despite not having an economic value. Gifts change hands between people (and organizations) as a gesture, symbolic communication or a reciprocal act. Mauss (2002) describes how gifts establish and affirm continued relationships between actors. This, he argues, is because expectations of continued giving are inherent in the gift. In comparison, the relationship between actors trading commodities ends with each trade. As Çalışkan and Callon (2009, p. 387) explain, ‘a gift circulates while preserving the presence of its giver embedded within it, while a commodity erases that connection’. In other words, some things circulate based on the relationship and networks between people (or firms), while others are de-contextualized and involve only the trade itself. Thus, the dynamics of circulation linked to reciprocal gift exchange obey alternative logics to the instrumental rationality corresponding with bartering and trading of commodities in markets.

While commodities versus gifts serves as a useful distinction, Çalışkan and Callon (2009) argue that there is a variety of such modes of valuations (e.g. pure gifts, part gifts, counter gifts). Furthermore, the function of gifts between formal organizations is inherently different from those between people. A key characteristic of the former is that a variety of actors compete to participate in defining goods and valuing them (Çalışkan and Callon 2010, p. 8). Fixing a price on a commodity is always the outcome of a struggle between agencies trying to impose their modes for measuring a commodity’s value and qualities (Stark 2011). In order to understand how particular things are valuated and circulate, we must therefore investigate how actors negotiate their meaning and apply them in local contexts.

These insights have inspired a few empirical analyses on how waste resources are valuated differently and entered into different forms of circulation. Webb and Hawkey (2017) draw on ‘modes of valuations’ in their study of how intermediaries in the UK failed to assemble markets for heat network infrastructure. They show that negotiations and controversies over the value of surplus heat became inseparable from a market framing, which dissolved any notion of ‘public good’. They argue that risks of economic short-termism, the reliance on price as a proxy for value, and failure to encompass the societal value of innovation for clean energy, need to be at the core of negotiations about the structuring of markets. A similar argument is proposed by Hobson and Lynch (2016, p. 22), that the social and cultural meanings of ‘exchange’ require further exploration and expansion within the CE research, since also non-monetary forms of sharing and swapping goods, ideas and experiences are essential to a truly transformative agenda. Building on these insights, this chapter explores how actors valuate surplus heat, and how these valuations structure how the exchanges are organized.

METHODOLOGICAL APPROACH

To obtain an understanding of the multiple ways of valuating and organizing surplus heat exchanges, we draw on case studies from three industry-research projects in the period...
2011–20. The topic of these projects was *energy efficiency*, with utilization of surplus heat as the main technological focus. Our role, as social scientists, was to facilitate innovation processes and investigate regulatory issues, barriers, and enablers towards implementation of technologies. As the projects were technology and industry driven, we gained access to several existing, ongoing and even failed attempts at establishing surplus heat exchanges. Thus, this chapter builds on a multi-case study of 14 surplus heat initiatives (Figure 11.1).

*Figure 11.1 Four concepts for utilizing surplus heat*

The studies included site visits, workshops, focus group studies, document analysis and a total of 53 interviews. The informants included representatives from firms at the supplying and receiving end of the surplus heat exchange, and intermediary actors facilitating the exchange. We also interviewed representatives from DH providers in relevant cases as well as local authorities (e.g. municipality, county council). Municipalities are in charge of area regulations for new industries, and are usually the owner of the DH company. In addition, we interviewed representatives from national authorities to improve our contextual understanding of the frame conditions. We conducted two workshops in 2018 and 2019, specifically discussing challenges with surplus heat utilization with firm representatives, technical researchers and policy makers. As such, the analysis builds on a broad range of perspectives from various actors in the Norwegian setup. We anonymize firm names and refer to case numbers when using quotes.

