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# The circular economy of food waste: Transforming waste to energy through 'make-up' work

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## Abstract

This article unpacks the neat straightforwardness of the 'waste regime' of the circular economy of food waste and its main idea: 'waste as resource'. It explores the making of circularity by paying detailed attention to what is conceptualized as 'make-up' work, i.e. how interruptions and leaks along waste flows are handled in practice. Make-up work capitalizes on its double meaning. First, it highlights the covering of cracks needed in order to transform waste to energy. Second, make-up work pinpoints that the neatness of circularity is far from a straightforward technical system, but is continuously made. Through an interview-based study in Sweden, the article illuminates three steps of transformation of food waste into the commodity of biogas, analysing the material and cultural transformations, showing that the micro-management of preventing such interruptions is crucial. Problems such as lack of or misfit material, difficulties in sorting the substrate effectively, over/underproduction of gas and the political decisions steering the conditions for supply and demand are equally crucial and pose the threat that the production will be viewed as inefficient. Based on these results, the article emphasizes the need to problematize the paradigm of the circular economy and the zero-waste regime, on the one hand, and to recognize the work involved in striving for a sustainable society, on the other.

## Keywords

biogas, circular economy, food waste, make-up work, Sweden, waste regime

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## Background

In 2017, city buses in Malmö, Sweden, were covered with advertisements stating: 'Banana peels in the tank! We make biogas from your food waste' (see Figure 1). The campaign visualized how discarded food could be transformed and, as such, refined and re-valued through the so-called 'circular economy' (CE). This counteracts traditional models of waste as a linear process of extract–produce–use–dump. Instead, the main logic behind the CE is that of discarded materials as potential resources that can be assigned a value through different steps along the chain of production and consumption (Gregson et al., 2015). The 'waste-as-resource' model mainly targets market and consumer behaviour as well as policy improvement. To problematize this picture, we argue that the CE is made through mundane careful and competent alignment of policy and the practice done by workers on the assembly. As we will show, continuous work is needed to keep the 'circle' from leaks and disruptions. We introduce 'make-up work' as a probing concept with which to analyse the practice that contributes to reproducing the neatness of such circularity (see below).

It is no coincidence that the banana peel campaign would emerge in Sweden. The country has a high profile in the area of environmental issues (Ideland, 2018), and sustainable management of food waste has been on the political agenda at least since the 1990s, making it a fitting case for studying food waste management. This study stretches beyond the commonplace understanding of the straightforwardness of waste management in a 'modern' and 'sustainable' country such as Sweden. One of the contributions is to show that paying attention to human waste labour is essential not only when studying the Global South (e.g. Doherty, 2019; Ureta, 2016), but crucial also in the seemingly advanced techno-based North.

In the circular economy of food, one of the aims with waste management is to produce resources: bio fertilizers and biofuel. The most valuable product is biogas – a non-fossil fuel used for commercial and private vehicles, and for heating. Biogas infrastructures involve the flows of food waste management explicated below, but also pipes, transport trucks and gas stations for supplying the fuel. Often, the biogas is mixed with fossil natural gas because of uneven production of the former. Swedish production of refined biogas is the third highest in Europe (SOU [Statens offentliga utredningar: Swedish Government Official Reports], 2019: 78), and the Swedish Parliament intends to launch initiatives (e.g. production support) to further increase the use of Swedish biogas. With 280 production plants around the country – of which most are small and run on wastewater, and some are large and depend mainly on food waste – there is indeed fertile soil for infrastructural readiness and the political will to realize a shift towards the waste-as-resource paradigm. About one third of all food, most of it perfectly edible, is thrown away, and the national goals state that:

> Efforts must be made so that by 2020 at least 50 per cent of the food waste from households, catering kitchens, shops and restaurants is sorted out and treated biologically so that plant nutrition is utilized, and at least 40 per cent of food waste is treated so that energy is also used . . . Digestion provides energy in the form of biogas and can replace other, non-renewable energy. (Naturvårdsverket, 2019)


**Figure 1.** We make biogas from your food waste (VASyd.se).

The responsibility for working towards the objectives is distributed across different authorities, among which the municipalities have a prominent position, as they are obliged to organize the handling of waste at the local level. Municipalities, in turn, translate environmental goals into concrete work, the aim being to increase waste recycling and develop fossil-free fuel options, for example through infrastructural investments or information campaigns like the one above.