We analysed documents and interview transcripts to uncover challenges with framing surplus heat as a resource (e.g. regulatory issues), and how surplus heat was valuated across the cases (e.g. market price, free of charge). This involved an analysis where we identified the actors’ perspectives on the exchange. Through this, we extrapolated different modes of valuating surplus heat, each carrying different principles for organizing the exchange. We also identified the main barriers towards continued operations particular to the different modes. This resulted in three archetypal modes of valuating surplus heat.
In the following, we first report on key issues of framing surplus heat as a resource, and continue with presenting the different modes of valuating surplus heat. We present these as archetypes to enable comparisons with different types of industrial innovation processes and CE contexts.

Framing Surplus Heat as a Resource

Identifying and matching heat sources with possible heat users is not a straightforward task. Onshore fish farms and greenhouses are examples of industries with heating demands where it could be economically profitable to utilize surplus heat to reduce primary energy consumption. A barrier reported by several informants is the need to establish such industries close enough to surplus heat sources: ‘When something is established in Norway, there is no overview or checklist on existing opportunities for exchanges’ (C-5).

In Norway, municipalities oversee area regulations as well as energy planning, and could play an important role in facilitating this match-making process. Despite existing regulations, that states new firms and buildings must connect to nearby DH networks, these are not always enforced: ‘We only hear about it when the factory is already established’ (C-5).

We also found regulations counteracting increased utilization of surplus heat. Previously, buildings in Norway could achieve high energy- and environmental ratings by connecting to DH networks. Today, the heat source must be located within the organizational boundaries of the firm (or building) in order to achieve zero-emission or passive house certification. As reported by our informants, it is now more difficult to achieve good ratings when utilizing surplus heat from other firms or DH networks: ‘It is an extremely sub-optimal way of doing it and it undermines the collective system […] if you are really interested in the climate effects, you would look at it holistically’ (C-7).

This reported lack of attention from municipal actors shows the need for framing surplus heat as a resource, and heat demand as an opportunity. These barriers spring out of an institutional framing disfavouring, or not considering, surplus heat as a resource.

Valuating Surplus Heat

While there are many existing surplus heat exchanges in Norway, considering surplus heat as valuable is still a relatively new idea. One recurring issue is the (practical and philosophical) question of ‘who is doing whom a service’, as surplus heat exchange benefits both heat producer and user. Thus, agreeing on its value is neither uniform nor obvious to the various actors. Local actors sometimes value this commodity differently, or do not think of it as a commodity at all. We have identified several ways of valuating, as well as legitimizing the value, of surplus heat in local collaborations, which can be expressed through three different archetypes presented below.

Valuating surplus heat as a market commodity

A common notion is that surplus heat should be a commodity with a competitive price. One informant from a processing plant reasoned that the main issue with ‘triggering increased utilization of surplus heat’ (C-11) was the need to ‘price surplus heat correctly’ (C-11). If
this is done, the commodity could compete with alternative energy sources and facilitate demand from potential users. Case 1 illustrates how surplus heat can be valuated in this way as a *market commodity* and organized in a local market where the participants negotiate the price structure (Box 11.1).

**BOX 11.1 A CASE OF VALUATING SURPLUS ENERGY AS A MARKET COMMODITY**

In Case 1, a metal and processing plant delivered surplus energy to two nearby firms, as well as peak load capacity for the DH network. The informants argued that ensuring a competitive price was essential for the collaboration: ‘Prices on alternative energy sources are changing. Therefore, we have to ensure that our product is favoured when it comes to price.’

The firms organized the exchange with a set price on energy, contracts spanning three years, and with a third party in charge of operations and maintenance. While contracts between producer and consumer of heat were bi-lateral, the price was equal for all parties, resembling that of a market. The receiving companies argued that this was necessary to accommodate eventual changes: ‘[…] a three-year horizon is good. So if there are drastic changes in subsidies from the government, CO₂ compensation or the carbon credit prices change drastically, it might be tempting to do something else.’