The organization of food waste management in Sweden differs greatly across municipalities (Corvellec, 2016; Hultman and Corvellec, 2012). One common way to manage the collection and transportation of household waste is through public procurements of the service, i.e. outsourcing management to private entrepreneurs, whose contracts need to be renewed regularly. Another solution is for food waste to be managed by public-owned cooperatives – including one or several municipalities – that are not procured or profit driven. The commodification of waste by transforming it into commercial products (here biogas and biofertilizer) is arranged by either municipal or private companies, or, as is most often the case, by hybrids of the two (Lindqvist, 2012). In other words, this is an industry supported by political initiatives, involving public and commercial actors where the latter often makes the profit.

Unpacking of the neat straightforwardness of the 'waste-as-resource' paradigm, we argue that the CE is made through mundane careful and competent alignment of policy, and the practice done by workers on the assembly. The aim of the article is to explore the making of a CE of food waste in practice and, based on this analysis, to make a theoretical contribution to the field of waste studies by proposing 'make-up work' as a useful concept. Through an interview-based study of transformations of food matter, from banana peels to biogas, we ask the following research questions: (1) what are the potential interruptions, leaks and inflows in the CE of food waste? and (2) how are these interruptions prevented and handled by waste workers?

In the following, the theoretical underpinnings of make-up work, food waste materiality and CE as a particular 'waste regime' (Gille, 2010) are presented. The next section

highlights the methodology of 'trash-tracing' as well as interview and observation data. After this review, material and cultural transformations of the food waste are analysed in three parts: *refining leftovers*, *a feeling for the slurry* and *making biogas*. In the concluding discussion, we further argue for the relevance of our make-up work approach: how the potential inflows and leaks challenge the neatness of the CE of food waste and, thus, that the micro-management of preventing interruptions is crucial.

## Food waste in the circular economy

Waste as a social and material object becomes de-valued and re-valued through cultural and institutional processes (Douglas, 1966; Reno, 2009). Such processes concern, for example, how waste is sorted and classified as a resource vs 'still rubbish' (e.g. Lucas, 2002; Roshizawa and Hird, 2019). Food waste has always been a matter of societal concern due to its symbolic relation to dirt and disgust. However, it has also served as fertilizer and compost soil, and more recently as a substantial basis for the production of biogas. Organic household waste does indeed have a history that illustrates its ontological contingency, not least because it is materially plastic. This tension between cultural de-valuing (construction of 'waste') and economic re-valuing ('waste as resource') makes it methodologically advantageous to study as waste flows, in which social relations, materials, values, agencies, bodies and knowledge are linked together against the backdrop of political frameworks, municipal responsibilities, national law and international policy regulation (see Hird, 2012). Thus, waste is not passively signified. It transforms and is transformed by the very networks in which it is produced (Roshizawa and Hird, 2019).

In her analysis of how waste unfolds as social relations and materializations at various scales in different contexts, Gille (2010) offers the notion of a 'waste regime'. She states that social institutions determine what waste is considered valuable in a society and can be studied at both the macro- and micro-levels, or rather how they interplay: 'the concept of waste regime extends attention to the very production of waste and allows us to understand the economic, social, and cultural origins of specific wastes as well as the logic of their generation' (p. 1056). Using Gille's concept of waste regimes, we approach contemporary Swedish politics, practices and materializations of transforming household food leftovers into valuable commodities, i.e. the non-fossil fuel of biogas and bio-fertilizer.

As mentioned above, Sweden has for decades aimed to become a 'green superpower' (Ideland, 2018). In line with this national branding and building on, for example, an extensive (social, moral, legal and material) system for recycling and decreasing pollution, the government communicated a national strategy for CE (Regeringskansliet, 2020). The aim is to make Sweden the first fossil-free country in the world through shifting patterns of production, consumption and recycling. The public sector, the industry and the civil society are key actors in the striving for a better world. Political will, material conditions and cultural norms are assembled to transform waste into something desirable and valuable. However, studies on how the CE is understood and played out address the tension between the political will to uphold an idea of circularity and the impossibility of doing so in practice (Winans et al., 2017; for Swedish cases see, e.g., Corvellec, 2016; Rosenlund, 2017).

As also mentioned above, the basic logic of CE is that the resource model counters that of extract–produce–use–dump. Kirchherr et al. (2017) conceptualize the CE as 'an economic system that is based on business models which replace the "end-of-life" concept with reducing, alternatively reusing, [and] re-cycling . . . materials in production/distribution and consumption processes' (pp. 224f). The CE aims to accomplish sustainable development environmentally, economically and socially, reached through practices at different levels, creating flows of circularity and re-generativity for material and energy within a society (Korhonen et al., 2018). The regime of CE – which has informed, for example, EU policy since the 1990s – builds on a waste hierarchy that prioritizes management methods on the basis of environmental benefit: from waste prevention at the top to disposal at the bottom (Gregson et al., 2015; Hultman and Corvellec, 2012). The less transformation of material and energy during the process, the better. In other words, re-use via flea markets is more resource efficient than food waste processing, which necessarily involves inflows, and resource and energy leaks (Kirchherr et al., 2017). Alexander and Reno (2012: 5) state that the 'contemporary recycling discourse is the extent to which the idea of a perfect circle is taken for reality'. Valenzuela and Böhm (2017: 26) claim that the zero waste CE is a capitalistic dream; 'a "zero-waste" gloss, results paradoxically in the arousal of a fetishistic desire to consume them more intensely and thus to keep up the wasting of their leftover parts.' It is not hard to see the appeal of the idea of endless recycling. It is precisely because this model is so elevated in both the instructive and academic literature that 'it is important that the circular economy be subjected to critique' (Gregson et al., 2015: 219).

Research on urban metabolism and science and technology studies have successfully used the lens of maintenance/repair work in showing that breakdowns are part of the production of the 'thing itself' and illustrated the importance of 'human labor and ingenuity' to infrastructural flows (Graham and Thrift, 2004: 4). Abrahamsson (2019), in his study on composting and dumpster diving, states that 'food is a fragile and temporary achievement that is made possible thanks to the infrastructures of maintenance' (p. 297). Ureta (2016) approaches waste management as a kind of care, involving tinkering practices and affects – but also as a form of power since the caring is to set up the conditions. Waste management is thus far from just a technical system.

Building on this scholarship – while focusing on the avoidance of disruptions of the neatness of circularity – we introduce 'make-up work' as a useful concept for studying how the waste regime of CE is played out on the micro level where it is defended, but also challenged. Speaking with Gille (2010), the focus on make-up work helps us understand the cultural production of waste values in a specific context. The approach seeks to understand how the 'zero-waste gloss' (see Valenzuela and Böhm, 2017: 26) is upheld in the Swedish CE regime, and how it is necessary for the transformation of food leftovers into bus fuel. Studying the production and transformation of values through work allows us to scale in and out between workers and regimes. Make-up work thus builds on the 'repair' or 'maintenance' approach. However, it adds an additional layer with its double meaning. Make-up work covers cracks on the surface, but more importantly, it implies that the assumed tidiness of circularity, like any aesthetic quality, does not come naturally but is continuously made. We conceptualize 'make-up work' as concerted and organized acts that paint the neatness of, and in effect closes, the circle. This theoretical

approach informs the methodological approach that allows us to deepen our understanding of how the abstract concept of CE takes material shape through work.

## Methodology: Trash-tracing

In order to study the flow from discarded food to biogas, as well as how interruptions in the CE are handled and solved through make-up work, we employ the method of 'trash-tracing'. This action-oriented approach means we avoid starting from the top of the organization and studying 'down', but rather 'follow the trash' in order to get a grip on waste regimes. This approach is inspired by Kopytoff (1986), who argued for investigating the 'cultural biography of things' to examine the trajectories of objects as they go through material and value transformations.

Tracing food waste from household deposits through the transformation into biogas, we encounter a number of value-adding waste workers and have interviewed 42 of them in three Swedish municipalities: Gävle, Malmö and Uppsala. The informants were chosen based on their key positions regarding their specific expertise in waste management. They are mainly positioned within the municipal organization: CEOs, city planners, communication officers, maintenance, permit and legal experts. Commonly, they have a higher education background, e.g. in engineering or communication. A large proportion have extensive experience from working with the organization, for example, 'Lottie', quoted later on, who is a manager at a large food waste plant and has been working herself up the ladder for 20 years. Actors from the commercial sector include directors of recycling plants, local managers and marketers, their firms being highly visible in the sustainability branch. One such interviewee is 'Leif', a civil engineer who is specialized in energy systems and works with biofuel development for an international group of companies.

The interviews lasted between one and three hours; they were then transcribed and analysed in different steps. The transcripts were first manually coded at a content level. In a second analytical step, quotes from relevant codes such as 'waste as resource', 'value', 'biogas production', 'bio fertilizer', 'torching', etc. were extracted and analysed in depth. From there, we identified the leaks and inflows, as well as paradoxes and ironies, of the waste-as-resource paradigm. In order to report the analysis, we selected examples illustrative of the complexities of the CE, and how these are dependent on actors' knowledge, skills and conditions being invaluable to value production.

## Transformations

As stated above, the Swedish national goal is that municipalities should make use of at least 40 percent of their food waste (SOU, 2019). Individual municipalities may have even more ambitious goals. However, the common denominator is that there are numerical goals towards which they work. Different actors play different roles along the path of transformation of household food leftovers, through the processing plant to the biogas production facility. Citizens/consumers, communicators, environmental strategists, engineers, companies and new consumers all contribute to keeping the CE of food waste up and running through the mundane practices of making things work.