The informants mentioned external events such as changing energy prices, legislations or companies exiting, as the main barriers for the exchange. For example, when the price on alternative energy sources for heating plummeted a few years previous, it led to re-negotiations of the price of surplus energy. The manager of one of the receiving companies argued that even though changing energy source would disrupt the ‘cluster concept’, ‘that is just how it is; it’s the costs that matter’.

We find similar valuations in Cases 1, 7 and 11, where the informants argue that competitive energy prices are the key motivation of the exchange. Here, the mode of valuation revolves around organizing the exchange with formal contracts assigning it an *economic value* and organizing its trade by establishing local heat markets. As argued by the informant above, this is a viable way to ensure that the receivers achieve competitive prices of surplus energy. Such framings highlight how playing into the hands of economic rationalities can potentially increase utilization rates. This also illustrates the main barrier of this way of organizing surplus heat exchange, as changing circumstances affecting how surplus energy is valuated can put pressure on the collaborations and lead to *re-valuations* of the commodity or potentially disrupt the exchange.

**Valuating surplus heat as a common good**

In other cases, the informants spoke less of economic value, but rather emphasized the mutual benefits of exchanging surplus heat. As shown in Case 2, the valuation of surplus heat can also be grounded in the relationship between individuals and firms (Box 11.2). The collaboration between the firms framed the way they valued and organized the surplus heat exchange.
In Case 2, three companies established a local network of utilizing surplus heat in 2010. The energy exchanges involved surplus heat from an industrial dairy and a poultry processing plant to a nearby greenhouse. In addition, two of the companies utilized the CO$_2$ from their natural gas combustion in the photosynthesis in the greenhouse. In sum, the circulation of surplus heat and CO$_2$ significantly reduced the environmental impact of the cluster as a whole. The firms agreed on a mutual beneficial price structure on surplus heat that was equal for all companies, and distribution of costs where all parties covered infrastructure on their own property: ‘We have had the basic idea that as long as there are no net costs, we are in. In terms of how much money we make on it, we will see.’

Here, the valuation of surplus heat was not merely an economic price of the commodity, but was also a token of reciprocity and shared values between the stakeholders in the firms: ‘… it is exactly like he always says, no one can “insert the straw”, it has to be “win-win”.’

The exchange relied on a form of self-organization with no centralized party enforcing the exchange, nor constant re-negotiations of prices. While there were formal agreements on price, ownership and operations concept, informal relations and trust were essential as well: ‘It has to be an open and transparent system where they can trust us, and we can trust them. And it has been exactly like that.’

The informants also argued that this way of organizing the exchange was dependent on maintaining a good relationship between the firms, as well as key personnel: such as ‘I think that with or without him is the difference’ and ‘If you get a crossing of interests, projects like this will strand’. This highlights the importance of inter-organizational networks and trust in order to facilitate, establish and maintain such relationships over time.

This kind of valuation highlights the ‘common good’ and illustrates how a whole can be greater than the sum of its parts. While these cases are rare in our material (Cases 2 and 10), they are interesting both because they show another way of valuating surplus heat and prove that this approach can be very successful as long as the informal organizational challenges involved are addressed.

**Valuating surplus heat as regional anchoring of industrial plants**

Many DH networks in Norway are the result of long-term collaborations between local municipalities and ‘cornerstone’ metal and processing companies providing surplus heat. In several of these cases, we found that the firms deliver the heat free of charge or at a reduced price, to a DH provider often owned by the municipality. ‘Our free outtake of surplus heat is based on a historical agreement […] the DH company achieved the rights on surplus heat from the ovens at the plant indefinitely, which we administer’ (C-8).

Delivering the surplus heat free of charge does not mean that it is without value. Rather we find that it is valuated in non-economic terms serving other purposes, such as supporting the local community, achieving political goodwill, as well as environmental purposes as mentioned by one informant: ‘Our motivation for giving it away free is also about the environmental perspective. We wish to have an as environmentally friendly factory as possible, and utilizing the energy in an efficient way is positive’ (C-6).
In most of these cases, there is an interdependency between the company and community, not just in terms of energy supply, but also the survivability of the community and firm. ‘Yes, it is very good [that we get it for free], but it depends on whether the industry is able to survive, that their local frame conditions are good’ (C-8).