**Figure 2.** Don't make it harder (www.gordetintesvarare.se).

## *Step 1: Refining leftovers*

Successful management of the first step of our trash-tracing depends on the everyday unpaid waste work performed by citizens. But citizens are not reliable as a group because they do not always do as they are told, even when it is supposedly easy. Of the food waste that is thrown away, 50 percent is sorted incorrectly and, to a large extent, becomes residual, waste-to-energy material. In an international, comparative perspective, these are exceptionally good numbers but, in the Swedish context, the aims at the municipal level are set even higher. In order to avoid this waste of leftovers, public authorities do what they can to make it as easy as possible to contribute to the CE, for example through PR campaigns such as 'Don't make it harder' (2018, see Figure 2):

This advertisement was placed at, for example, bus stops and distributed to consumers via mail. It states: '(1) sort the garbage, (2) throw the bag in the food bin, (3) done! You have saved the Earth!' Decompostable 'brown bags', such as the one depicted, have become iconic symbols of food recycling in Sweden. The cost of the bags is covered by the waste management fee, and the bags are typically distributed to households, or available at recycling stations or grocery stores.

The bags come with careful instructions, the goal being to make people want to voluntarily sort discarded items and do it correctly. First, to use the bags correctly, there must be a definition of what food waste *is*, for example, what should be sorted into the bags. Typically, 'food waste is anything left over that can't be saved after preparing or eating food' (VASyd, 2018). The list of food categories includes meat, eggshells, bread and coffee filters. Instructions say to combine them, to assemble food stuff that is not usually mixed. Mixing organic things is the starting point for the composition of new material and the process of compostation. The process taking place within the bag might become messy, with dripping or even broken bags resulting in reluctance. It is, however, a challenge to teach citizens to use them correctly. Thus, the bags come with information

and advice on doing this in the right way, on how to achieve less moisture, fewer odours and – maybe most important of all – how to prevent the full bag with messy leftovers from falling apart.

In one of the municipalities studied, the brown bags had just been introduced. According to Oscar, who has insight into the project, one material condition that seems to be crucial for success is the container that holds the bag because it prevents dripping and odour. At the same time, Oscar thinks that people usually do not care that much, or at least that the potential lack of dryness is not of great concern:

> . . . smell and dampness foremost are some of the things that you notice as the biggest challenge with it, right. But the challenge is not so big that it makes people stop or dislike the system, which is also worth noting. They see the challenges but they're at an everyday level, so you don't worry so much about them. (Oscar)

Countering the general impression, he points out that, although the challenge is the smell and dampness, when considered in an everyday perspective, perhaps the problem is not as great as the policy implication workers imagine.

As pointed out by Douglas (1966: 15), paying close attention to the combination of form and formlessness is essential if one wishes to understand dirt. Here, the clean waste is produced through typically dirty practices – mixing categories or forms of stuff and letting them mould together into formlessness. By becoming too wet or smelly, the contents of the bag threaten to become 'sticky', as liminal matter between solid and fluid, fluid and gas. Following Sartre, Douglas expands on stickiness as an unstable cross-section of a transformation process. But stickiness is also enriching: one learns through sensuous experiences about the world (p. 59), and perhaps some dirt can be tolerated or even welcomed by consumers if it is constructed as a sustainability object within the CE (Corvellec, 2016).

The next critical step of the process of producing clean food waste is to place the bags in the right container, for later transportation to the plant: a functioning infrastructure of disposal is needed for sorting and collecting food waste that is as pure as possible. After sorting the right stuff into the brown bag, you also need to throw it into the right bin, distinguishing catering waste from residual waste. Several material conditions need to be fulfilled. The bins should be clearly marked and coloured so that you do not confuse different kinds of garbage. In addition, there should be easy access to dustbins and recycle rooms should be clean and safe. Osanna, who works with sustainable waste management strategies, provides a concrete example of how they have worked to fix problems in one of the city districts:

> . . . the recycling rooms were dark, disordered, scary, kind of, you don't want to be there, it smelled bad, and like messy too. No order in the placing of bins, they were too small, the signs hanging crisscrossed. They just signalled that . . . this is not important. (Osanna)

Making waste recycling matter in this instance means fixing the facilities so that they enable smooth and obstacle-free disposal. Architectural disorder and darkness do not contribute to this end but, on the contrary, signal that recycling 'is not important'. Apart from lack of clarity resulting in mis-sorting of waste, feelings of insecurity in the waste

rooms – often located in the basement of apartment buildings – are a recurring theme in the interviews: 'you don't want to be trapped in there' (Anna). Achieving neatness by fixing badly functioning infrastructures for recycling, such as ordering and marking dust bins, improving lighting and even reconstructing the physical space, is considered a successful approach. In the cases above, it is stressed that such investments in attending to the bins and recycling rooms have increased the amount of sorted food waste and the cleanliness of this fraction.

In the story outlined above, one subtext is the importance of working closely with citizens, for example through neighbourhood projects and campaigns that resonate with everyday practices. However, authorities may run the risk of transgressing privacy boundaries. Anna, one of the communicators interviewed, tells a story about when garbage collection truck drivers noted that food waste bins were sometimes empty. This emptiness bore witness to a lack of compliance with recycling policies. The communication department sent out letters to the property owners involved, in essence stating that 'we have noted that you haven't used your food waste bin, and we wonder if you need more information or if there is something that does not work' (Anna). Some recipients complained that they felt offended, and one even reported it to the State Data Protection Authority. The incident made the headlines in the local newspaper. Altogether, it resulted in acute make-up work, for example, through chats on the major daily newspaper's website excusing and informing as well as trying to restore citizens' confidence.

In this section, we have investigated the process of producing clean food waste and focused on make-up work, interpreted as the prevention of mess by smoothing the process of recycling. The handling of catering waste is culturally viewed as disgusting in many respects. During the summer there are fruit flies, maggots, bad smells and rotten food, and the bags are in danger of dissolving and leaking. Management of this waste involves information, as in the 'Don't make it harder' example and the public letter campaign above, or in the organization of waste bins and renovation of recycling rooms. Various categories of staff at the studied municipalities put much effort into simplifying recycling and making people feel comfortable and safe when doing so, thus accomplishing alignment between policy goals and practice as well as working towards closing the circle. However, striving for neatness and cleanliness may risk creating a distance and disconnection from the waste, thus ultimately reducing responsibilities for the matter (Hawkins, 2006: ix). The particular make-up work presented in this section concerns efforts to increase citizen awareness of, and essential contribution to, policy goals. This work foregrounds the supply of material conditions for smooth recycling, making it easy to produce high volumes of pure, 'good' leftovers. For the CE of food waste to work, rich good leftovers with the right composition and high degree of purity are needed for the next step of the process: the production of slurry.

## *Step 2: A feeling for the slurry*

In two of the studied municipalities, the brown bags, thrown away in the brown bins, are transported by dedicated trucks to a waste plant where they are squeezed and refined into slurry. This is more or less a mechanical process. Non-organic material is separated from the substrate, together with food that cannot be crushed, such as raw potatoes (see Figure 3). The out-sorted stuff is called '*rejekt*' (in Swedish) and may be transformed into central

**Figure 3.** Food waste processing plant. © Photograph: Malin Ideland.

heating at a waste-to-energy plant. The food leftover mixture, now wet and fluid and termed slurry, is then transported to the biogas production facility. This may sound like a straightforward transformation process, but slurry is precarious in nature. In order to function fully, it needs to have the right composition, texture, dryness, etc. Although most of these qualities are monitored and fixed according to standards, there are still risks of unforeseen hazards that require specific kinds of tinkering in order to produce smooth material: slurry that can be digested into energy-rich biogas and nutritious biofertilizer. To illustrate this, we look into the make-up work required to produce good slurry – with the right ingredients, texture and characteristics. Like the process of making 'good' leftovers, good slurry does not come naturally. We ask how make-up work is done to produce good slurry and how it contributes to upholding circularity.

As mentioned above, one kind of matter that disturbs the smooth process of slurry production is the out-of-place waste, for example non-organic stuff that has been thrown into the brown bags. The stories about what this stuff can sometimes be are staggering: irons, fryers and other electronic equipment. More ordinary is cutlery that has accidentally been dropped into the brown bag, objects that end up in the residual *rejekt*. The number of rejected items seems like a sensitive balancing act, as large amounts mean less slurry to digest (Lottie). This balancing involves economic values, but is also important for maintaining public trust in circularity.

While large items, such as cutlery, are easily sorted out, it is more troubling when pieces of fabric get stuck in the screws that are crushing the food. The most serious obstacle reoccurring in the interviews is the plastic wrap used in, for instance, vegetable packaging. Plastic interrupts the process, partly because it gets stuck in the presses, but mainly because it *does not* get stuck but gets conveyed into the fermentation process and is eventually spread onto farmland. Regarding retail food waste, plastic packaging more or less stops the waste from getting into the circularity at all. Instead, just like the *rejekt*, plastic-packaged food is burned to produce central heating.