We find similar argumentation in Cases 3, 4, 6, 8 and 9, where the companies provide the heat cheap or without charge. The rationale for providing low cost (or free) surplus heat is a regional anchoring of an industrial plant in the local community, as illustrated in Case 3 (Box 11.3).

BOX 11.3 A CASE OF REGIONAL ANCHORING INDUSTRIAL PLANT IN A LOCAL COMMUNITY

Case 3 involves a ‘cornerstone’ metal and processing firm localized in a small town. The company uses large amounts of electricity, thereby producing a vast amount of surplus heat. The available heat was the basis for establishing the DH network, owned by the municipality through a DH company. There was so much surplus heat that only the heat from one of the factory’s four stoves was needed, finding new uses for the heat was therefore a goal especially for the municipality and the DH company.

From the firm’s perspective, the informant argued that they provide the heat almost free of charge: ‘we sell it for a symbolic sum’ (C-3), with the benefits mostly concerning political goodwill and contributing to a well-functioning community. Although the factory, and thus the municipality, consumed large amounts of energy (with significant carbon emissions), it was regarded as a ‘Green Municipality’ in government documents because the factory’s surplus heat supplied the entire community with DH. While the low-cost surplus heat was beneficial for the community, they were at the same time completely dependent on the company’s survival. Conversely, the firm were dependent on services and personnel from the community.

Modes of Valuating Surplus Heat

Establishing local CE for utilizing surplus heat involves processes of framing and valuating it as an entity. Actors hold different opinions on what kind of entity surplus heat is, and what it is (and should be) worth. Our cases illustrate how the first step for surplus heat to be treated as a commodity or gift is that it needs to be framed as an entity by the industry actors that are to utilize it. The second step is to specify this entity as a scientific object, separated from all other objects by its measurable characteristics (e.g. kWh, degrees Celsius, price, etc.). The third step is to legally and formally assign the object an ownership, so that it can be given as a gift or sold as a commodity. These valuations and ways of organizing waste products differ across localities, firms and people. As such, there is a variety of possible modes of valuations and circularity. Table 11.1 presents these as archetypes of modes of valuation, principle of circulation and main barriers.

In some cases, surplus heat is valued as a commodity with a price structure resembling alternative energy costs in the market. This mode of valuation is also visible in studies highlighting economic opportunities and barriers (e.g. Jakobsen and Steinmo, Chapter 13 this volume), and business models perspectives (Pääiväriinne et al. 2015). Surplus heat can also be
Table 11.1 Archetypes of utilization concepts of surplus heat

<table>
<thead>
<tr>
<th>Mode of valuation</th>
<th>Market commodity</th>
<th>Common good</th>
<th>Regional anchoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>De-contextualized</td>
<td>Market commodity</td>
<td>Contextualized commodity</td>
<td>Commodity or part-gift where the value lies in legitimizing the firm and region as sustainable and making them inter-dependent</td>
</tr>
<tr>
<td>Relationship between firms and individuals</td>
<td>or part-gift, embedded with cultural and social values</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Principle of circulation</td>
<td>Market relations and economic rationalities</td>
<td>Inter-organizational networks, trust and shared values (win-win) between participants</td>
<td>Formal long-term contracts ensuring local embeddedness of company</td>
</tr>
<tr>
<td>Main challenges</td>
<td>External or internal events can trigger re-valuations of commodity and potentially disrupt collaboration</td>
<td>Valuation dependent on relations between individuals.</td>
<td>Power asymmetry between heat provider and consumer (community). Exit of company would be detrimental</td>
</tr>
<tr>
<td>Cases</td>
<td>Cases 1, 7, 11</td>
<td>Cases 2, 10</td>
<td>Cases 3, 4, 6, 8, 9</td>
</tr>
</tbody>
</table>