It might seem reasonable that items like cutlery and plastic matter are causing problems within the process. But the production of good slurry is much more sensitive than that. The raw material of the food waste matters. Waste workers have developed a certain tacit knowledge over the years, through different kinds of experiences. For example, uncooked carrots and potatoes are too hard to be transformed into slurry, hazelnut shells disturb the process and are useless for producing biogas (Lottie). Citrus fruits can start fermentation that may have disastrous consequences – especially in combination with yeast or baking soda. In the worst-case scenario, the trucks transporting slurry to biogas plants can explode. Such incidents can be prevented by staff who have learned to reduce these risks. Lottie, who has worked for more than 15 years at a food waste processing plant, explains:

> You can't do much about Christmas, when the citrus fruits come in. But sometimes we get large quantities, for example of orange juice, and then we don't run it all at once you have to take it a bit step by step. This is something you learn with time, there's no one who has the whole solution, saying that this is the way to do it or not (Lottie).

She knows that the composition of food waste unloaded at the plant varies during the year and how the quality depends on upstream actors, the origin of deliveries: yeast from bakeries, juice from food markets and so on. Lottie explains that her strategies to prevent fermentation are to divide the waste into fractions – making smaller portions – and to slow down the production process.

Actors like Lottie have a good deal of knowledge and practical skills concerning composition problems (sugar), texture (dryness) and temperature variation (heat), gleaned especially from critical moments when things have gone wrong. Anders, who works at a biogas facility, explains:

> First and foremost, you have a problem with possible fermentation. We see it from the slurry too, that at certain periods when the weather gets warm and a lot of sugar substances are in it, then it may start fermenting in the trucks. And it's happened once, that we drove from Malmö and the driver had to stop halfway and unload some of it. (Anders)

Having to unload stinking slurry onto the road is not an ideal situation and does not result in good publicity. Make-up work entails ensuring that the transport trucks carry smaller loads, which create extra space in case of fermentation. Anders provides another example of a composition-gone-wrong incident when he experienced a large amount of fat mixing with the slurry. Fat is a well-known problem for sewage water systems, but it also causes trouble with slurry because it fluctuates between fluid and solid forms depending on the heat:

> We got 600 tons [fat], it took me three years to get rid of . . . the problem was that it was liquid right, at 40 degrees Celsius, but at 20 degrees it was rock-hard. (Anders)

Here we can discern a peculiar balancing act. Anders received a large amount of fat that was almost impossible to digest ('it took me three years'). Yet he nonetheless puts time and energy into doing this. Here we can discern an interesting moral dimension: stuff that can be recycled *should* be recycled. What is potentially a resource should be turned into a resource. Devalued solid fat can, thanks to Anders' skilled efforts, become revalued (Lucas, 2002).

As pointed out by Reno, after 'having been cast aside, tossed around, and mixed in with other discarded things, waste breaks down and becomes less predictable' (Reno, 2009: 34). This is especially true of slurry: it should ferment – but only in the digester (not in the slurry-maker or even worse the truck). It has to be separated from the wrong kinds of waste – but without producing too much *rejekt*. There is a need for large amounts of material, but not to be mixed in any way and not at the cost of including too much packaging material, such as plastic. And even waste that is of the wrong texture and composition can be turned into a resource: the hazelnut shells used in energy production, the fat that is slowly, slowly transformed into digestible slurry. There are no patented solutions to the problems, but the waste workers interviewed have developed what we call a feeling for the slurry and an ability to handle problems along the way. The feeling for the slurry is acquired with earned skills and know-how, and a great deal of pride. The make-up work we have highlighted above, concerns the embodied acts that uphold the assumed neatness of circularity. Contrary to the discourse of a mechanical, almost automatic, process, the production of good slurry ultimately depends on manual skills and dedication.

## *Step 3: Making biogas*

After the food waste moulds into the messy, smelly and potentially unruly slurry, the next step is to transform it into green – and pure – bio fuel. Transferred to a biogas plant (see Figure 4), the slurry is mixed with fertile mould – for example, manure or fat – in order to achieve the right composition, before it ends up in the digestor for about a month. Here, in an oxygen-free environment, anaerobic bacteria can produce potential methane. At the ideal temperature of 37 degrees Celsius and with the right quality of their feed – the slurry – they produce gas, which in turn goes through a refinement process, reducing carbon oxide and producing the 'clean' methane that is called biogas. This biogas is then, alone or mixed with fossil natural gas, traded on the market as car fuel or as another energy source, such as gas heating. According to the market logic, a balance between demand and supply is strived for: a continuous inflow of material needed for the production – for example, slurry – as well as a predictable and profitable outlet of biogas. In reality, this balance is far from perfect. Make-up work is thus involved in the act of balancing supply and demand: both a surplus of and a lack of gas threaten to disrupt the final step of the CE of food waste.

The first problem discussed here is a political one: how can we make the transition from petrol to renewable energy when doing so, ironically enough, requires the inflow of

**Figure 4.** Biogas site, Kristianstad. © Photograph: Malin Ideland.

another fossil fuel – natural gas? The interviewed waste workers talked about how to adhere to such political incentives in practice: in terms of demands on infrastructures, the shape of the gas and the location and functions of the biogas plant. Sofie, who works with coordinating biogas producers regionally, describes how biogas production took off in the mid-2000s and how they lacked an infrastructure for selling the gas.

> You cannot build a new biogas facility unless you have an outlet for the whole produce. And this means that biogas production grows stepwise, but the market grows more linearly, and then you get these huge gaps. (Sofie)

The gaps Sofie talks about are to be found both in the line of consumption (cars and buses still run on petrol) and in the line of production. Gas is a strange matter. It cannot easily be transported and, even though the outlet varies, the gas keeps flowing:

> We have a stop time here for several weeks so we can't just open and close the taps and stop producing gas. (Anders)

One solution to the problem of maintaining continuous flows is to mix it with natural gas. Erik, who manages a biogas plant, states:

> We sat there with a state-of-the-art facility, fantastic really. It was amazingly nice, with this gas, and we had 40 new gas buses. But we had no fluid biogas and the facility could not digest compressed gas. So, the first thing I had to do was to make a deal with natural gas. (Erik)

Ironically, then, stable use of fossil fuel is more or less necessary to uphold the supply of fossil-free fuel. The production needs to be ongoing, and biogas is an object that needs to be handled with care and knowledge; just like the brown bags and the slurry, the biogas is slippery. It does not adapt to the political or material conditions, but needs to be in a flow – constantly produced and consumed. So, even if the inflow of fossil gas risks disturbing the neatness of the circularity through a disconnection of the straight relation between biogas and climate-friendliness (Corvellec, 2016), it is crucial to the CE of food.

Another way to practically handle the lack and instability of biogas production is to mix it with imported gas. Southern Sweden, e.g. Malmö, is experiencing a lack of biogas and solving this problem by adding natural gas as well as Danish biogas (Leif). The commercial energy company Eon, which distributes the biogas at ordinary gas stations in the whole region, also runs biogas plants in Denmark. The Municipality of Gävle serves as a contrast. Just like Malmö, Gävle invests heavily in living up to the national as well as environmental goals of sorting out larger proportions of food waste and replacing fossil fuel when providing an alternative. However, while Eon thrives on an extensive infrastructural system, including gas stations, Ekogas annually produces a negative balance and cannot offer more than a few gas stations. Because of the lack of gas pipes and other infrastructure for transport and refuelling, at the time of the interviews, Gävle was underconsuming gas, leading to overproduction and the need for leaks to maintain circularity. Given that biogas cannot currently be stored to any greater extent, one kind of make-up work was to sell the biogas cheap to a local industry for heating and energy. The other was to let out – that is, to 'torch' – a rather large proportion of it.

The torching of biogas has not been the focus of public debate. This lack of media attention is in a way fortunate for producers, as such attention would put the promise of the CE of food at risk. If my banana peel is not turned into bus fuel, this can be considered a waste of the resource that leftovers are supposed to be. Olle, who manages a biogas plant, explains what happened when their torching unwillingly became the focus of media attention:

> Of course it upsets the public. It was what they chose to focus on and we had really started out very smoothly with production and produced more than we actually first expected . . . then if you increase production and don't have a market for that gas, then of course it will get torched. (Olle)

It is suggested that torching biogas is the result of a lack of readiness on the part of the market. Better and more intense marketing is the strategy promoted. However, Olle still worries about what this does to the political climate around the CE; paradoxically enough, overproduction could kick back as an excuse for not investing in the infrastructures necessary to counteract underconsumption. A 'moral economy of resource recovery' is produced through different social relations and material conditions (Gregson et al., 2015).