Valuated as a contextualized commodity (or part-gift), where the exchange is rooted in mutual exchange between parties and reifies the collaboration. While previous studies of industrial symbiosis have shown the importance of networks and trust (Walls and Paquin 2015), this finding shows how social ties explicitly connect with how firms valuate waste products. Finally, surplus heat can be valued as a ‘gift’ between a firm and the local community. In several of our cases, the community and firm are interdependent, and the non-monetary exchange of surplus heat contributes to the mutual benefits and prosperity of both. In line with Hobson and Lynch (2016), this finding shows a form of non-monetary exchange, which has received less attention in CE.

These archetypes are not necessarily mutually exclusive, nor exhaustive. However, different valuations between parties can potentially be conflicting. In line with Webb and Hawkey (2017), we find that applying models grounded in market framings can make it difficult to gather actors around a common good framing of heat networks. This illustrates the challenges of assigning surplus heat an objective value across localities or ‘constructing a national heat market’ (C-11) as suggested by one of our informants. The different framings and valuations of surplus heat are rarely complementary. While there is certainly evidence of learning across cases, for example through participation in industry-research projects, valuations must nevertheless be made and remade each specific exchange. These findings substantiate Fontaine and Rocher’s (2021) call for the need to better understand the local contexts that favour or hinder realization of surplus heat concepts. The importance of this local co-production goes to the essence of the findings in this chapter. There is no one-size-fit-all concept, deducible to a generic business model or economic device. Rather, our analysis shows the importance of facilitating local collaborations and innovation processes by providing stakeholders with tools and best-practice examples, in order to develop utilization concepts and valuations to fit local needs.

CONCLUSION

This chapter has explored different processes of how waste energy is valuated. While the case of surplus heat constitutes a limited and practical example, the findings have a broader...
relevance for research on innovation for a CE. Valuation processes are imperative also for other by-products. Earlier studies have highlighted the need for novel sustainable business models for CE (Bocken et al. 2019). Our study complements these perspectives, in opening up the ‘black box’ on how negotiating value is an integral part of innovation processes. As such, we argue for the importance of directing attention towards the local grounding of valuations, work of local entrepreneurs and their institutional and social context. This is in line with studies highlighting the importance of informal networks and trust between entrepreneurs in facilitating CE innovations (see e.g. O’Shea et al., Chapter 12 this volume).

In line with Webb and Hawkey (2017), our findings also indicate that there can be a tension between different modes of valuating waste energy and materials. Future research could investigate such tensions further and whether they constitute a barrier for innovative utilization of by-products. These findings also feed into literature that focuses on barriers and drivers for innovation for a CE. For example, Jakobsen and Steinmo (Chapter 13 this volume) show how drivers and barriers to industrial symbiosis changes over time. Our findings contribute to this literature by showing how different modes of valuating waste resources across localities can produce successful results, but also articulate different barriers. Exploring and theorizing barriers and drivers for innovation for a CE dynamically, such as (1) over time, (2) across localities, and (3) the particularities of different waste products, are promising avenues for further research.

Implications

This chapter is a first effort of investigating surplus heat exchanges across wide data material, and there is certainly room for more in-depth analysis. Still, the chapter provides some specific recommendations for firms, public actors and policy makers to unleash the potential for utilizing by-products. Our findings suggest that institutional framings and policies somewhat disfavour surplus heat through energy certifications and focus on energy efficiency within buildings. There is also a need for considering such exchanges when localizing new industrial plants (both heat producers and consumers). Here, local municipalities or energy companies can take a leading role, which is already done by some. Regional mapping of waste sources and end-use can be a valuable tool to this end. Local and regional government actors should have a role in facilitating inter-organizational networks lowering collaboration barriers towards CE. Lastly, while business models ensuring mutual economic benefits are essential to trigger exchange of by-products, our findings also indicate opportunities for considering non-monetary forms of exchange and incorporating the social values of innovations.

REFERENCES