Examining the work inside the CE, we see quite a paradoxical situation in which the supply and demand of fuel do not always adjust to each other. The production of biogas requires both leaks (torching) and inflows (fossil gas) in order to keep up with the material conditions and the policy for infrastructure and energy transition. Today, there is a risk that the electrification of cars and buses will become a problem for the CE of food

waste. The user of commodified gas is predominantly the public transport system: city and regional buses. In the recently published white paper on biogas (SOU, 2019), the need to mix biogas with fossil gas is also suggested as a necessity for the transition towards renewable energy. Actors along the chain do not just need the right tools for refining leftovers and a fine-grained feeling for the slurry, but also the infrastructures and political conditions for handling the volatility of biogas. From this example, we can discern de-circularity as refined biogas becomes the new waste. We also notice how human labour and the innovative ideas of 'stabilization' (supply) and 'de-stabilization' (torching) are both repairing and creating leaks in an attempt to keep the circle going (see Roshizawa and Hird, 2019). The underlying narrative of CE is that of a market where demand and supply harmonize. The make-up work highlighted concerns efforts to align uneven production and consumption. In order to close the circle, waste workers juggle with importing gas, mixing with natural gas and torching. Mobilizing fossil fuels and burning non-fossil fuels are needed in order to produce the sustainability object of biogas.

## Discussion

As has been argued, food waste management is far from circular. By spotting and analysing interruptions of the circle, we 'un-blackbox' (Graham and Thrift, 2004: 8) the practices upholding the CE, while recognizing the make-up work done: mobilizing citizens' responsibility, capitalizing on workers' tacit skills, as well as covering unsustainable energy use. The empirical contribution of the present article is that it pays attention to interruptions, leaks, inflows and practices along the waste chain, and how they are handled at the micro-level in order to 'keep the circle'. In the first step, we detect a number of the social and material strategies used to produce as much 'clean' waste as possible, including neat disposal rooms, information campaigns and brown bags handed out, accompanied by tips on how to use them and avoid disgust. Materiality matters when fostering citizens to produce clean waste, thus enabling further processing. In the second section, we focus on how waste is carefully transformed into potent slurry. Not all food waste 'behaves' in the same way, and the waste workers develop a 'feeling for the slurry', which helps them to dose and mix the messy stuff. In other words, the make-up work performed entails a careful mix of raw materials to produce valuable slurry. In the third step, we visit the biogas plant. At this point, the main make-up work concerns the act of juggling supply and demand: both the surplus and lack of gas might interrupt the view of the valuable gas as a 'sustainability object' (Corvellec, 2016). Again, the right mixture is required to acquire a pure product. The slurry needs to be mixed with grease and manure to get the right degree of wetness and the right conditions for the methane-producing bacteria to thrive. In addition, the refined gas might need to be blended with natural gas to enable an even distribution on the market. Balancing supply and demand to uphold the flow and securing value is demanding, but potentially profitable work. Taken together, this analysis demonstrates the particularities of the creative and moral work of transforming degraded household food leftovers into valuable commodities – and re-devalued outflows. The moral commitments expressed by the interviewees is crucial to the CE (Gregson et al., 2015).

The particular analytical contribution we bring to the field of waste studies is the concept of make-up work. With its focus on practice, the concept allows us to understand

how policy is performed and thus what pitfalls it may face. In addition, the concept reveals how the transformation and refinement of heterogenous matter such as food waste involve practices of cleaning that, in turn, generate new waste. We ask for alternative strategies, such as prevention of waste. Edensor (2005), who investigates ruins and ruined objects, states that the disordering and dislocation of the material world might create alternative interpretations, experiences and materializations. Make-up work also enables us to analytically bind together entire waste flows, while attending to the specificities and micro practices of each step. Each step requires different closings of the circle, through patchwork, handling in- and outflows, or translations. Make-up work capitalizes on its double meaning. First, it highlights the covering of cracks needed in order to transform waste to energy. Second, make-up work pinpoints that the neatness of circularity is far from a straightforward technical system, but is continuously made.

As stated, we start from the perspective of a 'waste regime', which draws attention to the specificities of the institutional origin of waste and its generation (Gille, 2010). In the Swedish CE regime, the policy discourse focuses on behavioural modifications and the motivations of citizens to sort out their food waste. However, there are more crucial dilemmas connected to conditions that are rarely highlighted in public. Problems such as lack of or misfit material, difficulties in sorting the substrate effectively, over/underproduction of gas and the political decisions dictating the conditions for supply and demand are equally crucial and pose the threat that the production will be viewed as inefficient. Furthermore, by making these factors visible, a system – built on the trust of citizens – might be challenged and questioned. However, adding complexity to the simplistic waste-as-resource paradigm is necessary if we wish to stop our escalating consumption and the dream of endless recycling (Valenzuela and Böhm, 2017). If, for any reason, my banana peel is not turned into biogas, perhaps I would consider buying more locally produced fruit. In this article, we engage critically with the zero-waste discourse, hoping to ensure that waste stays on the agenda.

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